INTERNATIONAL JOURNAL OF BUILT ENVIRONMENT & SUSTAINABILITY

eISSN 2289-8948

Vol 9, No 3 (2022)

https://ijbes.utm.my/

UTM
UNIVERSITI TEKNOLOGI MALAYSIA

IJBES

International Journal of Built Environment and Sustainability

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Cover Design and Type-set by: Shamsulhadi/Hairunnisa/Azman

The IJBES is an international peer-reviewed Journal
Published in collaboration between Faculty of Built Environment and Surveying and Penerbit UTM

E-ISSN: 2289-8948
ISSN: 1511-1369

IJBES

Vol. 9, No. 3, 2022

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IJBES

International Journal of Built Environment and Sustainability
Published by Penerbit UTM Press, Universiti Teknologi Malaysia
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Exploring the Potential of Homestays as an Alternative Stay Preference in Indian Tourism

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ABSTRACT

Homestays refers to locations for the tourist attraction of sites that may be on beaches, mountains, lakes or homes, typically places of scenic beauty. Three aspects: operation, amenities and attractions are the main attributes of homestays. Closeness to local culture further enhances guest satisfaction, helping to retain the rich heritage of the region. Domestic resources and natural habitats are used to promote sustainable tourism. Therefore, the promotion of tourism depends primarily on active private sector involvement and societies playing a beneficial role. The past researches on homestays lack the various attributes that plays a significant role towards guest experience in homestay and how they create a significant impact on their overall satisfaction.This paper focuses on understanding the concept of Homestays in Tourism and the various factors affecting its overall satisfaction through guest experience during holiday homestays. A field survey was conducted along the coastal belts to understand the guest preference, their cultural experience and their satisfaction level during the duration of their visit. It also analyzes the relationship and impact between overall tourist satisfaction and residence quality of homestays. This helps all stakeholders create sustainable tourism strategies, including host tourism. The outcome of the research is to explore the perception of tourist satisfaction with India during vacation homestays. Recommendations were made for further enhancement of Homestays' based on the findings.

Article History

Received: *10 February 2022*
Received in revised form: *02 May 2022*
Accepted: *08 July 2022*
Published Online: *31 August 2022*

Keywords:

Home stay, local culture, guest satisfaction, rich heritage, tourism.

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DOI: 10.11113/ ijbes. v9. n3.935

1. Introduction

A home-stay operates as home as a paid guest for a limited time on its joint terms (home-stay). However, these tourists come from various families and cultures. The Home-Stay Regulation approved to have it as a person or group (Timlasana, 2012). Home Stay endeavors to attract visitors belonging to sophisticated and over populated urban areas to the countryside, which offers stunning natural scenery and healthy, simple and inexpensive accommodation and cuisine. Homestay gives visitors a special experience both local and personal. It provides the potential for modern, untapped places to make fresh touristic destinations popular and alternative income for rural people (Gangotia, 2013). Home guests spend time with their families studying their customs and cultural values in experiencing rural life (Devkota, 2010). India is a renowned holiday destination and a cultural and geographical heritage.

In homestay tourism, environment and culture are commercialized; visitor demand creates value for the market. It gives local Aboriginal groups financial support for environmental conservation and restoration. (Laurie et al, 2005). This strategy focuses on tourism as a development driver, demonstrating how positive and negative impacts increase (Ashley, 2000). Tourism home entails rural poverty. Includes cycling, cultural tourism, agro tourism, education, ecotourism, all forms of tourism. [Devkota, 2010]. It's a strong income source. This decreases the difference in payment balance, creates higher tax revenue, stimulates domestic economic growth and improves job opportunities. It can also

provide new markets for fishing, animal husbandry and other goods (Budhathoki 2013). Tourism development helps people seek higher education and find new employment as literacy increases. This helps re-determine new generations' cultural and racial identities. Local residents provided hospitality training and basic communication skills to learn techniques of hygiene, tourism, and conservation.

Increasing tourism at some location has had a positive effect on the area's survival but also on the lifestyles of the local population, which have lost their cultural heritage and legacy (Pandey et al., 1995). Tourism documented worldwide biodiversity. This leads to lack of local gain and lack of a safe climate, high relative to tourism's economic growth (Banskota and Sharma-1995). Changing tourist traffic and parking can also contribute to increased road traffic, urbanization, and increased pollution (Gurung et.al 1996). Women trafficked more, alcohol intake increased, adverse effects on local people's lives, destruction of natural infrastructure, impacts on religion and cultural heritage, etc. Both reasons endorse a pessimistic attitude towards tourism. Tourism also needs to protect and support neighborhoods, use local energy and services, and improve the economy of a city. Sustainable development must be a priority for tourism. Homestays, including economic, cultural, social and climate, will be a major rural development tool in all fields.

Homestay tourism in India

Productive housing is available worldwide. India has cultural and natural resources, providing additional insight into this (homestay) phase. India's traveler gateway, natural beauty, seasonal diversity, cultural abundance, ethnicity and community hospitality are main factors. Staying in luxurious hotels, lodges, resorts and bungalows is a delicate mix. Highlights are roads north of Ladakh, Spiti (Jammu & Kashmir). Similarly, Himachal Pardesh recorded the number of resorts registered under tourism services including Kullu, Shimla, Chamba, Solan, etc. (Gangotia, 2013). Nanda Devi Valley and Flower Valley were Uttarkhand's key residents (Macek, 2012) where homestays are identified. Delhi's NCR has wonderful home spots. Assam is one of the registered tourist houses of great cultural, biological diversity. The presence of Darjeeling in West Bengal was marked by its far-east home. Rajasthan's vibrant state has Dera Rawatsar west, and Jaipur's general retreat home has a huge tourist attraction. Ahilya Fort Maheshwar Home (Madhya Pradesh) is a popular tourist destination. South India homestay destinations own Kerala, Karnataka, Tamil Nadu. In South Karnataka's 225-acre, coffee and spice groves, Honey Pot House and House of Cardamom are predominantly identified. Homestay is an incidental house constructed in Western Ghats along edges of monsoon climate, relying on Kamarjar lake. Kerala, with many locations like Casa Del Fauno, is a gateway to South India. Home opportunities include Allappuzha, Phillipkutty Kumarakom, Fringe Ford Mananthavadi and Hideaway Kolagapara. Tourists enjoy fun, quiet holidays in an atmosphere of exquisite environmental beauty if one selects Kerala's experience. Many locals find India beautiful. To exploit its vast potential, this tourism idea must be given due consideration by evaluating its opportunities and challenges in India.

The research is an endeavour to explore the various attributes that contribute towards the guest satisfaction during their duaration of time they spend in the homestays. While studies have been conducted as to why tourists choose homes, their feelings have not yet been studied. Since community tourism is found in communities, it is highly contextual due to cultural differences. Therefore, there are lack of literature that had discussed on the influencial attributes and their inter-relationhsip for overall tourist satisfaction level in hoemstays . Thre research attempts to look into these aspects through a survey and responses taking Indian coastal belt homestay tourism and the experience of tourists during their stay.

2. Literature Review

Several papers had been written on customer care from various viewpoints. There is no Indian-based study on tourist satisfaction and homestays. The exisitng literature review describes international literature. Such literature notes that customer satisfaction can be based on the selection of aspects between the cognitive experience of the consumer and the objective existence of the product / service.

a. Concept of Homestay Tourism

Homestay is an accommodation arrangement where visitors live as a family member with households in a location. (Gu & Wong, 2006) for payment (Andriotis & Agiomirgianakis, 2013). Homestay tourism is, according to (Jamal, 2011), a type of tourism that attracts a specific market segment where people want authentic experiences based on nature, culture and local tradition. Unlike other lodging options, homestay helps visitors to learn about local life and culture (Kontogeorgopoulos, Churyen, & Duangsaeng, 2015). Interested visitors typically have empty rooms in private homes (Hjulmand, Nielsen, Vesterlokke, Busk, & Erichsen, 2003). Hosts are invited to raise additional income and meet people from around the world (Lanier & Berman, 1993; Gan, Inversii, & Rega, 2018). Homestay's growing demand has earned substantial research attention (Mura, 2015). Several longitudinal studies were conducted to understand which homestay attributes encourage visitors to choose accommodation. Homely scenery, customized amenities, home-cooked food, authentic local experiences, cultural immersion remained the key reasons for tourists to select housing while traveling (Wang, 2007; Gunasekaran & Anandkumar, 2012; Agyeiwaah, 2013). Although homes are part of experiential & cultural tourism (Wang, 2007), empirical findings indicate that price also plays a role when tourists decide to stay in homes (Hsu & Lin, 2011; Rasoolimanesh, Dahalan, & Jaafar, 2016). Previous studies also show quiet local destiantions have (Tussyadiah & Pesonen, 2016) decreased noise, landscaping, attraction, relaxation and leisure (Hsu & Lin, 2011). Sentiment analysis using online customer feedback (Yu, Duan & Cao, 2013) is one way to learn about other goods or services.Women, minorities and locals play a critically important role in the cultural, environmental and social growth of local tourism businesses at the local level (Harris, Wise, Gallagher and goodwin, 2001). By participating in the

marketing, commercializing, objectification and abuse of their tourism goods, the good tourism approach is demonstrated by Ruiz-Ballesteros (2010) and Herna'ndez-Ramı'rez (2010). Such corporations were able to merge their social relations with the capitalist system with a greater influence on their tourism operations. Via tourism, these areas have benefited as alternatives economically. The research also demonstrated the shared support and self-esteem of community members. The community was assigned to control its collective resources in these two Ecuadorian societies. A lifecycle, rapid growth and better economic results were reported in the Zapata, Hall, Lindo and Vanderschaeghe (2011). Zapata, others. His research proposed that donors and policy makers should focus on policy redeployment which improves the skills, wealth and circumstances of community-based firms and improves domestic management. The results were favorable for community tourism, particularly women, minorities and local residents, from these Latin American studies. The most enticing draw of tourist attractions is nature and culture (MacDonald & Jolliphe, 2003; Musa, Kayat & Thirumoorthi, 2010), Anand, Chandan & Singh 2012. Gu & Wong, 2006). In community management and socio-cultural processes, it retains critical modalities. In many popular rural homes in Nepal, Thailand, Malaysia and India, code of conduct helped establish cooperation and regulatory relations between stakeholders. Besides promoting low-cost, eco-friendly rural tourism (Holden, 2010; Mowforth & Munt, 1998; UNWTO, 2004a; Honey, 1999; Jones, 2005; Touch, 2004). The goal of the program is to reduce poverty and to reduce the climate and social inclusion (Holden, 2010; As components of sustainable development, the WCED (1987) established poverty alleviation and deterioration of climate. Visitor hosting promotes exchanging history, knowledge and experience. Studying abroad, however, is also a student's first experience to move away from his parents and family. Host can assist with separation, anxiety, and other problems. Hosts and students staying at home may experience mild culture shock symptoms and must adapt accordingly. Despite potential problems, host families can learn about other cultures, including kids. Long after returning home, several host families keep in contact with visitors. Sometimes, a host family or person wants to use only the financial advantages of a home residency arrangement and may have little to no interest in the other party's interests. People also use it to improve their skills and learn local lifestyles. Some countries encourage domestic residences to grow their international tourism. Host family may make money to host a participant at home. Students prefer to plan a stay with their relatives, but they may arrange one informally, usually at negligible expense, by linking students to host families. Home options vary from family to simple room rental. A home stay aims to plunge visitors into their host's society. Tourists will enjoy family activities such as restaurants, fun parks, campsites and travel. The visiting student can claim part of the cost of events such as flights, parking, fuel, and travel expenses.

Literature analysis reveals group engagement in sustainable tourism. Communities lack the skills to start and actively engage other tourism stakeholders, including NGOs; governments serve as catalysts. Companies will take tourism alone to overcome the initial challenge. Sensitization and conditioning play a significant role. The study shows growing challenges, challenges and barriers to community-based tourism development, but they can be overcome. Although tourism is practiced at various levels in India for different types of tourism, they did not attract academic research. The Homestay System is alternative tourism in countries that allows visitors to experience the lifestyle in a traditional village. This form of tourism becomes more and more popular with international tourists. The aim is ideally to be small-scale, low-density, versatile and spontaneous, unlike mass tourism. More importantly, municipal government manages and conducts it to ensure that their economic gains are directly realized. Homestay is well-known as community-based tourism in many Asean countries. The Home Activities program promotes local culture, the arts and craft industry, encourages the preservation of cultural and historical resources, and enhances conservation efforts through community education. So many foreign tourists from around the world looking for rural tourism in ASEAN countries, a more systematic growth of home-based tourism would be vital for creating a 'new brand,' exhibiting rural lifestyle, offering a practical type of holiday so much cultural and educational elements. The home system's point of sale is not the village's physical structure, but the village's overall experience, where youth and group events are highly important. The efficacy of the ASEAN Home Activity Program is largely dependent on a good understanding of the fundamental requirements of a high-quality home visitor experience. It is therefore necessary to establish the ASEAN Homestay Standard, which will enable standardization of basic home understanding and minimally organized understanding across all ASEAN member countries. To mitigate disputes, most residential arrangements include a host group-guest arrangement or written agreement. Following a stay, oral agreements can change contractual conditions based on developments. The guest is typically listed under the terms of a contract, which can include work (e.g. cleaning, laundry) curfews, Internet use, television or telephone usage and alcohol, drug and prescription laws. Agreements can also provide lodging, equipment, utilities, meat materials, materials, communications and entertainment. The host normally uses a private space with lock and washroom sleeping and learning. Many other items can be negotiated for quality and price.

b. Tourists Satisfaction

Knowing what drives tourist satisfaction is a leading area of tourism research (Petrick 2003; Prebensen 2006). To knowing tourism, joy is key (Ross & Iso-Ahola, 1991). Literature on this subject is limited due to several key factors and the consequent lack of holistic approach (Corte et al., 2015). The definition of customer satisfaction includes a sense of well-being and pleasure that comes from a good and/or service that is desirable (WTO 1985). The outcome is that Bigne, Sanchez and Sanchez (2001), based on one's own emotions and inner nature defined satisfaction. However, the reactions often apply to the focal point, usually a company that draws users to a particular destination. The overall evaluation of good or service transactions and user experience is often defined as customer satisfaction (Hui et al. 2007; Flint et al. 2011; Qi et al. 2012). A person's "absolute feelings or attitudes about a product after purchase" are calculated by customer satisfaction (Solomon, 1992). The relationship between two variables — its degree of expectations or desire, and their perception of outcomes, outcomes in satisfaction. If a service is successful, the buyer is

satisfied; if the production is lower than expected, the buyer is disappointed. Satisfaction is a 'healthy situation' (Engledow, 1977, p. 88, quoted in Pizam, Neumann, & Reichel, 1978) from a common appraisal of the customer's relationship with suppliers (Lam et al., 2004).

c. Attributes of Tourist Satisfaction

Overview: Researchers found several reasons for tourist satisfaction. Calculating visitor satisfaction is extremely complex (Pizam, Neumann & Reichel, 1978). To evaluate the degree of tourist satisfaction, various factors promote the psychological process required by the evaluation of the experience of a specific product must be taken into consideration (Peter & Olson, 1996). In particular, homestay assessment there are few literatures. Overall, tourism values and tourism satisfaction are addressed in terms of cultural and cultural heritage tourism, although none directly applies to homes. Tourist destinations have been recognized as settings of economic, socio-cultural and environmental events. These include housing, shopping and food, shopping and entertainment (Pizam, Neumann & Reichel (1978), etc.), shopping and leisure. Giese & Cote (2000) stressed that satisfaction rates must be specified according to their context. Three fundamental elements are defined: an emotional decision response; a certain component of service, and a certain moment in time. Tourist satisfaction metrics were derived from the following: Pizam, Neumann & Reichel (1978), Beach (destination) choices, prices, lodging, food / drink facilities and hotel facilities. Chi's G.C. Includes attractions, housing, restaurants, shopping, entertainment and culture. According to Prayag (2008), attributes include comfort, protection and facilities, cultural and commercial attractions, tourism and atmosphere and diversity and accessibility are accessible. The sense of genuineness depends on the point of view and so credibility is always the consumer's preference (Tarssanen, 2009). Other factors influencing tourism satisfaction include quality, local culture and environment (Pizam, Neumann and Reichel 1978). There is no consensus when assessing tourist satisfaction in past research (Kozak and Rimmington, 2000). A significant number of other requirements, such as cultural excursions (Ross & Iso-Ahola, 1991), other features of the tourist network (Heide et al., 1999,) efficiency features, safety problems (Mutinda & Maiaka, 2011), transport facilities (Yeong et al., 2010) and personal concerns (NorlidaHanim et al., 2011, John and Ron, 2000).The conceptual framework for tourist satisfaction is summerised below in Figure 1.

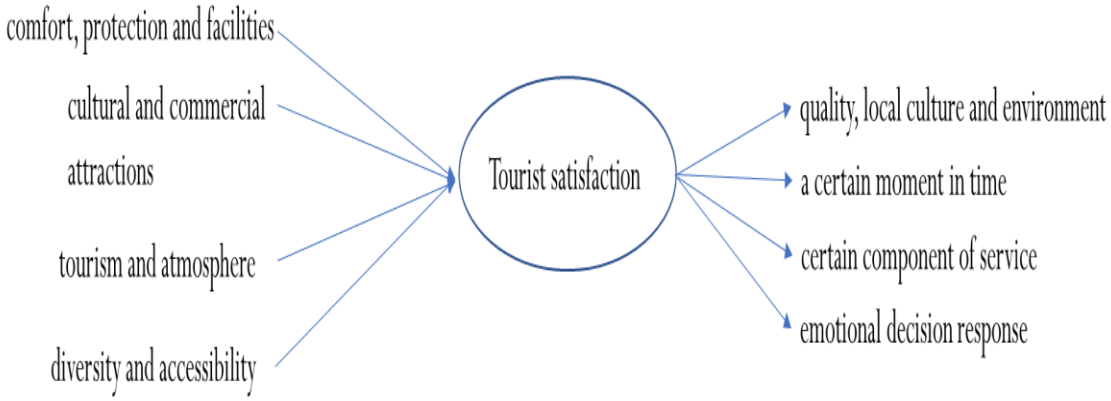

Figure 1: A conceptual framework for overall tourist satisfaction *(Summarized by Author)*

Homestay View: The host family's contacts with tourists are important aspects of a household that can distinguish tourism from other types of accommodation, such as hotel resorts, etc. where visitors are professionally involved. Home connections, such as personal accommodation, host families open to the public, are important aspects. Education, entertainment, food, lodging and hospitality are some of the elements needed (Levitt, 1986). Homestay focuses on local lifestyle, culture, and traditions (Bhuiyan, Siwar, 2013). Similarly, Murphy et al. (2000) and Truong & King (2009) explain the cultural characteristics of a host country such as its history, culture, practices, architecture, food, rituals, works of art, music, craftsmanship and dance, offering visitors valuable and productive attractions.

3. Research Design

Research Objectives

I. To develop in-depth knowledge of tourism satisfaction with experience of homestay tourism.
II. To identify the challenges and opportunities faced in the development of homestay tourism in India.

In this respect four elements were basically based on the Homestay attributes system for questionnaire design. Aspects include cultural appeal, hospitality, facilities and security at the home.

Hypothesis: There are no ties to overall tourist satisfaction with Homestay in India between different Homestay attributes (after factor loadings).

Research Strategy and Design: Analysis was a quantitative exploratory study that investigated whether there are strong ties between tourist satisfaction and housekeeping in India. The data is collected from the tourists visited to coastal belts of Udupi, Karnataka, who came to visit Malpe, Kaup beaches and river islands with Hanging bridge. Samples are collected from Adigas Beach Village Home Stay, situated on the beachfront of Udupi Beejadi district, about 400 meters from Kundapur – Udupi motorway in the inner city. Udupi is 35 km south of Kundapur. It is a Heritage Home Stay where one enjoys the traditional stay in Karavalí modern homes. It is located in the heart of Udupi, close to Beejadí beach, Udupi District. Adigas Beach Village Homestay, a 20-minute walk from Kundapura, just a 30-minute drive from Udupi City.

Sample and Data Collection: The study is based on a convenience sampling (non-probability sampling method) of 45 respondents who have visited these coastal belts from different parts of the country. In order to gather data from their guest (tourist), the questionnaire was randomly distributed to their nearby homestay and later collected in good time. The method of data collection was via an online questionnaire and data was collected directly in the cloud.

Data Collection Instrumentation: The survey was conducted in two phases: Firstly, on a broader understanding about Choice for Selection of Homestays. A self-designed tool contains 7 Likert scale-based manifest items. Four factors drive the manifest questionnaire items: cultural attraction, hospitality, services, and home security. Second part comprises of Tourist Experience in Homestays. In reality, a latent statement of 1(1) was defined as a dependent variable of overall satisfaction. Van de Ven and Ferry (1980) assessed satisfaction with the current 5-point location. Although internal consistency reliability cannot be calculated for a single variable, research has shown that certain elements are consistent and replicable and may represent satisfaction more closely than other aspects (Scarpello & Campbell, 1983). Manifest variables concentrate primarily on home factors such as cultural value, hospitality, services, and home security.

4. Analysis and findings

Inferential analysis is used to generalize the results obtained from a random (probability) sample back to the tourist population from which the sample was drawn. This analysis is taken as the sample is drawn by a random procedure. The variables used for analysis are aspects that include cultural appeal, hospitality, facilities and security at the home. Out the 45 respondents, 27 were male and 18 were female. Of the 45 interviewees, 12 were in the 20-30 age group, 16 were 31-40 years of age, 7 were 41-50 years of age, 10 were 51 year of age and older.

Hypothesis I (Table-1):

H0: The age group of respondents does not connect them in a significant way with the key reasons for opting for home facility.
H1: The age Group of respondents is substantially related and the main reasons behind opting for the home facility are established.

Table 2Testing of Hypothesis-I

Age * Choice for selection of Homestays : Cross tabulation					
Age	Strengthen local culture and traditions	Hospitality	Host families' services	Home security/ Privacy offered	Total
20 - 30 years	6	3	1	1	12
31 - 40 years	4	5	3	0	16
41 - 50 years	5	2	1	0	7
51 and above	6	2	2	0	10
	21	12	7	1	45
Expected P-Value					
Age	Strengthen local culture and traditions	Hospitality	Host families' services	Home security/ Privacy offered	Total
20 - 30 years	6.13	2.93	2.67	0.27	12
31 - 40 years	8.18	3.91	3.56	0.36	16
41 - 50 years	3.58	1.71	1.56	0.16	7
51 and above	5.11	2.44	2.22	0.22	10
	23	11	10	1	45
p	0.596				

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.299a	3	0.63
Likelihood Ratio	8.568	3	0.36
Linear-by-Linear Association	.043	1	0.83
No of Valid Cases	45		
a. 4 cells (50.0%) have expected count less than 5. The minimum expected count is .40.			

Findings: We can see that the measured chi-square is more than tabs [0.063 > 0.05] for Chi-square. We therefore reject the alternate hypothesis and support the null hypothesis, meaning the gender of respondents does not have a substantial connection and the principal reasons for selecting a home facility are given to them.

Hypothesis II (Table-2):
H0: No major relationships exist between the gender and mention of the primary reasons for opting for homestay facilities.
H1:The gender of the respondents is substantially correlated with the key reasons for selecting a homestay facility.

Table 3: Testing of Hypothesis-II

Gender * Choice for selection of Homestays : Cross tabulation					
Gender	Strengthen local culture and traditions	Hospitality	Host families' services	Home security/ Privacy offered	Total
Male	10	7	7	2	26
Female	11	5	3	0	19
Others	0	0	0	0	0
	21	12	10	2	45
Expected P-Value					
Gender	Strengthen local culture and traditions	Hospitality	Host families' services	Home security/ Privacy offered	Total
Male	12.13	6.93	5.78	1.16	26
Female	8.87	5.07	4.22	0.84	19
Others	0	0	0	0	0
	21	12	10	2	45
p	0.632				

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.144[a]	9	0.520
Likelihood Ratio	8.263	9	0.508
Linear-by-Linear Association	0.953	1	0.329
No of Valid Cases	45		
a. 13 cells (81.3%) have expected count less than 5. The minimum expected count is .16.			

Findings: It is clear that the measured chi-square is more than the tabulated chi-square [0.596 > 0.05]. We therefore deny the alternate hypothesis and support the null hypothesis. This means that there is no important connection between the age group and the reasons why they have chosen a household.

Exploratory factor analysis of the tourist experience of the qualities of homestay in India (Table-3):

Homestays are seen as a form of tourism focused on the culture of vision, lifestyle near the host destination. A five-point scale-based Likert questionnaire was used for gathering tourist impressions of objects with 22 attributes. This involves significant variables of cultural appeal, hospitality, services and security at home. Table 3, for all variables used in the study, summarizes the communalities. The key component research approach extracts all factor opinion statements. Extracted communalities are smaller than the initial value.

Sl. No.	Opinion Statements (Key words only)	Factor Loading	Communal (h2)
Factor 1: Facilities & Safety during stay in Homestays			
Q1	Provision of accessibility	0.5	0.6
Q2	Local tours and excursion	0.8	0.7
Q3	Provision for nightlife entertainment	0.6	0.5
Q4	Shopping local souvenir	0.5	0.5
Q5	Tourists information	0.7	0.8
Q6	Provision of emergency healthcare	0.9	0.9
Q7	Provision of safe deposit boxes	0.8	0.8
Q8	Provision of fire safety	0.8	0.7
Q9	Provision of first-aid kits	0.7	0.8
Q10	Personal safety	0.4	0.7
Percentage of Variance: 24.0, Cumulative Percentage: 24.0			
Factor 2: Warmth of the facility by the host families			
Q11	Excellent and unforgettable services	0.7	0.7
Q12	Warm, friendly and generous gesture	0.7	0.6
Q13	Proactive towards solving any problem	0.6	0.7
Q14	Full attention by host	0.8	0.7
Percentage of Variance: 5.1, Cumulative Percentage: 26.5			
Factor 3: Local Cuisine & Accommodation			
Q15	Accommodation cleanliness and hygiene	0.6	0.7
Q16	Accommodation comfortable with clean toilet facilities	0.5	0.6
Q17	Local cuisine (food and drink)	0.7	0.7
Percentage of Variance: 4.4, Cumulative Percentage: 30.5			
Factor 4: Local Life Style & Costumes			
Q18	Local lifestyle	0.7	0.7
Q19	Local costumes	0.5	0.8
Percentage of Variance: 3.3, Cumulative Percentage: 37.5			
Factor 5: Cultural Performance			
Q20	Cultural programs (traditional dance and songs)	0.7	0.8
Q21	Other cultural events	0.8	0.6
Q22	Authentically presented culture	0.7	0.5
Percentage of Variance: 3.1, Cumulative Percentage: 38.5			
Extraction Method: Principal Component Analysis, 5 components extracted. Rotation Meth Varimax with Kaiser Normalization. Rotation converged in 5 iterations.			

Factor summary and interpretation

Factor 1: The first factor resulting from Exploratory Factor Analysis (EFA) is called "Facilities & Safety". This aspect includes manifest variables such as provision of accessibility, potential local tours and excursions, provision for nightlife entertainment, stock of local souvenirs to purchase, accessible tourist and emergency primary healthcare information focuses on local facilities. Likewise, this aspect also differs in content such as fire protection, first-aid kits, feeling of personal safety and secure deposits at home destination.

Factor 2: The second factor arising from EFA is called "Warmth of the facility". This aspect consists of manifest variables such as service quality, host behavior, guest focus and host pro-activity problem-solving towards the guest.

Factor 3: The third aspect of the EFA is called "Local Cuisine & Accommodation". This aspect involves manifest variables based on food quality and lodging at home destination.

Factor 4: The fourth aspect resulting from the EFA is regarded as the "Local Life Style & Costumes". Included in this consideration are the obvious improvements which are based on local rural life and local costumes and which the guest perceives satisfactorily.

Table 4: Exploratory Factor Analysis

Factor 5: The EFA's fifth component is known as "Cultural Performance". The manifest variables concentrate on genuine cultural elements of the visitor.

Opportunities for Homestays:

Foreign tourists can and should be redirected to rural destinations in India as one of the Indian Government's tourism policies. There are various temporary issues which can nevertheless be overcome by suitable solutions and proper preparation, which can be done by the communities and private enterprises to support all parties involved in a win-win situation. The following is a list of opportunities that can be considered to develop the Homestay concept along with the sustainable parameters.

Social Opportunities of Homestay:

a. An ideal intercultural forum (guest-host interactions).
b. Minimize tensions between various races and nationalities.
c. Preserving young people by engaging them in local occasions.
d. Apprentice new languages, skills and create local confidence.
e. Make local people tech savvy and "smart" as the modernization is slowly passing through and autonomous.

Economic Opportunities of Homestay:

a. Transform rural economic and job opportunities and thus reduce poverty.
b. Foster domestic and international tourism investment · Promote the micro-business of tourism and its many other associated industries.
c. Related economic benefits – food intake, accommodation and the purchase of souvenirs.
d. The preservation of potential to be local, such as the arts and crafts.

Environmental Opportunities of Homestay:

a. To persuade local people to keep their buildings, kitchens and toilets clean & tidy
b. To increase their knowledge of the environment in the areas of hospitality would be very helpful in reducing the common hygienic disease.
c. Assembly of physical environment protection funds.
d. Tourism related Opportunities:
e. Tourists get an opportunity to see the richness of nature and culture.
f. Increasing the ability of the destination for accommodation to be supplied.
g. Prevent the seasonality issue by supporting the destination during the year.
h. Increase understanding of tourism through constant involvement through key players among local and foreign tourists.

Infrastructural Opportunities:

a. Keep through connectivity to villages by linking them to easily accessible highways.
b. Increase the number of capacity building education and training centers.
c. Increasing health and protection for local residents and visitors at the appropriate destinations.
d. Improving education and healthcare in rural areas.

Challenges of Homestays:

a. Poor infrastructure and services such as good highways, transpirations, electricity, health care, communications and other residential facilities are not easy to develop and facilitate better support for current and future home visitors without such facilities.
b. The shortage, because of lack of availability of education and training institutes, of trained human capital such as guides, businessmen, professionals.
c. There are insufficient legal provisions such as homestay registration, reservations for homestays and other related policies.
d. In the region, too, there is lack of marketing and promotion of home tourism. The expansion of marketing and networking in the country cannot be properly planned.
e. A mismanagement is missing between different players in tourism, such as government, players in tourism, intermediaries in tourism and other NGOs related to homestay tourism.
f. Awareness of natural and cultural resources protection among local population. Continue The absence of ecotourism is also a significant challenge to India's successful homestay growth.
g. Improper resource utilization at the destination is also a major obstacle to expand the feasibility of home stays.
h. Weak protection of situations of stability, security and uncertainty that demotivate international tourists to visit India.

5. Recommendations

These homeowners' greatest concern is their poor marketing. Sensitization among local and national residents. The popularity of these units, if increased, would not only improve the concept, increase sales and also maintain the culture and heritage of our country. Sufficient advertising campaigns should be displayed to familiarize the visitor with the idea, airport hedging, train stations, big tourist centers etc.

The issues of living in a stranger's house with his family cannot be resolved immediately until the meaning is well understood. The host of the home may also have questions about the guest. There must also be increased public awareness and security. During a specific time of the year, these units also have guests. The third-largest risk is company seasonality. Since the buildings are aged, their elegance, atmosphere and charm need special maintenance.

Professional advice and arrangements are required for these homeowners to make their business prosper all year round. This also meets sales goals and tourists can enjoy their stay throughout. The involvement of host families plays a significant role in hosting. The comfort, honesty and sympathy given for the guest led to guest satisfaction and ultimately to the success of these homes.

After plunging deep into Indian home-tourism, some suggestions have been summarized and these homestays need to hit a greater height. In short, the recommendations are as follows:

a. Homestay planning and growth for the local people are important. Therefore, it should be theoretically supported to prepared the planning and creation of the local citizens of the proposed restaurant destination.
b. Local residents in the homestay tourism destination should be educated to provide quality service for visitors through leadership, hospitality, food and drink (with the use of local menus).
c. Loan subsidy and other tax incentives for upgrading the current facilities, including bedding, lodging, bathrooms, toilets and cleanliness, should be provided to local citizens.
d. The tourism destination of Home Stay should also be connected to other national tourist stakeholders.
e. The government will provide public servants with the 'Leave Travel Concession' and allow them to take on home tourism.
f. There is a benefit-sharing issue between all community members in most homestay tourist destinations. Increasing community member must therefore be taken care of for the benefit-sharing process during the planning of the homestay tourism creation in the region.
g. Establish Community Tourism Fund to invest in the growth of resources and infrastructure in tourist resort destinations.
h. Practice Home-style tourism operations should be differentiated and handled by the government during the assistance and other facilities in community and private.
i. There is a need to build the tourism home database to make it easy for tourists to discover, select and book their stay.

6. Conclusion

The identification of tourist satisfaction with tourism goods and services is of paramount importance. This affects the subjective interpretation and consequent actions and choice of destination of the person. In order to promote tourism activities in a given destination, it is important to understand the phenomenon and obtain comments from a tourist. Such qualities should be improved by destination hosts, managers and other teams. Similarly, a clear correlation was formed between five independent variables and the dependent variable. It is worth reviewing and stressing these values fairly so that tourist satisfaction is sustainable. Similarly, Reception has a greater effect on tourist fulfillment out of five variables. Subsequently, facilities and protection, local cuisine, local lifestyle and costumes, and cultural performance have a significant impact on tourist satisfaction. According to the results of the study, we may also infer that both gender and age doesn't have any impact on the reason for choosing homestays. In order to further popularize the term, better marketing and advertisement should be done. All the members of their families should be prepared to welcome their guests at home. One should get better offers and more exciting deals. There should be an increase in the number of rooms available for each facility and the number of homestays should in general, particularly heritage homes. The security and safety of the guests should take precedence, which is why home service providers should have more protection, gadgets and safety equipment. For people who have encountered a Homestay, their experience is always enjoyed, although some of them feel that rooms should be bigger, the food range can be expanded to serve all kitchens if appropriate. Tariff will include both meals and Indian Program prices. Homestays also tend to be an alternative lodging for travelers in India. Homestays have a broad variety when the idea is well marketed with the growing demand for rooms and the shifting attitude of the millennial visitor. "Vasudhaiva Kutumbkam" is a testimony to the Home Idea. This Sanskrit phrase is derived from the Hitopadesha, meaning that the universe is literally a family. The philosophy that for hundreds of years has been a part of Indian culture, and we truly are the "Atithidevobhava" brand ambassadors.

Finally, it is critical that host and other stakeholders are best positioned to assess the degree of satisfaction of tourists when they classify segments of tourists by their responses. It will help them ready themselves for the long-term survival of their home in India. This will also help them build their potential plans for marketing and enhancing efficiency. It is extremely necessary to act timely and to establish successful strategies. The use of quality management strategies and guaranteeing quality efficiency in relation to expectations should also underline ongoing research into consumer preferences and preferences. Government should also prioritize sustainable tourism preparation, including household tourism, with other priorities.

Acknowledgements

The author wishes to thank the Manipal Academy of Higher Education, India for the support given whilst conducting the research

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IJBES

International Journal of Built Environment and Sustainability
Published by Penerbit UTM Press, Universiti Teknologi Malaysia
IJBES 9(3)/2022, 11-17

Evaluation of School Children Crossing Facilities and Traffic Conflicts in The Vicinity of Schools in Selangor

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ABSTRACT

Half of the world's road traffic deaths involve vulnerable road users—pedestrians, motorcyclists, and cyclists. In Malaysia, there are several strategies introduced to improve the road safety level of school children. However, crashes involving school children are still worrisome. Recent trends of school children involved in crashes in school vicinity have become the nation's concern. Therefore, this study aims to investigate the contributing factors of pedestrian-vehicle conflict involving school children in vicinity of the school. This study focused on the utilization of the facilities provided at school, exposure measures, and demographic characteristics of the schools. The facilities that are being considered in this study are; a zebra crossing, pedestrian bridge, drop-off, and pick-up zone, and the presence of a traffic warden. A total of 57 schools in Selangor were assessed for this study. The important variables were analyzed using the Negative Binomial Regression model to identify the significant attributes. Non-parametric analysis was used to compare the differences in characteristics of the schools. The findings of the study conclude that the road type and pedestrian volume are the underlying factors that would increase pedestrian-vehicle conflict in the school vicinity.

Article History

Received: *28 February 2022*
Received in revised form: *08 July 2022*
Accepted: *15 July 2022*
Published Online: *31 August 2022*

Keywords:

Crossing, Conflict, School Children, School Vicinity, Negative Binomial

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DOI: 10.11113/ ijbes. v9. n3.945

1. Introduction

Pedestrian is one of the vulnerable road users that have always been neglected. Based on the WHO report, half of the world's road traffic deaths occur among vulnerable road users where 22% of them are pedestrians and 23% are motorcyclists while cyclists contributed around 5% (WHO, 2015). In Malaysia, generally, the number of pedestrian death shows a decreasing trend from 2007 to 2020 (Royal Malaysia Police, 2020). However, when evaluated closely annually, the fluctuating pattern can be seen as shown in Figure 1. Statistics from Malaysian police record that pedestrian death increase by 6% in 2016 (Royal Malaysia Police, 2020).

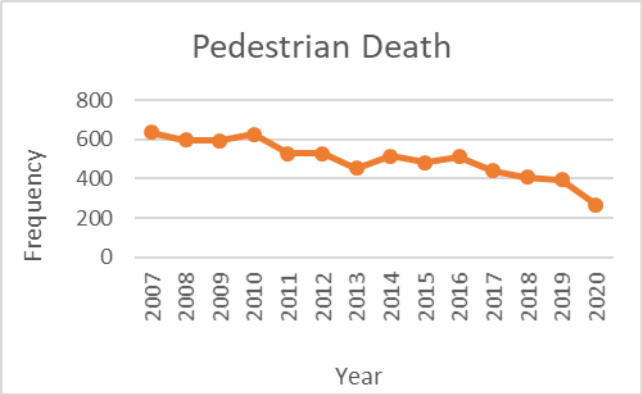

Figure 1 Pedestrian death from 2007-2020

The leading cause of deaths among young people in the world is road traffic crash and it becomes the main cause of death among those aged between 15-29 years old (WHO, 2015). Young road users are at risk due to their small physical or growing characteristic that increase the risk. In addition, insufficient consideration of the young road users' specific needs when roads are being planned. Pedestrian safety especially for school children constitutes a world concern. Beterem (2008) reported that in Israel, 61.8% of children are injured in road traffic crashes where 29.2% of them are in motorized vehicles and 27.3% the pedestrian. In Korea, the annual number of child death due to road crashes is decreasing but the rate is still approximately 50% higher than the fatality rate of other developed countries (Lee and Lee, 2014).

In Malaysia, 25% of road deaths in 2016 are those aged below 20 years old (Royal Malaysia Police, 2016). Focusing on young pedestrians aged below 15 years old, generally, the number of deaths involving them shows a decreasing trend in ten years. The statistic was higher than 15 years ago which led to the introduction of the Road Safety Education (RSE) program in 2007. This initiative was introduced to provide knowledge pertaining to road safety awareness to schoolchildren (Road Safety Plan 2014-2020). Providing a safe environment for young citizens has always been one of the governments priorities in Malaysia. Another program that will be implemented is speed control measures by installing traffic calming to reduce vehicle speed in school and residential areas (Road Safety Plan 2014-2020).

Nevertheless, crashes resulting in deaths or serious injuries involving school children are still worrisome. Recent trends of school children involved in crashes in school vicinity have become the nation's concern. It has resulted in the increasing statistics of young pedestrian deaths in 2016. There are several studies which examined the factors that affect child-pedestrian involvement in road crashes. Some studies found that land use, urban environment, and the neighbourhoods of childrens residences affect childrens risk of being involved in pedestrian road crashes (Wedagama et al., 2006; Petch and Henson, 2000).

In addition, many studies highlight the poor transportation facilities, such as pedestrian crossways, traffic signs, parking facilities, narrow roads, and the absence of shoulders; as well as the lack of traffic-law enforcement as factors that increased the childrens risk of being injured in pedestrian road crashes (Elias et al., 2010; Elias and Shiftan, 2011; Al-Masaeid, 2009). Another study done by Clifton and Kreamer-Fults (2007) on the environmental attributes associated with pedestrian–vehicular crashes near public schools find that the presence of driveways improves traffic flow and congestion in the school area, thus reducing the severity of crashes involving children of all ages.

In addition, a study was done to estimate the impacts of built environments on child pedestrian crashes at the street segment level in Austin, TX USA conclude that no sidewalks, crosswalk density, longer block lengths, and commercial land uses around schools may affect child pedestrian safety (Hwang, Joh, and Woo, 2017). On top of that, crossing behaviors also play a significant contribution to the increase in the risk of a crash. Children who cross the road alone usually do not look before crossing and running to cross the road (Hamidun, Liew & Roslan, 2022; Zhang et al., 2013). Another study on children crossing behavior was done in China and it is observed that the children show unsafe behavior such as sneaking behind a vehicle, entering and crossing a lane with a moving vehicle approaching (Schwebel et al., 2018).

Traffic conflict has been used as a measure of the potential for traffic crashes (Davis et.al, 1989). Nevertheless, the study regarding the pedestrian-vehicle conflict is still deficient, especially regarding traffic conflict in the school vicinity. Most studies on pedestrians focused on the risk of crashes. Thus, this study aims to investigate the contributing factors of pedestrian-vehicle conflict involving school children in the school vicinity. This study focuses on the utilization of the facilities provided at school, exposure measures, and demographic characteristics of the schools.

2. Methodology

57 schools in Selangor, Malaysia have been selected as a sample of the study. The selected schools include primary and secondary schools with the involvement of students aged from seven to 17 years old. The schools were selected based on the area type; either urban or rural area and based on their road type (highway, primary and secondary road).

Naturalistic observation has been chosen as the data collection method for this study. There are two types of observations used; on-site observation and video observation. Figure 2 shows an example of the research assistant position during an on-site observation. Variables collected during the on-site observation were the number of pedestrian facilities utilization, number of students crossing, availability of the pedestrian facility, and demographic of the selected school. These variables were collected after school hours. During on-site data collection, a video was installed for an hour to record the schools' situation.

Figure 2 The research assistant position during observation

Through video recording, a few important variables were extracted. The number of pedestrian-vehicle conflicts, pedestrian and vehicle volume were recorded. The pedestrian-vehicle conflict might occur when a driver has to take some action such as breaking, slowing down, weaving, or honking in order to avoid a collision with a child pedestrian.

The discrete response variable of this study has counted data as the possible outcome. The simplest Generalized Linear Model for count data is Poisson Regression Model. It has a single parameter $\mu > 0$, which is both its mean and variance $E(Y) = Var(Y) = \mu$. This study has a response variable, Denote Y= number of pedestrian-vehicle conflicts in the school area and its $E(Y) = Var(Y) \neq \mu$. Its variance was larger than its mean which this phenomenon is called overdispersion. In the presence of Poisson overdispersion for count data, an alternative distribution called the Negative Binomial Distribution may avail a better model.

The Negative Binomial distribution was formed from the Poisson means to follow a gamma distribution with parameters μ and β. Let $Y \sim$ Negative Binomial (μ,β) then the $E(Y) = \mu$ and $Var(Y) = \mu + D\mu 2$ where D is nonnegative dispersion parameter.

3. Results and Discussion

This section will discuss the result of the study. The number of pedestrian-vehicle conflicts and the type of pedestrian facilities provided at school will be discussed. The Negative Binomial model was regressed to identify the contributing factors. The model parameters estimate that was included in the model are shown in Table 1.

Table 1 Explanatory Variables

Variable	Values
School characteristics	
School type	Primary, secondary
Area type	Urban, rural
Road type	Highway, primary, secondary
Availability of zebra crossing	Yes, No
Availability of pedestrian bridge	Yes, No
Presence of a traffic warden	Yes, No
Availability of drop-off & pick-up (D&P) zone	Yes, No
Exposure Measure	
Vehicle Volume	Vehicle volume count
Pedestrian Volume	Pedestrian volume count
Pedestrian facilities utilization	Utilization of zebra crossing or pedestrian bridge count
Number of student crossing	Student crossing count number
Proportion of mode of transport used to school	Proportion of students use their parent's car and motorcycle, student's motorcycle, bicycle, school van/bus or walk to school

3.1 Facilities provided at school

A child's ability to safely cross a road is limited due to their inability to judge the safe crossing gap. Thus to provide a safe environment for the school children especially for crossing the road, several facilities must be provided such as a zebra crossing, pedestrian bridge, drop-off, pick-up zone, etc. The pedestrian facilities that are being considered in this study are; zebra crossing and pedestrian bridge. Usually, zebra crossing is located near the school gate and the facilities are painted with yellow and white colour. Other facilities that should be included are the presence of the drop-off and pick-up (D&P) zone and traffic warden. The D&P zone is the specific area provided to drop off or pick up the students while a traffic warden is provided to control the traffic especially while students cross the road.

Table 2 shows the number of facilities provided by the type of schools. Out of 57 schools, around 44% of them have zebra crossing where 64% of the schools are primary schools. Only 11 schools have pedestrian bridges provided at their schools. Normally, a pedestrian bridge will be provided if the schools are

located at the high-volume road while traffic warden usually is provided at primary school. It is found that 47% of total primary schools have traffic warden at their schools and only 33% out of 57 schools have drop-off and pick-up zone at the school.

Table 2 Facilities provided by the type of schools

Facilities	Type of school	Available	Not available
Zebra Crossing	Primary	16	14
	Secondary	9	18
Pedestrian Bridge	Primary	5	25
	Secondary	6	21
Traffic Warden	Primary	14	16
	Secondary	2	25
Drop-off & Pick-up Zone	Primary	9	21
	Secondary	10	17

3.2 Exposure Measure Description

Exposure measure is often used to describe differences in the road safety situation. It is often used as a denominator in the index calculation to calculate the risk. The common measures are distance travel, population, traffic volume, etc. This study also collects the exposure perimeter for each school. Table 3 shows the description of the exposure measure by type of school. The parameter used to describe the number of student crossing, vehicle, and pedestrian volume is the mean whereas the percentage is used to describe the pedestrian facilities utilization and the proportion of mode of transport used to school.

On average, it was found that the volume of vehicles in primary school was 1329 vehicles while the average of vehicles that passes by the secondary school were 1205. On the other hand, the mean number of pedestrians after the school hour in secondary school was higher compared to primary school. Specifically, on average, there were 159 people during the midday after school hours at secondary school while only 106 pedestrians at the primary school. In addition, the number of students crossing was also higher in secondary school compared to primary school. This may be due to primary students are usually picked up by their parents while secondary students would go home on their own by bus or on foot.

Besides that, the percentage of pedestrian facilities utilization is also shown in Table 3. More than half of the primary students utilized the zebra crossing while only 41.1% of the secondary student used the facilities. The usage of the pedestrian bridge was lower compared to the zebra crossing. Of 2072 students observed, 41.7% of primary students used pedestrian bridges while only 30.3% of secondary students utilize the facilities provided. The fewer usage of the pedestrian bridge may be due to the students' behaviour such as being too lazy to climb the stairs or they think it will waste their time.

Table 3 The description of the exposure measure by school type

School Characteristics	Type	School Type	
		Primary	Secondary
		Mean	
Vehicle volume		1329	1205
Pedestrian volume		106	159
Number of students crossing		109	212
		Percentage	
Pedestrian facilities utilization	Zebra Crossing	54.7%	41.1%
	Pedestrian Bridge	41.7%	30.3%

3.3 Pedestrian-Vehicle Conflict

The occurrence of pedestrian-vehicle conflict was tabulated by the school characteristics and availability of the facilities at school. As shown in Table 4, the occurrence of conflict was significantly different by the availability of pedestrian bridge and drop-off & pick-up (D&P) zone. The Chi-square significant value was smaller than the p-value of 0.05. To understand further the traffic conflict occurrence, the odds ratio value of the significant variables was calculated.

Based on the table below, the odds ratio value for a pedestrian bridge after taking the reciprocal of the odds ratio is 5. This means the risk of conflict occurring is 5 times greater for schools without pedestrian bridges than schools that are equipped with the facility. Generally, schools with pedestrian bridge are located on a high-volume road in which the facility is needed for crossing the road. Furthermore, Ismail et. al (2018) indicates that a pedestrian bridge can be considered the safest and most efficient crossing facility.

In line with that, the presence of drop-off and pick-up zone reduces the risk of conflict occurrence. The odds ratio of the D&P zone showed that schools without a D&P zone are 3.3 times more likely to have pedestrian-vehicle conflict as compared to schools that have a D&P zone. The presence of the D&P zone eases the traffic flow during pick-up and drop-off time which during that time the probability of conflict occurring higher. A study done by Clifton and Kreamer-Fults (2007) ascertained that the presence of driveways and recreation facilities is statistically significant with the pedestrian crashes. Another study done in Toronto, Canada also found that designated drop-offs can be a protective measure against several risky pedestrian crossing and driving behaviours at uncontrolled locations mid-block as well as between parked cars (Rothman et al., 2017).

Table 4 The occurrence of pedestrian-vehicle conflict by school characteristics

Characteristics		Conflict		ratio)
		Yes	No	
School Type	Primary	18	12	0.077
	Secondary	22	5	(2.9)
Area Type	Rural	16	6	0.738
	Urban	24	11	(0.8)
Road Type	Highway	10	7	
	Primary	16	5	0.467 (-)
	Secondary	14	5	
Zebra Crossing	Yes	17	8	0.751
	No	23	9	(0.8)
Pedestrian Bridge	Yes	4	7	0.006*
	No	36	10	(0.2)
Traffic Warden	Yes	9	7	0.151
	No	31	10	(0.4)
Drop-off & Pick-up Zone	Yes	10	9	0.041*
	No	30	8	(0.3)

*significant at α=0.05

3.4 The Contributing Factors Of Pedestrian-Vehicle Conflict

Negative binomial regression (NBR) was used to identify the underlying factors of the occurrence of the pedestrian-vehicle conflict in the school vicinity. The assumption of the NBR needs to be checked before going further with the analysis. The NBR was used for over-dispersed count data where the variance is larger than the mean. The mean number of pedestrian-vehicle conflicts is E(μ)= 2 while the variance is Var(μ)=7.5. Indeed, the variance value is larger than the mean, thus can proceed with the model. The p-value of the Omnibus test for the full fitted model is equal to 0.013 and it is larger than α=0.10; hence we can conclude that the overall model is statistically significant by having all the independent variables.

Using the Wald Chi-Square analysis, the significant variables are shown in Table 5. Based on the table, the number of pedestrian and road types was significant at α=0.10, and all the other variables; school type, area type, vehicle volume, availability of zebra crossing and pedestrian bridge, the presence of traffic warden and drop-off and pick-up zone, proportion of pedestrian facilities utilization, number of student crossing, the total number of students, the proportion of mode of transport used to school were not significant.

Let μ denote the expected number of pedestrian-conflict and let Xs denote the explanatory variables.

The Negative Binomial Model is:

$$\text{Log } \hat{\mu} = -0.479 + 0.004X1 + 0.645X2(1) + 1.206X2(2)$$

The interpretation of the model is explained by the odds ratio value for each of the significant variables.

Table 5 The significant variables

Parameter	Variables	β	Exp(β)	Wald Chi-Square
X_1	Pedestrian Volume	0.004	1.004	0.076
$X_{2(1)}$	Road Type-Highway	0.645	1.906	0.063
$X_{2(2)}$	Road Type-Primary	1.206	3.341	
X_0	Intercept	-0.479	0.620	0.676

The odds ratio value for significant variables was calculated by exponentiating the β value as shown in the fourth column of Table 4. The Exp(β) gives the multiplicative effect on the fitted value for each one-unit increase in Xs. The Exp(β) value for the pedestrian volume is 1.004 and it can be explained simply as an addition of one pedestrian has a 0.4% increase in the estimated mean number of pedestrian-vehicle conflicts. Between highway roads and secondary roads, it can be said that the odds of the pedestrian-vehicle conflict occurring increased by 91% if the school is in front of the highway road. The Exp(β) value for the primary road is 3.34, which indicates that the pedestrian-vehicle conflict is 3.3 times more likely will occur on the primary road compared to the secondary road.

The same conclusion was also recorded in a study on the impacts of school sitting and surrounding environments on traffic safety. The study concluded that local road reduces pedestrian crashes whereas vehicle and pedestrian crashes will increase on the highways and commercial area (Yu and Zhu, 2015). A study that used the negative binomial model to perceive the environmental attributes of having a high risk of producing crashes near elementary schools also has the same conclusion. The study found that a higher number of student crossings, a wider road width, the presence of crosswalks, student-friendly facilities at the intersection, and four-way intersections were significant and positively associated with perceived crash risk among school-aged children (Lee and Lee, 2014).

A study done by Elias & Shiftan (2014) highlighted that the most vulnerable children that will involve in car crashes are boys from a low socio-economic group who live in a high-density area and mixed land use near a major road and who tend to walk to and from school and has additional activities after school. Besides that, a study conducted in Brescia, Italy by Bina et. al (2021) indicates that a lower probability of observed near-miss was associated with the presence of a 30km/h speed limit zone.

In 2007, a study in Orange County, Florida examined the crashes involving school-aged children (aged 4 to 18) and concluded that middle and high school children were correlated with the high frequency of crashes, particularly on high-speed multi-lane roads (Abdel-Aty et. al., 2007). A study done to examine the environmental attributes associated with pedestrian-vehicle crashes near public schools concluded that school area characteristics such as transit access, commercial access, and population density are commonly related to the increase of exposure measures which leads to the increase in the probability of crashes (Clifton and Kreamer-Fults, 2007).

Some other studies that investigated the influence of the micro street environment on pedestrian accidents in Seoul, Korea

found that vehicle traffic volume, pedestrian flow, commercial streets, and pedestrian crossings were closely related to pedestrian-vehicle collisions (Seo and Lee, 2014). Many studies have been done to identify the contributing factors to pedestrian-vehicle crashes. Among the factors that have been identified are road characteristics, environmental factors, motorized vehicle attributes, and demographic characteristics.

4. Conclusion

The high number of conflicts in school areas serves as a risk factor for students which can lead to crashes, hence a thorough investigation needs to be done. This study is aimed to investigate the contributing factors of pedestrian-vehicle conflict involving school children in the school vicinity. This study summarizes that the presence of a pedestrian bridge and a drop-off & pick-up (D&P) zone made a considerable difference in the occurrence of conflict. This study also concludes that the contributing factors are the number of pedestrian volumes in the school area and the type of road on which the school is located.

The increasing number of pedestrians obviously will increase the probability of the conflict occurring. Besides that, road type also plays a significant contributor to the occurrence of conflict. Different type of road has different number of volume which leads to a riskier situation. Suitable facilities such as a pedestrian bridge should be provided to facilitate students to cross with the help of a traffic warden to control the traffic. However, the traffic warden should be trained and equipped with safety tools. Besides that, installing traffic calming can reduce the risk caused by speeding, and providing a sidewalk is a good traffic control to improve students' safety.

There is very little study on pedestrian-vehicle conflict especially, in the school area. Knowing the factors contributing to the conflict, a preventive measure can be taken before the crash happen. Generally, many factors can contribute to the pedestrian-vehicle conflict or crashes particularly in the school vicinity. Human behaviour is one of the eminent factors to road safety mainly, for school children where the level of road safety awareness is less compared to an adult. This study focused on road engineering and environmental aspects, which based on other studies, there are a lot more variables that significantly contribute to the crashes such as personal characteristics.

Acknowledgments

This research was funded by a research grant from the Malaysian Institute of Road Safety Research (MIROS). Greatest appreciation to the Ministry of Education, School Management Division, Selangor State Education Department, all the District Education Offices in Selangor, teachers, and students of the selected schools who have worked hard, contributed their invaluable ideas, input, energy, and time towards the production of this report. A very special appreciation goes out to the staff of MIROS who helped with the preparation of facilities required for the study.

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UTM UNIVERSITI TEKNOLOGI MALAYSIA

IJBES

International Journal of Built Environment and Sustainability
Published by Penerbit UTM Press, Universiti Teknologi Malaysia
IJBES 9(3)/2022, 19-33

Evaluation the Impact of Spatial Configuration on Socio-Economic Parameters in Emerging Shopping Centers. Case study of Ritaj Mall in Constantine, Algeria

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ABSTRACT

This article questions the impact of the spatial configuration on user behavior and economic performance in the multi-level shopping center of Ritaj Mall in Constantine, Algeria. For ten years, large private real estate operators invest in different kinds of commercial building. The arrival of this new shopping complex in Algerian cities sis an opportunity to examine the question of architectural quality, especially that numerous papers and the theses have criticized the architectural production in Algerian, mainly in the residential and public sectors. Through the spatial analysis of the circulation spaces, the movement distribution and the architectural design parameters, the objective of this text is to better understand the correlation between "conceived" spaces and "lived" spaces. Their correlation constitutes a determining index of spatial qualities. For this purpose, an analysis is adopted according to a method of space syntax and completed by empirical surveys, and statistical correlation. Essentially, this paper shows that the axiality and interconnectedness of spaces largely determine the spatial quality of a commercial building. In addition, the central space (atrium) plays a determining role in the distribution of user flows over all vertical and horizontal spaces and extensions. It also shows the importance of spatial accessibility parameters in the distribution of economic and social activities.

Article History

Received: *12 March 2022*
Received in revised form: *12 May 2022*
Accepted: *08 July 2022*
Published Online: *31 August 2022*

Keywords:

Spatial configuration, Atrium, User behavior, Shopping center, Space syntax

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DOI: 10.11113/ ijbes. v9. n3.952

1. Introduction

Today, in Algeria, commercial structures tend to spread in a growing manner and become more and more a decisive component in the urban practices of the local population. Experience around the world shows that these commercial complexes constitute a proper atmosphere to multiple uses: social diversity, grouping of activities, exchanges, wandering, movement, promonade etc (Certu, 2003). It should be noted, however, that the scientific debate on the quality of use of shopping centers has been mainly oriented towards satisfaction surveys examining the spatial and environmental psychology of the architectural object, using cognitive surveys and behavioral maps. We were inspired by the research of Gümüs et al. (2021), who emphasized that spatial quality is related to physical, social, economic, cultural and environmental factors. In this paper, we focus on shopping centers, in order to examine their spatial quality, through an evaluation of

the spatial configuration, which could have a sustainable influence on spatial strategies (spatial navigation, location of activities, etc.).

For this purpose, the choice fell on a commercial structure "Ritaj Mall", located in Constantine's metropolis of eastern Algeria at the level of the new city Ali Mendjeli. Indeed, our approach, which is descriptive and explanatory, adopts a mixed method approach, based mainly on the Spatial Syntax. The approach we used in our research aims at developing a set of indicators to measure the degree of functional efficiency of space. Many authors have been interested in the concept of functional efficiency of the building, which is one of the factors generating architectural quality. We can consider two visions of this concept. The first approach, rather technical, which has grown significantly in recent years, is linked to the concept of eco-design and the consideration of environmental criteria in the design. The second approach, more supported by architects and to which we adhere in this article, focuses on the fact that functional efficiency is affected by the interior layout of spaces and the distribution of activities.

Space syntax is constituted of a set of techniques allowing the representation and interpretation of urban and architectural systems (Peponis, 1997). Indeed, it allows the interpretation of the elements that make up space and that determine social behaviour. It is an explanatory method of the relationships that individuals have with the architectural and urban living space, as a complement to "traditional" or "classical" approaches (Hillier and Hanson, 1984; Hillier et al. 1987; Hillier, 2007; Lévy, 2005).

The study will focus on the Maghreb context and more particularly Algeria. Indeed, the combination of characteristics of the sector, the market, the building, the economy, the politics, and the behavior of private actors makes the Maghreb a particular context of study. On the architectural and urban level, the Algerian city is generally a condensed paradox: uniform and monotonous architecture, large residential complexes and public buildings that age too quickly. Indeed, the issue of architectural quality is still perceived negatively in Algeria, especially for the residential building sector (Handel, 2011). Many researchers have agreed on the negative image and decline of architectural quality, with functionalist practices that continue to separate functions (Belguidoum, 2021). In addition to this, there is the devaluation of the profession of architect, the low qualification of the companies of realization, the administrative blockage, etc. Today, with private initiatives, we are witnessing a set of socio-spatial reconfigurations, linked to new commercial practices, favoring the emergence of commercial facilities of a new kind, not foreseen by the planning instruments. These structures, which remain a very understudied subject, began to spread in Algeria from the first half of 2010 - we have no official figures on the number of shopping centers in Algeria - and affected all major Algerian cities (Belguidoum, 2021). They play a decisive role in the reorganization of centrality and bring to light new spatial values that question the modalities of architectural design/production in Algeria. Contrary to the layout of souks (popular markets) and bazaars (shopping malls), the importance of the study of new shopping centers lies in the fact that they present new architectural signs - for the Algerian context - and a new way of interior arrangement of spaces in the service of consumption.. Our interest in spatial configurations and their relationship to users came from the absence of sufficient and qualitative studies conducted in Algeria that objectively treated the question of architectural quality in terms of «conceived» spaces and «lived» spaces. In fact, the designed space is the space made by professionals and architects: it is the programmed space. The lived space translates the way of social reception of the designed space. In other words, how the users invest themselves differently, according to their imagination, their cultures, their behaviors? It is the suffered space that the users try to appropriate and to modify by valuing certain places of the space more than others.

Thus, we start from the hypothesis that the spatial configuration plays an important role in the circulation strategies of users and the repartition of commercial activities.
In this logic, we have taken as a case study the shopping mall Ritaj mall, which is located in the metropolis of Constantine (Algeria). This building is a globalized space of consumption, which has imposed itself as a place that cannot be ignored, attracting a clientele that exceeds that of the city of Constantine. This model of shopping mall is inspired by the traditional Algerian house and offers modern architectural signs. Through this case study, we will try to understand how the new modes of consumption (openness to the outside) of Algerian society in general influence the design and architectural production in Algeria.

After having presented a non-exhaustive literature study focused mainly on the method of spatial syntax, the article will explain, in a first step, our methodology, the methods and the techniques on which we have based ourselves. It will then present our case study. Finally, we will present our main results of spatial simulation, field surveys and statistical correlations (scatter diagram).

2. Literature review

Research on architectural quality is declined in five major fields of concerns. 1st, the study of the relationship that a building maintains with a context that it crystallizes, . 2nd, the quality of buildings is also analyzed from the process of conception and realization, from which it is significant to interrogate the modalities of the collective production of the project, in terms of the strategies of the actors and the financial piloting. This is part of the "urban project" approach. 3rd, the analysis of the technical and physical performances (energy mastery, safety, materials, atmosphere, acoustic and thermal comforts, etc.). 4th, the study of the artistic and aesthetic sense (through visual simulations, etc.) of architectural forms, facades, colors, etc. 5th, the approach by functional analysis (poorly developed) to evaluate the quality of use of spaces and interpret the impact of the built environment on user behavior. This approach develops a set of indicators to measure the degree of functional efficiency of the space(Hillier, 2007 ; Lindal and Hartng, 2013 ;Marques et al, 2017)

Many researchers consider the spatial configuration and the interior movement system of architectural spaces as constitutive elements of the functional quality of buildings. Based on the work of Hillier and Hanson (1984), the quality of an architectural space is also related to the ability to achieve a coherent, if not optimal, relationship between the "designed space" and the "lived space".

The quality of use or functional quality of an architectural space derives its essence from several factors : the form of spaces/axes of movement and the manner activities are distributed (Voordt et al. 1997).The functionality of a building is largely a question of coherence and unity with the needs of the users in relation to the sensible qualities of the space, such as visibility, flexibility, forms, textures, colors, security, etc.A building has a certain functional quality when the spatial units have a coherent, if not optimal, relationship with the functions and intended practices (Hillier, 2007 ;Van der Voordt et al., 1997).

By spatial configuration we mean the form of spaces (axial, convex…) and the manner in which these spaces connect to each other (Hillier et al., 1987; Hillier, 2007). To this correspond the theories of spatial syntax, amethod based on the principle of digital modeling of urban and architectural form. It aims to simulate conditions of functioning and use of an architectural object or an urban environment (Major et al., 2020). In other words, it permits the testing and analysis of an architectural device or an urban spatial planning and the prediction of the repartition of flow densities. The simulation facilitates the analysis of the "form-function-movement" interdependence and allows the evaluation of the spatial arrangement in relation to the cognitive dimension of the space. During the exploitation of conception or spatial planning scenarios, it makes it possible to compare several proposals. This method can assume two roles: on the one hand, it allows the rethinking of the structuring of a spatial device and, on the other it allows the visualization of interaction and ambience phenomena that are traditionally evaluated downstream, thus facilitating the decision at relatively early phases of conception. This makes it possible to compare different conception hypotheses.

The capacity of users to identify themselves (cognitive aspect) and to orient themselves/move easily (physical aspect) is a decisive asset in determining the effectiveness of the whole spatial configuration (Sari and Alhamdani 2021).Considering that buildings are social objects (Hillier, 2007) and based on various building models, Hillier and Hanson developed the spatial syntax method permitting the analysis of the relationship between spatial configuration and social logic (Hillier and Hanson, 1984). This method is based on a set of theories, including the "economy of movement" theory, according to which the natural movement of individuals is affected by spatial configuration (Hillier et al., 1993).

It is an explanatory method of the reports that individuals make with the architectural and urban life space, in addition to the "traditional" or "classical" approaches (Hillier and Hanson, 1984; Hillier et al. 1987;Hillier, 2007 ; Lévy, 2005).Indeed, spatial syntax has been applied on different architectural complexes : museums, residential buildings, shopping centers, supermarkets, hospitals, university centers, educational center, administrative buildings, mosques, etc. (Dursun, 2007 ;Hillier and tzortzi, 2006 ;Kim et al., 2008 ; Major et al. ; 2020 ;Sari and Alhamdani, 2021).

In regards to commercial spaces, recent researches has attempted to understand the interactions between the conception parameters of shopping centers and socio-economic factors. These parameters mainly concern the distribution of shops/services, number and size of commercial premises, categories of users (Bai and Yao, 2018 ; Dong et al., 2017 ; Fezzai et al., 2020 ; Fong, 2005; Haofeng et al., 2017 ; Kong, E-M and Kim, Y-O, 2013 ; Min et al., 2012 ; Verdil, 2009; Yuo et al., 2013 ; Zhang et al., 2012). They have evidenced, even in part, the fact that the configuration of commercial structures (the layout of commercials' galleries and the arrangement of stores, entries, exits, etc.) has a direct impact on the deployment of commercial specialties (luxury shops, alimentary, services, etc.), the individual patterns of circulation spaces, and shopping practices.

Conclusions similar to the previous ones have been proclaimed: the most integrated commercial spaces tend to be more dynamic and more ambient than those less integrated. Fong (2005) shows, from a cross-comparison of shopping centersmodels in the United Kingdom, the mechanisms behind the location of commercial typologies (dispersion/clustering).The author found thatthe level of integration of stores plays an important role in explaining some locations of commercial specialties. However, he deduced that it is difficult to bring out a generalized trend that explains or conditions the deployment of these specializations: other factors are put forward such as competition and commercial complementarity, which exert an impact on movement forms indirectly. Zhang et al. (2012) applied the spatial syntax method on a multi-floor commercial complex. They point out that some local spatial planning parameters also have a significant impact on the distribution of movement flows, such as the position of vertical circulation elements (stairs, escalators, and elevators), entrances, temporary installations, and the spatial planning of the atrium.

Min, S.Y et al. (2012) studied the correlation between spatial configuration and visitor circulation in relation to the typology of commercial activities. This publication poses two important acquisitions. First, users tend to move to highly integrated locations, whichprovide a important field of visibility. In these first zones, the authors observed a high concentration of large-scale consumer shops. On the other hand, a few places characterized by a very low integration were found to receive an important mass of visitors at precise temporalities. Most of them are already familiar with the area and tend to make precise purchases. This means that users' movements are affected not only by the characteristics of the physical environment, but also by the distribution of commercial typologies. Second, in the case of a grand commercial structure, the connection to the external public space largely determines the interior movement system of visitors. In symmetry with the previous research, and through a comparative study of two shopping malls, Aydoğan and Salgamcioğlu (2017) examined users' circulation and shopping behaviors in relation to the morphology of commercial layouts. They concluded that users behaviors are not always guided by spatial configuration, in other words, spaces with high circularity do not necessarily correspond to the most integrated spaces. Other factors come into play, such as user experience, personal evaluation of the space, nature of the business, habits, user culture, gender, etc.Previous studies supported this finding (Dogu, U and Erkip, F., 2000), hence spatial configuration alone is not sufficient to characterize user behaviors within commercial spaces.

Broadly speaking, a significant number of research studies that use spatial syntax to evaluate the quality of spatial configuration are based on the following steps. First of all, is a spatial modeling using specialized computer software (Depthmap, etc.). Secondly, it is a question of immersing oneself in the reality of the field through empirical surveys (observations, quantification of flows…) on the modalities of appropriation, circulation and use of the space. At this stage, the aim is to carry out an in-depth analysis of the architectural space, to better understand the activity of individuals in the space and to identify the main difficulties encountered by the different users. The third step includes statistical correlations between the spatial analysis and the results of the empirical survey, contributing to constructing a detailed picture on the functional performance degree of the spatial disposition.At the same time, this step engenders a technical expertise for future conception modification proposals for the functioning of the studied architectural object (Hillier, 2007).

In fact, the complexity of studies on the layout of building spaces lies in the fact that the researcher is often at the interface of the social and technical sciences. Studying architectural quality requires the combination of a series of approaches: empirical investigations (in situ observation, field surveys, user surveys, etc.); statistical tests to deepen survey results. As such, focusing on constitutive technical methods, largely verified by case studies, should allow us to better understand and even deepen the relationships between the different elements of the architectural system. The empirical investigations allow to confirm, even to deepen the logics which underlie the functioning of the building. Statistical correlations allow to push further the strategic analysis and to go beyond the description of the functioning and the logics of movement in the spaces of commercial buildings. This description is interesting "factually" for the knowledge on the quality of the buildings, but scientifically could be insufficient

3. Methodology

In the goal of examining the characteristics of the spatial configuration of the Ritaj mall shopping center, we will rely essentially on the method of spatial syntax. This will be complemented by in situ observations, a qualitative and quantitative survey, field surveys of the commercial establishment and, finally, statistical correlation tests (Figure 1).

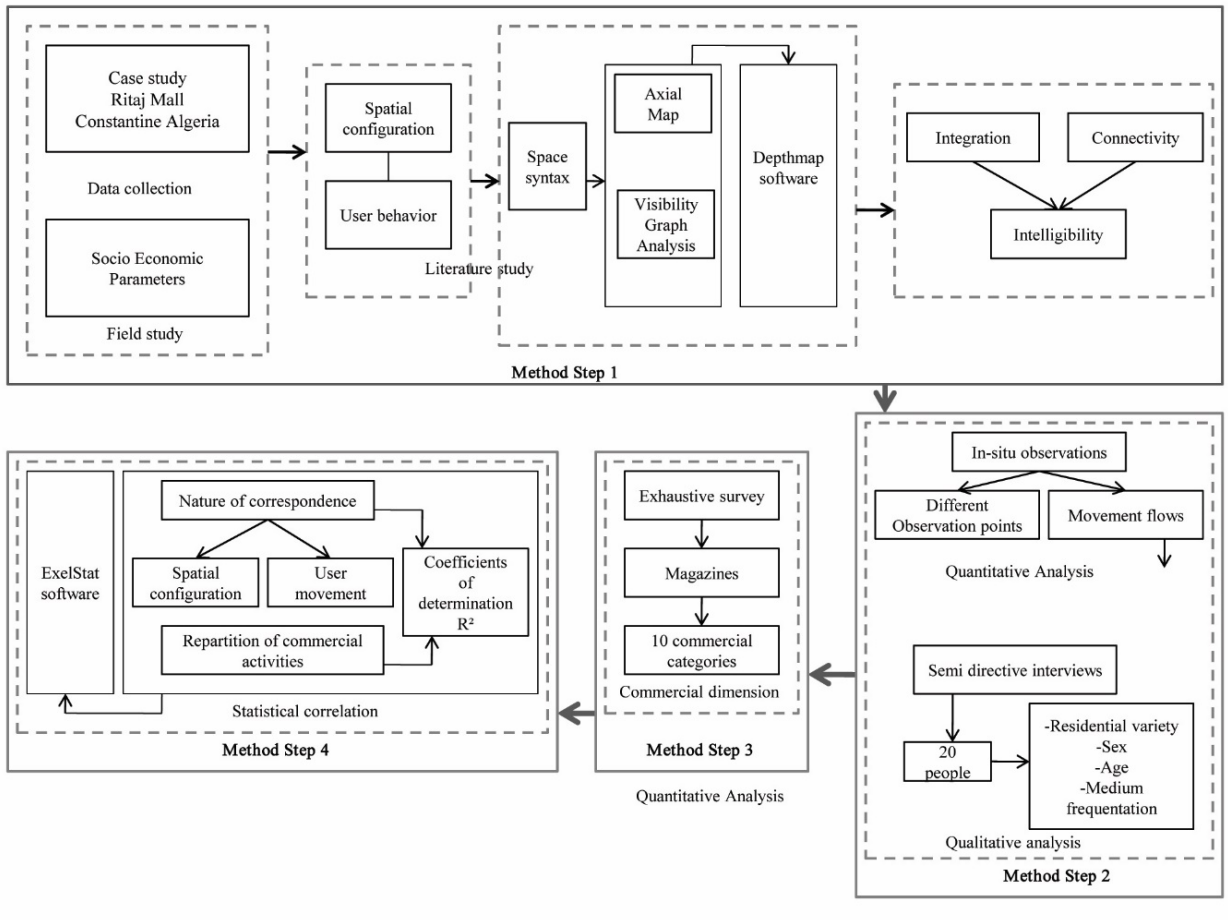


Figure 1 Diagram of the study process

3.1 Modeling Of The Architectural Configuration By The Method Of Spatial Syntax

Based on the concept of accessibility and visibility, specialists in this method have developed several analytical techniques. In this research, we use two techniques widely used by researchers: the axial map and the visibility graph (VGA).We used the Depthmap to modeling of the different floor plans.

First, the basic element of the axial map is the axial line: an axis of direct view (Hillier, 2007). The axial map represents a set of linear representations that indicate the longest possible, fewest numerous and most strategic axes of visibility or movement trajectories that traverse all convex spaces (Hillier et al., 1993, Yamu et al., 2021).

Second, the visibility graph analysis or VGA technique gives us a view of the visibility relationships of architectural and urban spaces (Turner and Penn, 1999; Turner, 2003). It tells us the extent to which a given point is visible from any other point in a spatial disposition. It is intended to analyze visual differences in this commercial structure, to understand the importance of visibility in determining users' preferences for displacement (Deb and Mitra, 2020).Through these two techniques, we can obtain several syntactic measures of spatial properties. Integration, connectivity and intelligibility.

- The integration can be local or global. Global integration (HH) takes into consideration all possible depths of a space (radius=n). The integration values are systematically given, by the simulation software in graded colors, going from red, for the highest integrated spaces (high values), to blue, for the segregated spaces (lower values). Integration is expressed as a quantitative value that reflects the potential quantity of movement (Hillier, 1999; Hillier, 2007). This variable is used to define the degree of integration or segregation of a space in relation to the entire architectural or urban arrangement. It is an indicator of centrality and accessibility (Mustafa and Rafeeq, 2017). Several research studies have shown significant correlations between high integration values, crowd concentration, etc. It describes the depth (changes in direction necessary to move from one space to another) or average permeability of a node relative to all other nodes in the spatial system (Hillier, 2007). Indeed, the higher the integration value, the higher the spatial accessibility.
- Connectivity measures the number of adjacent spaces that are directly connected to a given space (r=3).
- Intelligibility is expressed by the coefficient of determination R^2 between integration and connectivity.

3.2 Observation Of Pedestrian Movement Patterns

In order to understand the way of use, representation (perception) and circulation of the users in the shopping center, we based ourselves on a qualitative investigation, where it is not a question of obtaining a truly representative statistical vision. Concretely, our survey is based on in-situ observations and semi-directive interviews.

Firstly, the objective of our observations is to make a synthetic reading referring to the modalities of use of the different spaces (circulation itineraries, grouping of people, etc.). We have chosen different observation points for each floor, which are distributed in a balanced way (according to the convex spaces). In addition, we counted the movement flows, from 9:30 am to 7 pm, 5 minutes/ 1 hour and three times per session (15 minutes of observation/hour). These observations were spread over a sunny weekend (Saturday), May 1, 2021, after having narrowed the containment measures due to Covid-19. Second, we realized a survey of qualitative nature by semi-directive interviews with 20 people, between March and May 2021. We sought to ensure that our selection met the requirement of diversity.

Indeed, the interviewees were selected according to intentional sampling (Corbière and La Rivière, 2014, p. 19): residential variety, sex, age, medium frequentation of the Ritaj Mall. In almost all cases, these interviews were recorded in their entirety and then transcribed as faithfully as possible. The objective is to collect information that provides explanations on the behavior of users

3.3 Investing The Commercial Dimension To Examine Spatial Strategies For Commercial Distribution

As a first time, during the first week of May 2021, we conducted an exhaustive survey of the different magazines and the articles they commercialize. Based on our field surveys, the commercial structure of Ritaj Mall totals 265 commercial units. These magazines were classified according to their specialization and their situation (closed, under renovation, etc.). In a second step, and in order to facilitate the analysis of the repartition of commercial activities and the corresponding cartographic reading, it is important to standardize the raw data from the site survey; 10 commercial categories have been repertories. This classification is strongly inspired by Mérenne-Schoumaker (1982) and Lakehal (2013) with modifications that are consistent with the commercial specificities of the Algerian society

It should be noted that our presence in front of the magazines to make our site survey put us in a situation of incomprehension on the part of the managers of the shopping center.

3.4 Deepening The Spatial Logics Through Statistical Correlations

We Performed A Statistical Correlation Study to analyze the nature of correspondence of the spatial configuration with user movement, on the one hand, and the repartition of commercial activities on the other, based on the values of the coefficients of determination R^2. We use the ExelStat software for this purpose.

4. Description of Case Study

The Ritaj Mall shopping center is located west of the New City Ali Mendjeli, a peripheral city of the metropolis of Constantine (northeast Algeria).The centrality of this new city was summarized in small local centers that tended to compete, without the

emergence of a true urban center. Its different consumption spaces were in reality only a series of elements related to lodging. In recent years, however, this new city has taken a major growth turn by becoming an economic and tertiary pole, due to the scale of the investments being made there (Lakehal, 2017).The concept of this commercial structure is inspired by the architecture of traditional houses with a central patio in the Arab-Muslim city. This patio is the specific element of its architectural composition. It is open upwards and gives a centered and introverted aspect to the building. It is a real distribution room often playing the role of the courtyard in the Arab house

In fact, its architectural configuration is organized around a central atrium, which constitutes the heart of its commercial ambiance. It extends vertically over five levels, with subsoil and three entrances, two on the ground floor and one on the primary floor. This atrium opens onto two main entrances and has all the vertical transitional elements, except for the fire stairs.

Since its opening, a significant spread of shops and new public facilities has taken place in the areas adjacent to Ritaj Mall. The latter constitutes with the urban first floor an interconnected system. Indeed, thanks to its main entrance, it is directly linked to the street generating a spatial continuity, horizontal and vertical, between the interior and exterior of the building. It opens onto an ambient urban sequence and a lively public space where shops and services are mixed. The latter are essentially spread out at the foot of the buildings overlooking the main axis leading to this commercial building. This dynamic is actually one of the important commercial changes of the new city Ali Mendjeli. It also reflects a form of personalization of space. South of Ritaj Mall are gathered all the elements that make this structure a potential building. A few meters from its main entrance is an urban and regional bus station, and passes the line of the Tramway linking the new city with the city of Constantine. This also allows the commercial center to radiate at the level of the entire urban region by bringing him important flows from different residential areas. The presence of the university complex also reinforces this aspect of attractiveness, with a large student population that regularly visits this building. (Figure 2).

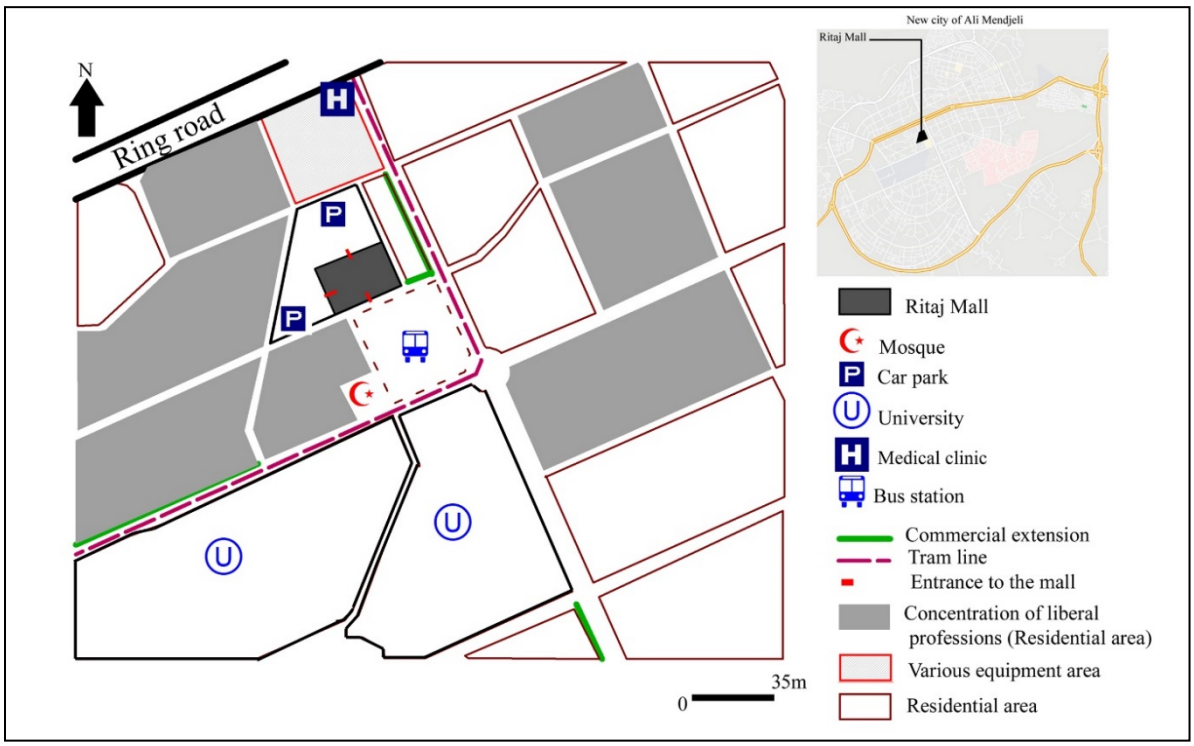


Figure 2 Situation of Ritaj mall shopping center (Authors, 2021).

5. Results and discussion

5.1 Axial Map Analysis

The axial lines have been generated automatically with the option Fewest line map. The axial maps of the different floors show us different values of integration and connectivity, ranging from 1.2 to 7.2 for the first and from 1-45 for the second (Table 1). This means that the shopping center has highly accessible spaces and other segregated ones. The analysis of the axial maps shows us that the color set indicating the distribution of integration and connectivity values is very close. It is clear that the coefficient of intelligibility which indicates, remember, the level of ease of displacement and spatial orientation is $R^2 = 0.81$ (average). This means that the spatial configuration of the Ritaj Mall, which is organized in a combination of linear and rectangular spaces, is overall well conceived so that users can easily circulate and orient themselves in the interior.

Table 1 Characteristics of the syntactic variables of the axial maps

Floor	Integration	Connectivity	Intelligibility
Ground floor	2.8- 7.2	2-37	0.84
First floor	1.2-5.8	1-39	0.82
Second floor	1.2-5.6	1-37	0.86
Third floor	1.4-5.1	2-22	0.88
Fourth floor	2-10	4-45	0.68

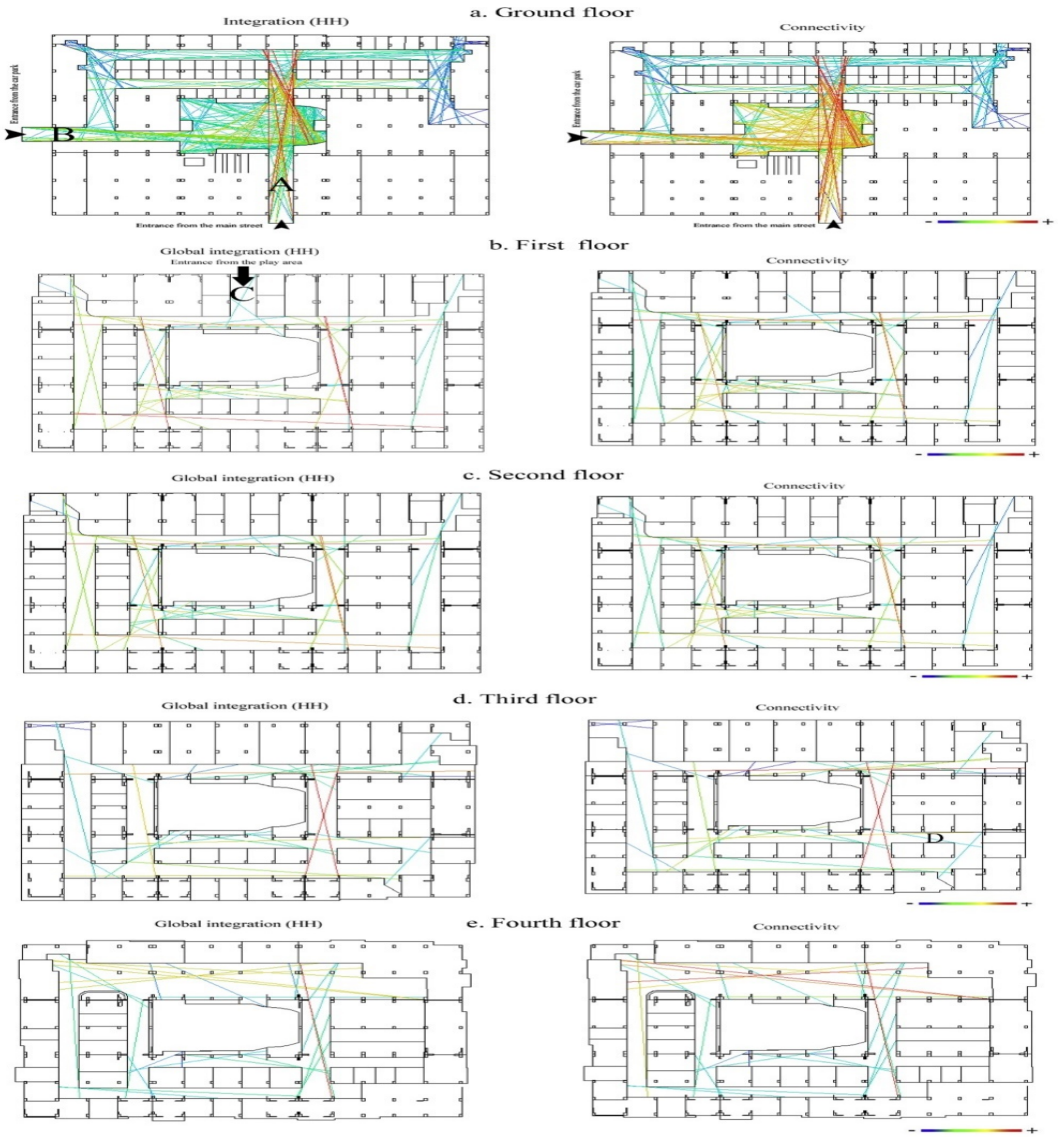


Figure3 (3a, 3b, 3c, 3d, 3e) Modeling results with the axial map. (Authors, 2021).

First, at the groundfloor, the plan shows that space A of the principal access from the road and part of the atrium (Figure 4) present high integration values, as shown in Figure 3a. This leads us to affirm that these spaces are more accessible, deeper, and well connected to the other spaces in the spatial disposition. In contrast, the second access (B) has a medium global integration value. The results show that the spatial accessibility of the atrium
is not equilibrated. In fact, the part of the atrium with the highest level of integration is the one that is in continuity with the principal access (from the road), which gives a strong possibility that people flows are concentrated in this zone. The majority of the vertical transitions are installed at this level. The rest of the atrium is moderately integrated, except for the angle zones which are segregated. On the other hand, this central space indicates relatively high connectivity values. The spaces that have direct connections to and from the atrium take on a red color, something that explains the high connectivity of the principal access spaces (Figure 3a).

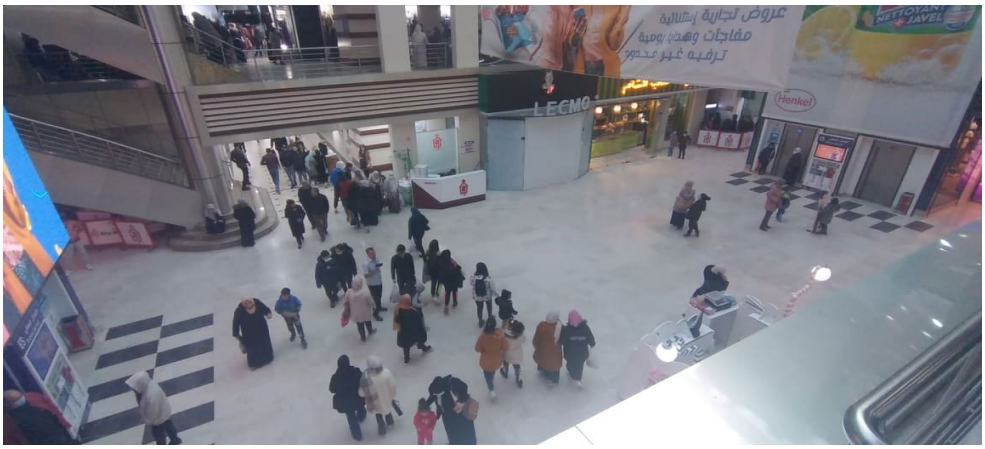


Figure4 View of the atrium. (Authors, 2021).

The axial maps of the existing spatial disposition of the first, second, and third floors (3b, 3c, and 3d in figure 3) show the importance not only of the most extensive circulation spaces in an east-west direction, which turn out to be more or less strategically important, but also of the north-south oriented spaces overlooking the elevators. These spaces have an integration value that varies between 3.2 and 5.5. We can notice more segregation at the entrance 3, the eccentric corridors and in the part where the sanitary facilities and the administration offices are.

This segregation is also observed quite clearly in the small zones associated with the escalators (same case in all levels), zones that emerge outside the structuring lines of sight. This state of fact can give place to a certain ambiguity for users not familiar with this commercial structure to find them. The axial map of the last level shows that the consumption zone (which is given on the restaurants) benefits from a more or less important degree of integration (3e in figure 3). The circulation spaces overlooking the elevators become highly integrated. The eccentric north-south oriented corridors remain segregated. This floor has been recently modified to create a new circulation space (D), in the form of an impasse, with low integration.

5.2 Analysis of the visibility graph VGA

With a few exceptions, the analysis of the visibility graph shows results very close to those obtained from the axial map (Figure 5). Overall, the VGA always shows the importance of spaces generating extended views that do not have elements that interrupt visibility (temporary installations…). These spaces are more important (in terms of visual connections) than the others. Moreover, this technique provides us with an important finding: the zones where the traffic corridors are crossing have the highest accessibility and visibility among the other zones of the shopping center.

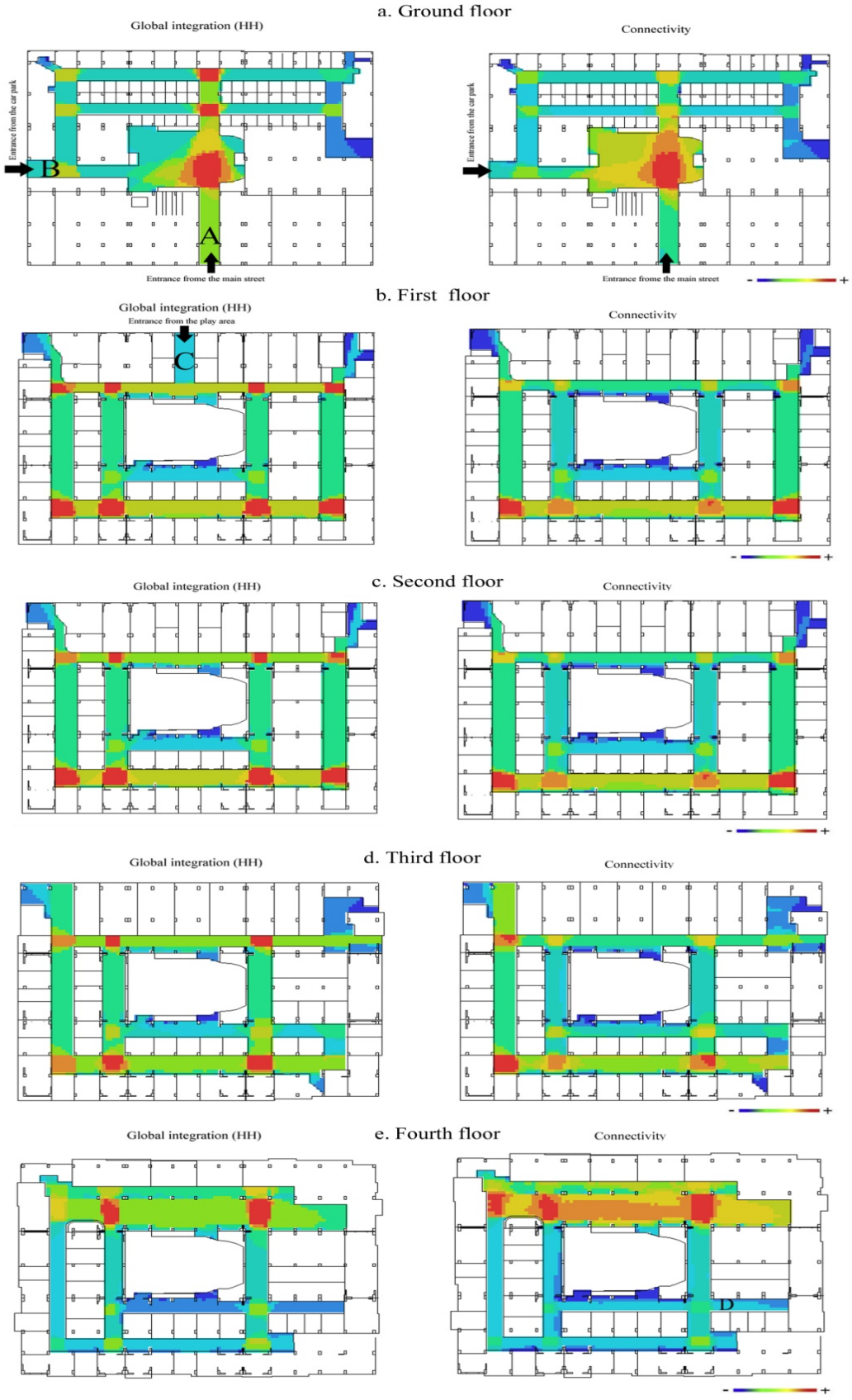


Figure5 (5a, 5b, 5c, 5d, 5e) Results of the VGA visibility graph analysis. (Authors, 2021)

5.3 Relationship Between Commercial Organization And Spatial Configuration

The shopping center has 300 commercial cells that can be distributed into 10 categories, as can be seen in Figure 6 and table.2.

Figure 6(6a, 6b, 6c, 6d, 6e) Distribution of commercial activities in the RitajMall. (Authors, 2021).

Table 2 Installation of commercial activities in the Ritaj Mall

TYPES of shops	Description	Staff	In%	Integration average of stores	
Ready-to-wear & Clothing for women	/	60	06	4.80	High
Ready-to-wear & Children's clothing	/	23	2.3	4.60	High
Ready-to-wear & Clothing for men	/	23	2.3	4.01	High
Jewelry and watches	/	11	1.1	2.24	Low
Beauty and Health-care	perfumery, cosmetics, haberdashery, herbalists	16	1.6	3.47	Medium
Library	/	05	0.5	2.92	Low
Entertainment	Photography studio, kiosk, CD sales, sale of birds and their accessories, cybercafé, computer equipment, fishing equipment	10	0.1	3.97	Medium
Home and Living	furniture store, rugs and blankets, hardware, household utensils, office supplies	14	1.4	4.11	High
Pharmacies/opticians	/	06	0.6	3.78	Medium
Food and Beverage	fruits and vegetables, general grocery, bakery, pastry, traditional confectionery, fishmonger, dairy products	69	6.9	2.41	Low
Restaurants and snaks	/	13	1.3	4.38	High
Phones and Electronics	computer equipment, tablets and telephone articles, household appliances-	15	1.5	3.91	Medium

As far as the spatial distribution of shops is concerned, it respects a certain alignment. We can distinguish two sets. On the one hand, the first five categories are roughly dependent on accessibility and are defined as "pleasure shopping", as one of the visitors to this building put it. The frequentation of these commercial establishments is not always oriented towards purchase: many visitors go there only to window-shop, asking about prices. These shops are also linked to "family shopping" and tend to be located in highly integrated and more accessible spaces. On the other hand, the other categories, particularly Food and Beverage, are spread a little far from the highly integrated spaces. The same logic can be observed for vacant stores.

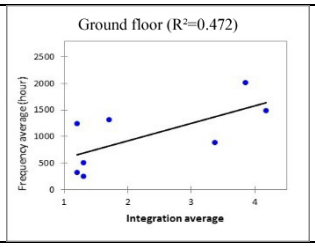
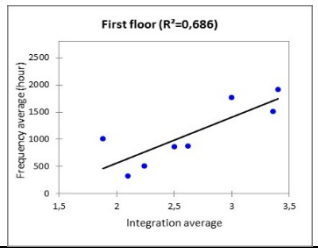
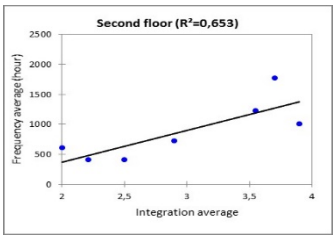
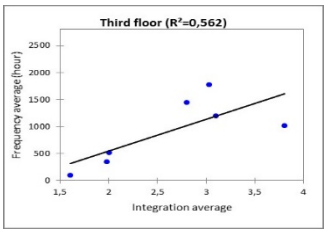
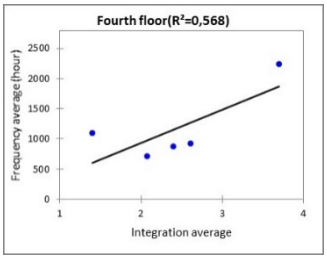
On the ground floor, stores Food and Beverage are largely prevail over other commercial specialties. The stands of this type of commerce are located to the north of the atrium, giving the aspect of a covered souk, in an area with low integration value. On the atrium, in its highly integrated part, stores specializing in luxury clothes for men's open. The stores selling phones and electronic are located on the principal entrance corridor, benefiting from a high accessibility and visibility. Relative to the first three levels, clothing/shoes (men's, women's), children's ready-to-wear, the beauty and Health-care appear to be distributed on the most extensive and integrated corridors. Home and living stors tend to be located in areas with medium integration value. In contrast to the ground floor, telephone stores are distributed on low integration value locations. Finally, on the last floor, restaurants and snaks open up to places with high integration and easy recognition, while jewelry and watches stores are distributed in the most segregated area (new extension) of this level.

5.4 A Significant Correspondence Between User Behavior And Spatial Configuration

Table.3 shows the correlation results between the spatial configuration, represented by the integration values, and the average user movement flow according to spaces.

Table 3 Illustrates the correlation results between spatial configuration, represented by the integration values, and the frequency average according to convex space

Ground floor			
Convex spaces	Frequency average	Integration average	Coefficient of determination R^2
1	2014	3,8	
2	890	3,37	

3	514	1,3	
4	1487	4,18	
5	1247	1,2	
6	1324	1,7	
7	247	1,3	
8	321	1.2	
First floor			
1	1014	1,88	
2	1774	3	
3	874	2,62	
4	871	2,5	
5	1914	3,4	
6	324	2,1	
7	1510	3,36	
8	514	2,24	
Second floor			
1	1771	3,7	
2	414	2,5	
3	725	2,9	
4	608	2	
5	1231	3,55	
6	1012	3,9	
7	412	2,21	
Third floor			
1	1674	2,8	
2	512	2	
3	1200	3,03	
4	347	1,98	
5	1021	3,8	
6	1201	3,1	
7	203	1,6	
Fourth floor			
1	2982	3,7	
2&6	514	2,4	
3	719	2,07	
4	871	1,4	
5	1748	2,61	

By comparing the different coefficients of determination (R^2) we can pose the following hypothesis: the modeling of the spatial arrangement by the spatial syntax was globally successful in predicting the nature of movement of uses in the studied shopping center. The coefficient of determination (R^2) varies between 0.472 and 0.686 which shows the positive correlation between the spatial configuration and the nature of movement of uses. This means that not only do the integration and visibility of the spaces have an impact on users' behavior movement, but also that the space is efficiently designed and the flows are more or less balanced

between floors. Nonetheless, there are a few locations that have an important circulation density even though they are located in zones with low integration.

At the ground floor, the coefficient of determination is R^2 =0.426, the lowest value in this foodstuffs commercial. This is due to the fact that the area that houses the food shops, although characterized by low integration and connectivity, drains a large flow of people who do their daily shopping; a weak correlation between this zone of the mall with user movement density. Furthermore, our observations have shown us that user flows are guided towards the atrium, which for most of the people surveyed constitutes a temporary space of transition and information on the environment, and then directed towards the other spaces and floors. The occupation of the atrium by users seems to be highly correlated with syntactic properties, as shown in Figure 7: the most practiced spaces roughly adjoin the most integrated spaces. We also observed spontaneous gatherings that emerge around spaces associated with elements assuring vertical circulation.

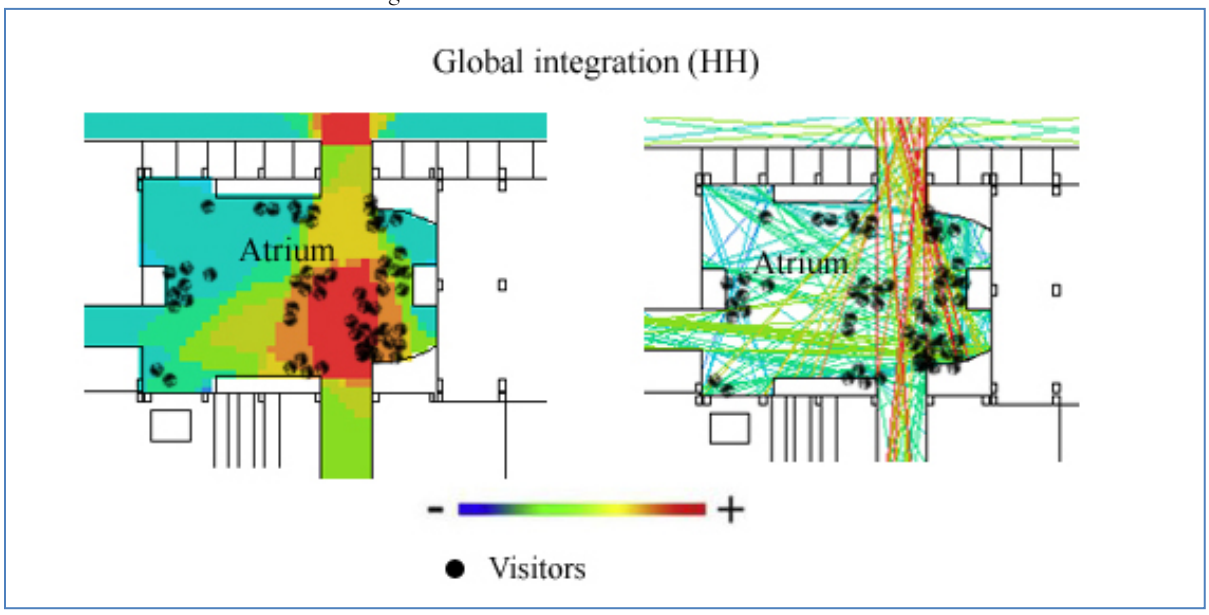


Figure7. Snapshot image (photo taken on 1/5/2021 at 5pm) overlaid on the integration map (atrium). (Authors, 2021).

The correlation between pedestrian movement and spatial configuration in the first, three levels was, for the most part, positive, as indicated by the coefficients of determination. Indeed, our observations detected that the most integrated spaces (associated with elevators, the most horizontally extended) register a higher density of movement than the rest of the spaces with low integration. On the spaces with a low level of integration, resting elements are installed, which creates, from time to time, certain groupings. While circulating, the connection with the atrium is searched for a large part of the surveys, indicating that the type of movement is exploratory for this category. The results showed that users tended to circulate in a circular scheme, maintaining striking views of the atrium. The purpose of circulation is not always purchase-oriented: many people interviewed go there only to window-shop, informing themselves about the prices offered. It is also important to note that many of the people surveyed said that they had difficulty finding the escalators.

The coefficient of determination of the last floor gives us to see an average value (R^2=0.568), which indicates that certain circulation spaces have a high quantity of movement despite their low degree of integration. This fact leads us to say that other parameters do affect the movement of uses, such as the nature of the commerce, the motives for travel, the notoriety of the store, etc.). (Min et al. 2012).

Based on this analysis, we can make the following design recommendations:

- The straight paths of circulation spaces, which provide more extensive corridors for circulation, help to increase the economic performance of the commercial building, provided that these spaces do not have elements that interrupt visibility. When users move along interconnected axial lines forming a circular configuration, flows intensify. Indeed, we have observed visitors who circle the same floor more than four times, without being scheduled to do so.
- The right way to optimize pedestrian flows in multi-level shopping malls is to place vertical transition elements at the central space - atrium - to create vertical visual connectivity
- In the distribution of commercial specialties, it is recommended to take into consideration the variation in the integration of the different spaces and circulation areas. In fact, it is recommended to reserve the less integrated areas, or isolated places, to the commonplace shops, which generate daily and programmed purchases. On the other hand, the anomalous shops should be installed in the most frequented spaces
- New expansion spaces should not form dead ends. It is recommended that they be built in visual continuity with existing circulation corridors
- The location of building entrances and continuity with the urban first floor are important indicators of optimal commercial building

design. Consideration should be given to creating a continuity of urban sequence between the exterior and interior of the building.

6. Conclusion

Given that an architectural object is an interactive spatiotemporal system, we tried to study the degree of coalition between the architectural configuration and the design of the different spaces with the practices of the users (movement, interaction, etc.). This is what Hillier and many other researchers have highlighted in the theories of spatial syntax. It is in this research perspective that we sought to explore the conditions and the different modalities of displacement and interaction of individuals within a mall of a medium size. More specifically, we sought to understand how an architectural configuration composed of several floors and a central patio affects the movement and interactions of individuals. In fact, our method owes much to an empirical approach, which combines field surveys with observations, spatial simulations through spatial syntax (allowing predicting the circulation of individuals) and statistical tests. The keystone of our methodology is the spatial syntax, which constitutes a theory and a method allowing the evaluation of the design of an architectural or urban device.

The spatial configuration is ultimately decisive because it determines, in part, the way in which individuals move, which supports the natural movement theory developed by Hillier et al. (1993), which indicates that individuals tend to choose and frequent spaces that are visually well integrated and connected. The various correlations between integration and the flow of people (par/hour) attest to this. Indeed, users prefer to circulate in the most extensive corridors, always seeking views of the atrium void. In addition to this, there are other parameters that influence the movement of individuals, such as the cognitive-emotional dimension (Higuera-Trujillo et al., 2021), etc. We also retained that the repartition of commercial specialties is partly also affected by the syntactic properties of the space (Andi et al., 2021).

In addition, the position and form of the central space play a decisive role in users' displacement choices, especially since the stairs and elevators are easily located (Zhou and Liu, 2021) and are in the most integrated and connected part of it.

This study showed that it was possible to predict the spatial effect on the movement patterns of individuals through syntactic modeling of space, at least for small and medium-sized commercial structures. Nevertheless, these results should not mask the fact that syntactic simulation does not allow for the analysis of the built environment in its three-dimensionality, i.e. as a complex system that organizes itself vertically. Indeed, it is limited to analyzing the space only in its horizontal dimension. For this reason, future research works could be in line with this research perspective by focusing on some possible improvements of the simulation rules.

Acknowledgments

We would like to thank the design office responsible for the technical study of Ritaj Mall for all the plans and documents that were made available to us.

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UTM UNIVERSITI TEKNOLOGI MALAYSIA

IJBES

International Journal of Built Environment and Sustainability
Published by Penerbit UTM Press, Universiti Teknologi Malaysia
IJBES 9(3)/2022, 35-46

Impact of Physical Learning Environment on University Students' Academic Engagement in an Online Learning Setting during Covid-19: Evidence from a Sri Lankan University

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ABSTRACT

The restrictions imposed due to the outbreak of Coronavirus 2019 led to a paradigm shift in terms of the learning arrangements. In such a situation, since curfew was imposed in Sri Lanka, the universities commenced their all-academic activities using different virtual platforms such Zoom and MS Teams to continue teaching and learning process. Active student engagement is vital for the success of the process. However, evidence shows that the level of student engagement is low in academic activities in an online learning setting and the studies that explored the impact of the physical environment on this situation are rare. Therefore, this study aims to study the impact of ambient and spatial attributes in the physical environment on the level of students' academic engagement in an online learning setting. Data were collected from a purposive sample of 238 undergraduates of University of Sri Jayewardenepura, Sri Lanka and were analyzed using Structural Equation Modeling with AMOS. The model fit assessment, path coefficient estimation and hypotheses testing were done at the data analysis. The study finding empirically validate the impact of ambient and spatial attributes of the physical environment on student engagement in an online learning setting. Out of ambient attributes, noise and lighting level were recorded as the most influencing factor while size and shape of the study area were recorded as highly influencing factors out of spatial attributes. The impact of air quality, layout and pattern on student engagement was found insignificant. The study finding broadens the components taken as physical resources considered in the Engagement Theory and provide insights for students, university officials, housing developers and policy makers on the importance of the physical learning environment for the student academic engagement in an online leaning setting.

Article History

Received: *12 March 2022*
Received in revised form: *21 June 2022*
Accepted: *08 July 2022*
Published Online: *31 August 2022*

Keywords:

Engagement, Ambient attributes, Spatial attributes, Online learning, Covid-19

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DOI: 10.11113/ ijbes. v9. n3.953

1. Introduction

The outbreak of Coronavirus Disease 2019 (Covid-19) has created unexpected challenges worldwide. In order to control the spread of the outbreak of SARS-CoV-2 virus, governments around the world have taken a set of actions and introduced control strategies. As a result, indefinite lockdown of whole regions, closing borders, closing of businesses, except for essential services, and enforcing self-isolation and social distancing rules restricting close physical human contact were the main and immediate actions taken (Shine, 2020). These restrictions have led to a paradigm shift in terms of

flexible work arrangements (Lee and Lee, 2021) as well as in terms of teaching and learning arrangements (Khlaif *et al.*, 2021).

Among the countries in South Asia, Sri Lanka is one of the countries, which have been affected by the Covid-19 pandemic, and the government imposed a curfew to control the spreading coronavirus *(Fowsar et al.*, 2020). In such a situation, all the Sri Lankan universities commenced their all-academic works and administrative works using technological devices and applications such as Zoom, MS Teams, WhatsApp, Viber, Moodle Learning Systems, etc. for work from home. The establishment of online education strategies instead of the general traditional face-to-face academic model can be identified as a considerable structural change that happened recently in the higher education sector in Sri Lanka. This was a novel experience for most of the academics, administrative staff as well as students in Sri Lankan universities as for a long time, the face-to-face teaching and learning process has been practiced in Sri Lankan universities. Therefore, it is essential to study this new phenomenon to identify the challenges faced and to overcome them for better performance to reach ultimate expected course learning outcomes. Although previous scholars found that students' engagement is low in academic activities in an online learning setting (Priyadarshani and Jesuiya, 2021), studies which explored the impact of the physical environment on this situation are rare (Lansdale *et al.*, 2011; Lonka, 2012; Sjöblom *et al.*, 2016). Therefore, it is essential to study this new phenomenon to identify the physical environmental attributes that affect students' academic engagement to reach the ultimate expected course learning outcomes.

The scope of this paper includes studying the impact of physical environment on the students' academic engagement in an online learning setting. Even though this has been widely studied at the university premises, studies are rare in online setting context. Originality of the paper includes broadening the components taken as physical resources considered in the Engagement Theory. Since online learning and teaching process continues for more than two years in many countries including Sri Lanka since the emergence of the Coronavirus 2019, this study's findings will be useful for many parties.

2. Research Problem

Student involvement plays a very vital role in students learning and satisfaction in distance education (Martin and Bolliger, 2018). However, several researchers across the world have conducted researches recently on the impact of Covid-19 on the academic performance of students in universities as well as higher education institutions and found that students face various issues. Those are the absence of traditional classroom socialization, response time and lack of direct interaction with the teacher during the Covid-19 pandemic due to the online teaching and learning process (Gonzalez *et al.*, 2020; Adnan and Anwar, 2020). Accordingly, it is evident that student engagement is relatively low in an online learning setting (Priyadarshani and Jesuiya, 2021) and teachers continuously emphasize the low level of student engagement as a major challenge in the online teaching and learning process.

This significant phenomenon encouraged researchers to examine the factors affecting student engagement. Moreover, (Kahn, 1990) stipulates in the Engagement Theory (ET) that given the right conditions; individuals will be engaged in their in-role performances. This theory further explains that people require to have the availability of psychological, emotional and physical resources to be able to engage well in their role (Khan, 1992). At an instance where they feel sick and where they worry about other matters, that will lead them to have lack of resources to be present and engaged in the role properly (Khan, 1992). As discussed, with this shift toward online education, students join online lectures from various locations around the country instead of traditional lecture halls in the university. This situation has led students to shift to new conditions such as environmental, technological, and psychosocial aspects to take online classes and study (Realyvásquez-Vargas *et al.*, 2020). According to the above-mentioned research results, the safety, health, comfort, academic engagement and performance of students can be influenced by the new conditions (Califano *et al.*, 2017; Lee *et al.*, 2016). Simultaneously, exposure to diverse levels of noise (Nava *et al.*, 2015; Lee *et al.*, 2016), temperature (Califano *et al.*, 2017), and lighting level (Omidiandost *et al.* 2015; Nava *et al.*, 2015) are key *ambient attributes* in the physical environment may cause discomfort and distraction to them. Moreover, students have to interact with their new study stations (table/desk, chair, computer, mouse, electrical outlets) and other *spatial attributes* such as size, shape, design, layout or arrangement, etc. of the study area which, if not designed and arranged from an ergonomic approach, can lead to students' body segments to adopt uncomfortable or forced postures (Nava *et al.*, 2015) and that can lead to less engagement in online academic activities. Although Kahn (1990) argued meaningfulness, safety, and availability as the three predictors of engagement, where availability is defined as "possessing physical, emotional, and psychological resources for investing the self in role performances".

Scholars state that the physical environment must be able to facilitate the teaching and learning experience for better academic engagement (Bouslama and Kalota, 2013; Dittoe, 2002; Miller *et al.*, 2001). However, when reviewing the literature, it was found that most of the articles focus on the impact of psychological and emotional resources on engagement in the online learning context and most of the studies done focusing on physical resources also have explored the impact of technology apparatus and related things on students' engagement. Further when considering the empirical studies on physical environments done by Küller and Lindsten (1992); Winterbottom and Wilkins (2009), on the other hand, have traditionally concentrated on factors related to physical health or discomfort. Knowledge on how the physical environment, instance physical spaces, tools, and equipment, is related to psychological and pedagogical phenomena is still scarce (Lansdale *et al.*, 2011; Lonka, 2012; Sjöblom *et al.*, 2016).

In addition, the relatively few attempts that have been taken focusing on the influence of physical learning environment on student performance (Yang *et al.*, 2013; Kong and Jakubiec, 2019) have been done in the classroom context of which, the findings will not be applicable in the home environment in an online learning setting. Therefore, this study will generate new insights useful in an online learning setting. Further, scholars have recommended further research to study the impact of variables such as lighting, noise, and temperature levels as well as the desk/table and chair design where students take classes on student engagement (Realyvásquez-Vargas *et al.*, 2020). By considering all the evidence,

the author reached the research question as "what physical learning environment factors affect the level of their academic engagement of students in an online learning setting?". Accordingly, the objective of this study aims to study the impact of ambient and spatial attributes in the students online learning physical environment on the level of their academic engagement of students in an online learning setting.

3. Literature Review

3.1 Students' Academic Engagement

When considering the more traditional context, students can straightly enroll and interact with the conversations, producing a more private approach to the loop of feedback, sharing new ideas, contributing to the debate, discussing personal or other nonobjective viewpoints, etc. In contrast, during conducting online classes, instructors are unable to directly interact and engage with students as it is done previously in traditional physical classrooms. It means if someone has a question, it is harder for the learner to get answers promptly (Realyvásquez-Vargas *et al.*, 2020). Students' effort and their engagement has been considered as the main key determinants for successful educational outcomes (Hopland and Nyhus, 2016). The engagement was originally described by Kahn (1990) as a significant and unique motivational concept that harnesses an individual's whole self-concerning physical, cognitive, and emotional aspects to role performances. Physical engagement refers to the level of physical effort taken to complete a task while cognitive engagement refers to the behavior of an individual that is more attentive, vigilant, and focused, and emotional engagement relates to the level an individual being connected to people around them emotionally (Kahn, 1990). In an online learning situation, this can be the connection with teachers and classmates in the same academic batch.

3.2 Learning Environment

Learning environment refers to "the diverse physical locations, contexts, and cultures in which students learn" (Edglossary, 2013). Online learning environment is usually called a virtual environment where learning happens rather than a physical environment. As literature shows that the architecture of educational space has been considered as one of the influential factors in education (Gilavand, 2016). The physical characteristics and attributes have been mainly classified into three categories; ambient, spatial and technology-related. This research studies only the ambient and spatial attributes of the physical environment and reviewed literature of those are discussed further in the next sections. Technology-related attributes were not explored as the study done by Karunarathne et al. (2020) reveals that majority of students have compatible devices and with internet services. Further, a special programme was carried out by the university to ensure all students have accessibility to required devices and services.

3.2.1 Ambient Attributes

Ambient attributes include temperature, air quality, acoustics and lighting (Earthman, 2017; Shaughnessy *et al.*, 2006; Lackney, 2000). Room temperature is a range of temperatures that denotes comfortable habitation for humans (Helmenstine, 2020). WHO (2005) has mentioned that good air quality pertains to the degree to which the air is clear, clean and free from pollutants which are dust, smoke and smog, among other gaseous impurities in the air. Noise, in acoustics, is any undesired sound, either intrinsically objectionable one or one that interferes with other sounds that are being listened to (Britannica Dictionary, 2021). Lighting or illumination is the deliberate use of light to achieve practical or aesthetic effects. Lighting consists of the use of both artificial light sources such as lamps and light fixtures, as well as natural illumination by capturing daylight (Daltco, 2019).

3.2.2 Spatial Attributes

Spatial attributes and needs are often discussed at the classroom level in previous literature. Spatial attributes include size, shape, furniture, seating arrangement, color selection and nature accessibility (Safer et al., 2005; Papadatos, 1973). This paper has considered the size, shape, layout/ arrangement, colour selection, nature accessibility, pattern/ design and materials in terms of the study area, doors, windows, walls, floor, roof, ceiling and furniture as the spatial attributes. Furniture entails the functionality of chairs, comfort, ergonomics and study stations whilst the arrangements and boundaries of the space are defined as the layout. (Yang et al, 2013). Nature accessibility refers to how the student can see or access to the natural environment and whether natural lights and ventilation can be accessed or not.

4. Hypothetical Model Development

4.1 Impact of Ambient Attributes on Student Academic Engagement

The ambient attributes studied in this paper are temperature, acoustics, air quality and lighting. As scholars reveal in previous studies, adverse ambient conditions for instance the extreme temperatures, poor air quality and inadequate lighting undoubtedly have negative impacts on the involvement of the students (Morrow and Kanakri, 2018). Further, surveys and quantitative tests have found that temperature to be the vital influential ambient attribute which is indicating the student perceptions of study areas (Liu *et al.*, 2011) and they prefer slightly cool or slightly warm thermal conditions (Hwang *et al.*, 2006). When it comes to air quality which refers to the concentration of indoor pollutants, especially that of CO2 (Lee and Chang, 2000), scholars state that poor air quality has been correlated with low efficiency, high absence rate, unsatisfactory performance and failure (Shaughnessy *et al.*, 2006). Regarding acoustics, student perceptions are affected by internal environmental sounds as well as by external sources (Dockrell & Shield, 2006). Poor classroom acoustics can contribute to a negative learning environment for students, as excessive noise causes distraction and annoyance (Yang *et al.*, 2013). The perception of lighting is governed by light levels, the spatial distribution of light, glare and color rendering in a space. Poor lighting leads to a negative learning environment and it can result in headaches, eyestrain, and fatigue (Yang *et al.*, 2013) which makes students distracted and less engaged in academic activities. Accordingly, hypotheses relate to ambient attributes can be advanced as;

Hypotheses 1a, 1b, 1c and 1d: The ambient environment attributes; lighting (Hypothesis 1a), acoustic (Hypothesis 1b), temperature

(Hypothesis 1c) and air quality (Hypothesis 1d) affect student academic engagement.

4.2 Impact of Spatial Attributes on Student Academic Engagement

The spatial design of study areas, incorporating furniture, layout and visibility has also been a frequent topic of many studies. The spatial attributes investigated in this study are size, shape, layout/ arrangement, colour selection, nature accessibility, pattern/ design and materials in terms of the study area, doors, windows, walls, floor, roof, ceiling and furniture. When comparing ambient attributes with spatial attributes, spatial attributes are less standardized by industry codes, and few studies have studied on the impact of spatial design on student engagement and performance in the learning process. However, several significant consensuses have been achieved to showcase that those spatial attributes are important for a supportive learning environment that leads to a higher level of student engagement; size and shape (Roskos and Neuman, 2011), layout/ arrangement, pattern/ design (Guardino and Fullerton, 2010), colour, materials (Yang *et al.,* 2013) and nature accessibility (Gilavand, 2016). Accordingly, hypotheses relate to spatial attributes can be developed as;

Hypotheses 2a, 2b, 2c, 2d, 2e, 2f and 2g: The spatial environment attributes; size (Hypothesis 2a), shape (Hypothesis 2b), layout/ arrangement (Hypothesis 2c), colour selection (Hypothesis 2d), pattern/ design (Hypothesis 2e), materials (Hypothesis 2f) and nature accessibility (Hypothesis 2g) affect student academic engagement.

4.3 Control Variables

In addition to the hypothesized relationships, the effects of age and educational level are controlled for as they may affect academic engagement (Yang *et al.*, 2013) and only university undergraduates in ages between 20 to 25 were selected.

The above hypotheses are graphically depicted in the conceptual model shown in Figure1

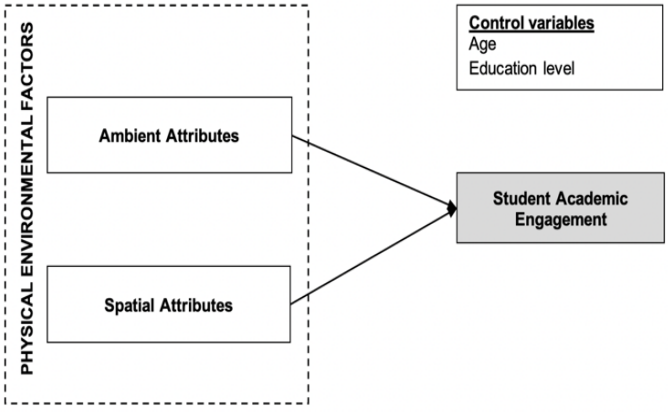

Figure 1 Conceptual model (Author using literature 2021)

5. Methodology

5.1 Participants and Procedures

This research study was carried out using a deductive approach under the positivistic research philosophy. The individual undergraduate who participated in online lectures regularly was selected as the unit of analysis. Data were collected from undergraduates of the Faculty of Management Studies and Commerce, University of Sri Jayewardenepura, Sri Lanka. As per the available statistics from University Grant Commission, Sri Lanka, the approximate number of total students enrolled in the Faculty of Management Studies and Commerce in all four academic batches is 4,700, yet the number of students participated in online lectures regularly during the Covid-19 period cannot be traced due to unavailability of reliable statistics. Accordingly, the sample frame cannot be defined. Hence the sample was derived from the purposive sampling which is a non-probability sampling technique and this quantitative cross-sectional study collected data from a purposive sample of 238 undergraduates which is an adequate amount (Kline, 2016; Hair et al., 2019), representing all four academic years of Faculty of Management Studies and Commerce, University of Sri Jayewardenepura, Sri Lanka using a structured questionnaire. The main reason for choosing university undergraduates is because, online teaching and learning were fully adopted nationwide by universities and as previous studies have found, the level of engagement of university students is relatively low than in other grades and categories. The survey instrument was pilot tested to ensure validity and reliability. In the main survey, the researcher administered the questionnaires online and 241 were received, however, only 238 (n=238) were usable for further analysis. The structural equation modeling (SEM) with AMOS was performed for the analysis of the collected data.

5.2 Measurements of Latent Variables

The measures used in operationalizing the constructs were obtained from previously used scales, questionnaires and items which are validated. Under engagement, perception on physical, emotional and cognitive engagements were measured using the scale used by Rich *et al*. (2010). To measure the physical aspect of engagement, items were drawn from Russell and Barrett's (1999) research on core affect and items used by Rich *et al*. (2010). Finally, for the cognitive aspect of engagement, items were drawn from Rothbard's (2001) measure of engagement. Each dimension consists of five question items. To measure the aspects of ambient attributes, items were extracted from the scale developed by Realyvásquez-Vargas *et al*. (2020). The aspects of ambient attributes were measured using a set of self-constructed survey items using literature. Each dimension consists of four to six question items. Items of all latent variables were measured on a five-point Likert Scale ranging from strongly agree to strongly disagree and the items are listed in Annexure 01.Demographic data and the subcategories were identified by the previous study done using university undergraduates in Sri Lanka (Karunarathne *et al.,* 2020). This included age, gender, academic year, department and usual study area used for online learning.

6. Data Analysis and Results

6.1 Profile of Respondents

This included gender, age and usual study area used for online learning. As shown in Table 1, when considering the gender, age, and the study place, the majority of the respondents are females, 23 years, and studying in their own bedrooms, respectively

Table 1 Profile of Respondents

Category	Categories	No of students	%
Gender	Male	93	39%
	Female	145	61%
	Total	238	100%
Age	20 years	4	2%
	21 years	22	9%
	22 years	62	26%
	23 years	91	38%
	24 years	47	20%
	25 years	12	5%
	Total	238	100%
Usual place used for online learning	Own bedroom	127	53%
	Bedroom shared with one sibling	36	15%
	Bedroom shared with more than one sibling	12	5%
	Study/ reading room	40	17%
	Dining area	4	2%
	Living area	15	6%
	Outside of the house	4	2%
	Total	238	100%

Source: Author (2021)

6.2 Construct Reliability and Convergent Validity Assessment

Before testing the measurement model, the data set was tested for common method bias, non-response bias, and multivariate assumptions, namely, normality, linearity, homoscedasticity and multicollinearity. Following the decision rules, the outcomes of these tests did not indicate any significant issue in the data set related to common method bias (Podsakoff *et al.*, 2003), non-response bias (Miller and Smith, 1983), normality (Kline, 1998), linearity, homoscedasticity (Saunders *et al.*, 2019) and multicollinearity (Sekaran and Bougie, 2016). Accordingly, the authors proceeded to test the measurement model.

Next, convergent validity and discriminant validity were tested through confirmatory factor analysis. According to the threshold value of 0.5 (Hair *et al.*, 2014), four items with component loadings less than 0.5 were eliminated. Those were AL4, AL9, AL10 and SN4, and their standard regression weights were 0.039, 0.018, 0.155 and 0.057, respectively. The model was retested for validity and reliability after refinements and the test results are given in Tables 2 and 3.

Table 2 Validity Testing for Variables

Dimension/ Variable	No of Items Remained	Standardized Factor Loading (Min-Max)	AVE	CR	Cronbach's Alpha
Lighting (AL)	7	0.459-0.885	0.502	0.813	0.759
Acoustic (AA)	5	0.571-0.908	0.456	0.802	0.789
Temperature (AT)	4	0.627-0.884	0.582	0.846	0.843
Air quality (AQ)	5	0.858-0.943	0.836	0.962	0.963
Size (SS)	6	0.674-0.806	0.581	0.892	0.892
Shape (SH)	7	0.730-0.996	0.791	0.963	0.969
Layout (SL)	5	0.890-0.938	0.749	0.936	0.931
Colour (SC)	4	0.835-0.963	0.804	0.942	0.942
Pattern (SP)	5	0.693-0.94	0.651	0.901	0.846
Material (SM)	4	0.853-0.991	0.852	0.958	0.951
Nature accessibility (SN)	4	0.469-0.948	0.698	0.897	0.819
Physical engagement (EP)	6	0.546-0.858	0.576	0.889	0.883
Emotional engagement (EE)	6	0.691-0.922	0.611	0.903	0.903
Cognitive engagement (EC)	6	0516-0.945	0.616	0.903	0.901

Source: Author (2021)

Table 3 Test Results of Discriminant Validity

Variable	AVE Vs. SMC													
	AL	AA	AT	AQ	SS	SH	SL	SC	SP	SM	SN	EP	EE	EC
AL	**0.502**													
AA	0.164	**0.456**												
AT	0.388	0.333	**0.582**											
AQ	0.272	0.131	0.526	**0.836**										
SS	0.323	0.165	0.235	0.065	**0.581**									
SH	0.466	0.159	0.462	0.233	0.465	**0.791**								
SL	0.278	0.135	0.247	0.090	0.761	0.526	**0.749**							
SC	0.378	0.109	0.385	0.175	0.452	0.811	0.486	**0.804**						
SP	0.277	0.090	0.331	0.118	0.540	0.661	0.654	0.774	**0.651**					
SM	0.223	0.125	0.463	0.270	0.205	0.658	0.293	0.774	0.562	**0.852**				
SN	0.408	0.226	0.317	0.128	0.409	0.759	0.485	0.629	0.523	0.388	**0.698**			
EP	0.042	0.270	0.248	0.200	0.001	0.093	0.011	0.049	0.037	0.130	0.156	**0.576**		
EE	0.008	0.181	0.093	0.003	0.072	0.064	0.121	0.052	0.074	0.075	0.128	0.374	**0.611**	
EC	0.015	0.251	0.007	0.000	0.011	0.004	0.040	0.002	0.014	0.006	0.047	0.422	0.590	**0.616**

Source: Author (2021)

The present study followed the guidelines of Hair *et al*. (2014) and Fornell and Larcker (1981) to assess scale reliability and validity. Accordingly, as shown in Tables II and III, all latent variables in the model of the current study are at a satisfactory level of convergent validity (AVE>0.5, Hair *et al*., 2011), Cronbach's alpha (α >0.7, Hair *et al*., 2011), composite reliability (CR>0.7, Hair *et al*., 2011) and discriminant validity (AVE for each construct is greater than the squared multiple correlations between constructs, Fornell & Larcker, 1981). The values of standardized factor loading that fall between 0.45 – 0.5 were also taken as valid as their rounded off value is 0.5, which complies with the threshold. The values of goodness of fit indices were; RMSEA=.078; CFI=.625; TLI=.632. RMSEA value should be close to 0 to be perfect fit. RMSEA value 0.78 can be considered as reasonable, as value that is less than 0.09 suggests a reasonable model–data fit (Browne & Cudeck, 1993; Hu & Bentler, 1999). A higher CFI and TLI values close to 1, indicate a better model fit (Hu & Bentler, 1999). Accordingly, values of the goodness of fit indices, the model fits the observed variables moderately, thus, proceeded to test hypotheses.

6.3 Structural Model

Once the measurement model was verified, three structural models were performed to test the developed hypotheses as well as the impact of the controlling variable on the dependent variable. According to the outputs of the first two models, the impacts of age and education level as control variables on engagement were found to be insignificant (age: p= .439 and education level: p= .315), and thus, this control variable was eliminated from the research model

at the data analysis level and was not considered in the other structural models. The third model was performed to test the other direct hypotheses (Hypotheses 1a to 2g) that relate to testing the impact of ambient and spatial attributes on student academic engagement.

Figure 2 shows the structural model and the standardized coefficients and the p-values for the direct paths are shown in Table 4

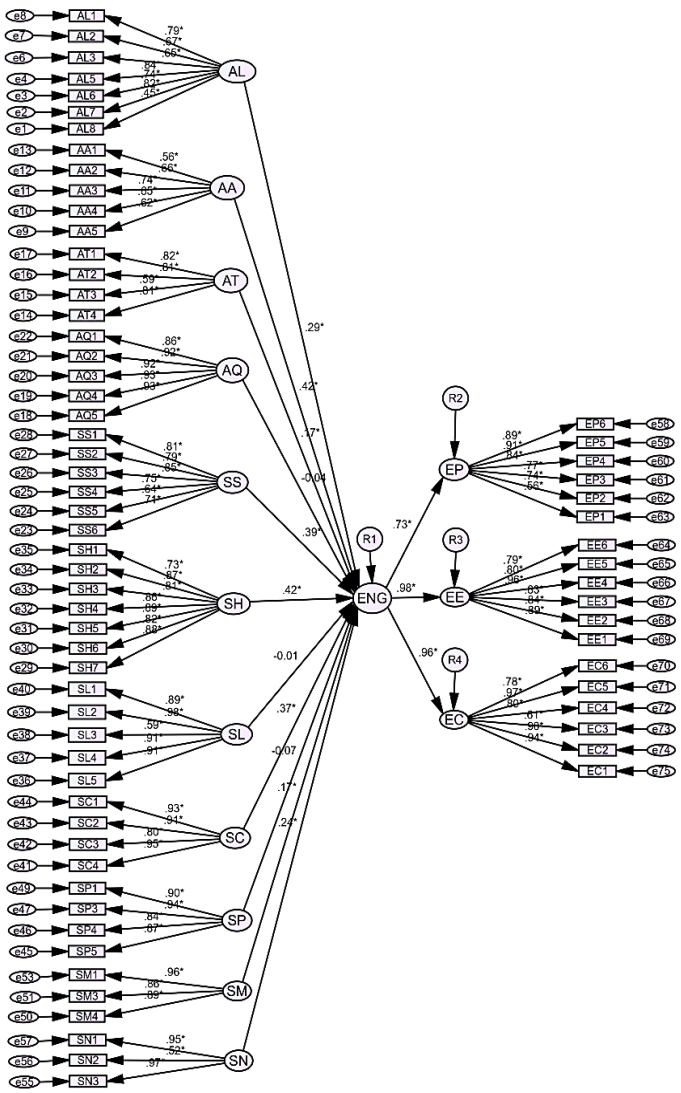

Figure 2 Conceptual Model (Source: Author 2021)
Source: Author (2021)

Table 4 Summary of Hypotheses Testing

Hypothesis	Path	Std. Coefficient	P-value	Hypothesis Result
H1a	Lighting → Engagement	0.29	0.000*	Supported
H1b	Acoustic → Engagement	0.42	0.000*	Supported
H1c	Temperature → Engagement	0.17	0.000*	Supported
H1d	Air quality → Engagement	0.04	0.142	Not supported
H2a	Size → Engagement	0.39	0.000*	Supported
H2b	Shape → Engagement	0.42	0.000*	Supported
H2c	Layout → Engagement	0.01	0.698	Not supported
H2d	Colour → Engagement	0.37	0.000*	Supported
H2e	Pattern → Engagement	0.06	0.087	Not supported
H2f	Material → Engagement	0.18	0.038*	Supported
H2g	Nature accessibility → Engagement	0.24	0.000*	Supported

Note: * Significant at level 0.05

The p-values recorded in the summary of hypotheses testing shown in table IV, reveal that all direct paths except H_{1d}, H_{2c} and H_{2e} are significant at the 05 percent level ($p<0.05$). Accordingly, all direct paths H_{1a} to H_{2g} except H_{1d}, H_{2c} and H_{2e} mentioned in table 4 were found to be statistically significant and were supported by the results of the analysis. This reveals that lighting, acoustics and temperature out of ambient attributes and size, shape, colour, material and nature accessibility out of spatial attributes of physical learning environments at homes affect students' academic engagement in an online learning setting.

7. Discussion

The objective of this study was to study the impact of ambient and spatial attributes in the students online learning physical environment on the level of their academic engagement in an online learning setting. As hypothesized, the findings suggest that adequate level of lighting, acoustic and temperature make a significant positive impact on student academic engagement. Consequently, when the illumination level in the study area is sufficient to see the around clearly, if it enables visual comfort to the student without causing any glare sensation from windows as well as from artificial lights, and if the lighting level can be controlled by the students, they tend to engage with academic activities enthusiastically and with high level of interest leading to improved emotional engagement. Further, when the study area is free from noise coming from external sources, enabling the student to concentrate more on the academic work, they engage more. This directly links to their cognitive engagement level that associates with their attention and concentration level on academic activities. Moreover, when the temperature level at the study area is bearable and if it allows students to take online classes comfortably and if the temperature level can be controlled by students, it affects them to engage more in academic activities in an online learning setting. These findings further supported the findings of the research work done by Realyvásquez-Vargas et al. (2020). The validated impact of adequate lighting level and visual comfort on engagement is consistent with the research work of Liu et al. (2011) and Yang et al. (2013). It proves that inadequate lighting undoubtedly can negatively impact the visibility and ultimately academic engagement of students (Morrow and Kanakri, 2018; Oselumese et al., 2016). As indicated by Singh et al. (2020), lighting levels from 250 to 500 lux are considered adequate for better academic engagement. This applies in an online learning setting also (Realyvásquez-Vargas et al., 2020) and it shows that the lighting level in the study area is significant for students' academic engagement.

The findings of the study done by Dockrell and Shield (2006) and Oselumese *et al*. (2016) are congruent with the current study's finding on the acoustic condition of the study area and its positive impact on students' engagement when the study areas are less noisy. The main reason is when the study areas are too much noisy, students face difficulties in concentrating and it leads to distractions (Yang *et al*., 2013). Braat-Eggen *et al*. (2017) in their study found that high level of noise as a factor that can distract students when they are engaged in cognitive tasks. This can directly influence the cognitive engagement level of students. Thus, a acoustic condition where internal and external noises from devices, people's talks, etc. are low, students can easily concentrate and engage with their academic work more effectively.

The positive impact of a tolerable temperature level on engagement was also found significant as per the perceptions of the respondents. The current study's findings coincide and prove the finding of research work done by Liu et al. (2011), Baarfi (2020), López-Chao et al. (2019) and Realyvásquez-Vargas et al. (2020). They also found that temperature is one of the most crucial ambient attributes in determining student perceptions of study areas. The desirability of the temperature level is decided when the environment is thermally neutral where it is not too cold or too hot. Further, when the level of temperature can be controlled by the students in their study area by turning on and off the fans, closing or opening windows, those also increases the perception of students on the temperature level. Accordingly, such supportive environment can lead to more effective student academic engagement.

The study findings further reveal that the impact of air quality on engagement was found insignificant. This contradicts the findings of the research work done by Shaughnessy et al. (2006) yet agrees

with the findings of the studies done by Hopland and Nyhus (2016) and Yang et al. (2013) where they have found that students have given low impact votes to air quality. Thus, students do not pay much attention to if they get natural lighting, if the air quality is appropriate and acceptable to take online classes and if they can control the air quality by opening a window or turning a fan or an A/C on when engaging in academic activities in an online learning setting.

When moving to the spatial attributes, the study findings reveal that size, shape, colour, material and nature accessibility make a significant positive impact on student academic engagement. The sufficiency of the sizes of the usual study area to reside, to keep furniture and also the size of the furniture and equipment; chair, table, computer, etc. is found significant for student engagement. Further, the shape of the study area, roof, doors, windows, and furniture was also found significant for students to comfortably engage in academic activities in an online learning setting. The colour and material of floor, walls, roof, ceiling and furniture also make an impact on the level of student engagement. As revealed by Greene, Bell, & Boyer (1983) and Plass, Heidig, Hayward, Homer, & Um (2014), warm colors such as yellow and orange, rather than using the cold colors such as gray which are used in materials can enhance students' learning and engagement. The findings of the positive impacts of size and shape on student engagement are congruent with the findings of the studies done by Roskos and Neuman (2011) and Yang et al. (2013). The findings of the impacts of colour selection, material and nature accessibility on engagement were also significant and those validate the findings of the studies carried out previously by Yang et al. (2013) and Gilavand (2016). As they revealed, desirable colors and materials of walls, floor, chairs, tables, etc. in students' study areas can elicit positive feedbacks and enhance learning desires. Similarly, Tanner and Kenneth (2000) also state that nature accessibility affects students' academic engagement.

On the other hand, the impact of layout and pattern on engagement were found as insignificant. Accordingly, it was evident that students do not pay much attention to the arrangement and pattern of doors, windows, furniture, fittings when engaging in academic activities in an online learning setting. This contradicts with the findings of the study done by Guardino and Fullerton (2010).

Overall, with the transformation of teaching and learning process to virtual platforms due to Covid 19 pandemic situation, different ambient and spatial attributes of the physical learning environment of the students' usual study place still affect the level of students' physical, emotional and cognitive engagement to the academic activities in an online learning setting.

8. Conclusion and Implications

The current study tested eleven hypotheses and found that when the ambient condition of the learning environment in terms of lighting, acoustic and temperature and spatial attributes in terms of size, shape, colour, material and nature accessibility are supportive and desirable, it can motivate students to engage more in academic work. In addition, although literature supports that air quality which is another ambient attribute and layout and pattern which are spatial attributes may also make an impact on engagement, the current study contradicts those findings and found that those factors do not significantly influence students' engagements. The main reason for this is, students not being concern about getting natural lighting, appropriateness of air quality, controlling air quality, as well as the layout arrangement and the pattern of doors, windows, furniture, fittings when engaging in academic activities in an online learning setting. Respondents do not consider these variables as influencing to their physical, emotional and cognitive engagement level in an online learning setting.

Accordingly, this study validated the impact of ambient and spatial attributes of the physical environment on the student engagement in an online learning setting and contribute to theory by broadening the components taken as physical resources considered in the Engagement Theory (1990) by including external environmental factors; ambient and spatial attributes as a key significant component in the availability antecedent. This study addresses the gap in empirical evidence on the impact of the physical environment on psychological and pedagogical phenomena in an online learning setting.

Based on the study findings, authors have suggested several implications for managers and other stakeholders. Those include, university guidelines given for students on online learning should include points on how to create a physical learning environment more desirable for a student to engage in academic work properly before starting lectures, selecting construction materials for walls that can absorb or eliminate external noises, the size and colour of the space can be made more desirable, adopting green building elements to improve the physical environmental conditions in terms of natural lighting and ventilation easily and conducting awareness programmes with the presence of experts on green elements would help to convince the residents of the importance of adopting these green elements to create a desirable learning environment. The findings of this study are also important for policymakers on the development and implementation of policies related to the education sector and institutions at regional, national as well as international levels.

9. Limitations and Further Research Directions

This study used non-probability sampling technique and the sample was selected from one faculty of a Sri Lankan university. This can affect the generalizability of the study findings. Future studies can carry out using probability sampling techniques to ensure high generalizability of findings. The current study examined only the impact of selected ambient and spatial attributes on students' academic engagement. However, due to the high complexity and heterogeneity of physical environments, there can be many other factors that can influence students' academic engagement. Subsequently, future studies may focus on examining those attributes such as privacy, safety, level of maintenance, etc. In addition, although the impacts of several attributes; air quality, layout and design/ pattern were found insignificant on engagement, future studies will be worthwhile to examine and validate these findings further. Moreover, this study examined the perceptions of students, yet the perceptions of academic staff also can add value to studying the situation of

student academic engagement. On the other hand, the academic staff also are engaging in work online distantly via technological platforms. Future studies may require examining their work engagement level and related areas as those would also generate new insights useful for various parties

Acknowledgments

This study was supported by the Centre for Real Estate Studies (CRES), Department of Estate Management and valuation, University of Sri Jayewardenepura, Sri Lanka.

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Appendix

Annexure 01: Operationalization of the variables

Attributes	Variables	Items
Ambient Attributes	**Lightening**	The level of lightening in my study area is sufficient.
		Only daylight is sufficient to illuminate my study area.
		The level of lighting in my study area allows me to see clearly what is around, as well as to concentrate when taking online classes.
		I can control the level of lighting in my study area when taking online classes (for example: opening/closing blinds, curtains; having a table lamp; dimmers within reach).
		The level of lighting (from lamps, computer screen) in my study area allows me to have visual comfort when taking online classes.
		The glare sensation caused by excessive light, bright reflections or contrast from the computer screen makes me uncomfortable when learning online.
		The glare sensation caused by excessive light, bright reflections or contrast from the windows makes me uncomfortable when learning online.
		The glare sensation caused by excessive light, bright reflections or contrast from artificial lights makes me uncomfortable when learning online.
	Acoustic/ Noise	My study area is free from noise.
		I have privacy in my study area when taking classes online.
		The noise level coming from devices in my study area allows me to concentrate, take the class, and clearly hear my teacher and classmates.
		The noise level coming from people's talks, external sources in my study area allows me to concentrate, take the class, and clearly hear my teacher and classmates.
		I can control the noise level in my study area (example: opening/ closing doors/ windows).
	Temperature	The internal temperature in my study area is bearable.
		The temperature in my study area allows me to be comfortable and concentrate when taking online classes.
		I use additional methods to control temperature (example: fans, A/C, etc.)
		I can control the temperature in my study area (for example: opening/closing windows, turning fan or A/C on/off) when taking online classes.
	Air Quality	The internal air quality in my study area is acceptable.
		I get natural ventilation to my study area.
		The air quality in my study area allows me to be comfortable and concentrate when taking online classes.
		The air quality in my study area is appropriate for taking the classes online.
		I can control the air quality in my study area (for example: opening/closing windows, turning fan or A/C on/off) when taking online classes.
Ambient Attributes	**Size**	My usual study area is spacious/ big enough to comfortably engage in online learning.
		My usual study area is spacious/ big enough to keep furniture and equipment used for online learning.
		The furniture I'm using (chair, table, etc.) are big enough to comfortably engage in online learning.
		The window(s) in my study area are large enough to comfortably engage in online learning.
		The door(s) in my study area are large enough to comfortably engage in online learning.
		The wall height is adequate to comfortably engage in online learning.
	Shape	The shape of floor in my study area is suitable to comfortably engage in online learning.
		The shape of roof/ ceiling in my study area is suitable to comfortably engage in online learning.

		The shape of walls in my study area is suitable to comfortably engage in online learning.
		The shape of windows in my study area is suitable to comfortably engage in online learning.
		The shape of doors in my study area is suitable to comfortably engage in online learning.
		The shape of furniture in my study area is suitable to comfortably engage in online learning.
		The overall shape of my study area is suitable to comfortably engage in online learning.
	Layout/ Arrangement	The arrangement of lighting fixtures in my study area is suitable to comfortably engage in online learning.
		The arrangement of windows in my study area is suitable to comfortably engage in online learning.
		The arrangement of doors in my study area is suitable to comfortably engage in online learning.
		The arrangement of furniture in my study area is suitable to comfortably engage in online learning.
		The overall layout/ arrangement of my study area is suitable to comfortably engage in online learning.
	Colour Selection	The floor colour in my study area is appropriate to comfortably engage in online learning.
		The wall colour in my study area is appropriate to comfortably engage in online learning.
		The roof/ ceiling colour in my study area is appropriate to comfortably engage in online learning.
		The furniture colour in my study area is appropriate to comfortably engage in online learning.
	Nature Accessibility	I can see natural environment through windows when siting in my study area.
		I can see natural environment through doors when siting in my study area.
		I can get natural lights to my study area.
		I can get natural ventilation to my study area.
	Pattern/ Design	The floor pattern/ design in my study area is appropriate to comfortably engage in online learning.
		The wall pattern/ design in my study area is appropriate to comfortably engage in online learning.
		The roof/ ceiling pattern/ design in my study area is appropriate to comfortably engage in online learning.
		The pattern/ design of furniture used in online learning is suitable and comfortable.
		The overall pattern/ design of my study area is appropriate to comfortably engage in online learning.
	Materials	The floor material in my study area is appropriate to comfortably engage in online learning.
		The wall material in my study area is appropriate to comfortably engage in online learning.
		The roof/ ceiling material in my study area is appropriate to comfortably engage in online learning.
		The material of furniture used in online learning is suitable and comfortable.
Student Engagement	**Physical Engagement**	I study with passion in online learning.
		I exert my full effort in online learning.
		I devote a lot of energy in online learning.
		I try my hardest to perform well in online learning.
		I strive as hard as I can to complete tasks in online learning.
		I exert a lot of energy on in online learning.
	Emotional Engagement	I am enthusiastic in online lectures.
		I feel energetic at online lectures.
		I am interested in online lectures.
		I am proud of engaging in online lectures.
		I feel positive about online lectures.
		I am excited about online lectures.
	Cognitive Engagement	At online lectures, my mind is focused on my studies.
		At online lectures, I pay a lot of attention to my studies.
		At online lectures, I focus a great deal of attention on my studies.
		At online lectures, I am absorbed by my studies.
		At online lectures, I concentrate on my studies.
		At online lectures, I devote a lot of attention to my studies.

UTM UNIVERSITI TEKNOLOGI MALAYSIA

IJBES

International Journal of Built Environment and Sustainability
Published by Penerbit UTM Press, Universiti Teknologi Malaysia
IJBES 9(3)/2022, 47-60

A Biomimetic Approach to Water Harvesting Strategies: An Architectural Point of View

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ABSTRACT

In the current century, due to global warming, pollution, climate change and the exponential growth of the world population, water resources are consumed at alarming rates. For this reason, sustainable methods of water harvesting have become an important research topic of today. In built environments, which are known to account for a significant share of total water consumption, places the development of alternative solutions for the acquisition and effective use of water to the forefront of the agenda. On the other hand, "nature" offers clues about how plant and animal species manage to use limited water resources with sustainable methods while also providing innovative solutions for "water harvesting". In this context, this research seeks to answer "Can water harvesting strategies of living organisms that manage to obtain water via sustainable methods be transferred to building design through biomimicry?" In this direction, considering the potentials of biomimicry in architecture, plants and animals that are successful in water harvesting have been researched. In addition, biomimetic designs inspired by these living organisms have been analyzed. As a result of this analysis, it has been concluded that, with the use of biomimetic design techniques effective water harvesting methods can be developed for buildings.

Article History

Received: *11 April 2022*
Received in revised form: *14 May 2022*
Accepted: *08 July 2022*
Published Online: *31 August 2022*

Keywords:

water harvesting, rainwater harvesting, biomimetic architecture, biomimicry.

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DOI: 10.11113/ ijbes. v9. n3.969

1. Introduction

Being the source of life that has no substitute, water should be preserved and left to future generations. The continuity of life on earth depends on the availability of sufficient and good quality water. Undoubtedly, water deprivation is one of the most critical environmental problems that are being faced today.

While almost 70% of the earth's surface is covered with water, according to the World-Wide Fund for Nature (WWF) report of 2014, approximately 1% of these resources contain potable and accessible fresh water. In the current century, the demand for water has increased continuously due to the effects of urbanization and population growth, as well as global warming, pollution, climate change, and the irreversible consumption of existing water resources. Moreover, it is expected that the world population will increase exponentially in the coming years and 2.5

billion people will be added to the existing population by 2050. According to a report of the United Nations Department of Economic and Social Affairs released in 2009, it is predicted that urbanization will continue to increase and approximately 60% of the population will live in cities.

As a result of population growth and urbanization, the growing demand and increase in water consumption in built environments is inevitable. Therefore, it is clear that the role of buildings in the perpetuation of water problems will be significant. In this direction, it is important to study and discuss alternative solutions in order to obtain, use and protect water efficiently in "built environments".

A significant portion of the worldwide consumption of water resources comes from construction and housing activities, which are necessary to meet people's basic needs for shelter. This situation increases the demands for developing water management strategies in built environments (Taskan, Mutlu-Avinç, Arslan-Selçuk). In this context, biomimetic solutions for water harvesting studies in buildings are frequently investigated in the literature. Badarnah and Kadri (2015) designed a wall surface capable of harvesting water. Similarly, Jalali, Aliabadi, and Mahdavinejad (2021) developed a water harvesting facade proposal based on water harvesting strategies in plants. Mazzoleni (2013) also investigated water collection strategies in living things in nature and presented conceptual solutions. These mentioned studies are single applications investigating biomimetic water harvesting applications. However, there is no study in the literature exposing the approaches on biomimetic water harvesting practices. In this context, this study aims to examine the water harvesting biomimetic design and application examples in the literature and to reveal the current situation.

In this context, the question that motivates this study is "Can water harvesting strategies of plants and animals that manage to obtain water via sustainable methods be transferred to building designs through biomimicry?" Within the scope of the research; strategies developed for the purpose of obtaining water needed in the buildings by using the potentials of the environment, especially rain harvesting, were investigated.

Considering the effective role of built environments in water consumption, modern solutions to the problem of water insufficiency on the basis of buildings have been researched by literature review method. As a result, for the effective use of water in modern buildings it was observed that 3 basic strategies were used, namely wastewater recycling (use of gray water and black water), water-saving installation selection and rainwater harvesting, but among these strategies, the focus was on rainwater harvesting, the variables of which are related to architectural design decisions. It is seen that there are very limited number studies on this subject in the literature. In this direction, 11 modern buildings serving different usage purposes were selected and their water efficient strategies and rainwater harvesting methods were analyzed. The building samples were selected from the buildings, which were designed and/or built for sustainability and water efficiency, and where various architectural design decisions were made in order to make rainwater harvesting in the design. Buildings with a uniform function and a certain size were not preferred, instead, a wide range of choices were made, from small-scale projects to complex projects, from single-storey buildings to high-rise buildings, from residential buildings to commercial, educational, cultural and sports structures. Thus, it is assumed that rainwater harvesting through structures will be evaluated independently of such criteria. As a result of the analysis, rainwater harvesting methods used in modern buildings were classified according to the quality of the architectural surfaces that collect rainwater, and it was revealed by which methods rainwater harvesting could be done in buildings.

In the next section, the water use strategies of living creatures in nature were examined, and the designs that could arise as a result of transferring the obtained data to the buildings through biomimetic design were questioned. Since the number of samples of biomimetic water harvesting is very limited in the literature, all samples obtained regardless of climate were examined. The designs were analyzed in terms of effective water use methods, and the differences and innovations brought by these approaches were revealed. To summarize, research has been done on traditional and modern techniques of obtaining water through structures, and then innovative methods introduced from a biomimetic perspective have been examined. Related methods were analyzed and compared with sample applications and designs, and potential architectural elements that could serve innovations and water harvesting were revealed in line with the data obtained.

2. The Relationship Between Biomimesis and Architecture

Biomimesis, which is referred to in literature by different terms such as biomimetic, biomimicry, and bionic, is the science that examines systems in nature and then mimics these systems, models, processes or strategies to solve related problems (Rao, 2014). This approach was embodied in the book "Biomimicry: Innovation Inspired by Nature" by Janine Benyus in 1997 (Rankouhi, 2012). According to Benyus, "biomimicry is a science for problem solving, which aims to use nature as a model, measure and mentor, and uses the information obtained by analyzing the models, systems and operations of nature in this direction" Benyus (1997).

Zari (2007) defines three stages for existing biomimicry applications: organism, behavior and ecosystem. The level of "organism" can refer to a holistic organism such as a plant or animal, but is also used to imitate a certain part or whole of the organism. The second stage refers to "behavior" and involves the transfer of specific / limited or broader holistic behavior of the organism. The third stage means imitating the entire "ecosystem" and this includes the transfer of its general principles. According to Zari (2007) two distinct approaches to biomimicry as a design approach exist: Problem-Based Approach and Solution-Based Approach.

Problem-Based approach was found to have different naming in various literatures such as "Design looking to biology" (Pedersen Zari, 2007), "Problem Driven Biologically Inspired Design" (Michael Helms, Swaroop S. Vattam and Ashok K. Goel, 2009)

and "Top-down Approach" (Jean Knippers, 2009) all having the same meaning. In this approach designers look to nature for solutions. The Solution-Based approach is also referred to as "Biology influencing design", "Bottom-Up Approach" or "Solution-Driven Biologically Inspired Design". In this approach, biological knowledge influences human design (Nkandu and Alibaba, 2018).

Looking at the history of architecture, inspiring / learning / adapting from nature is not a new approach and has been used for many years. Having learned to live in communities, human beings have started to observe formations in nature to address the need for shelter. Human beings have not only used materials obtained from nature but have started to develop initial building techniques by consciously or unconsciously observing or imitating natural constructions (Selçuk and Sorguç, 2007).

Looking at the architecture of ancient times, it is seen that the forms, structures and proportions seen in nature are often imitated. For example, it is known that columns, the main structural element of Greek and Roman temples, were developed to support roof and beam loads inspired by the load-bearing trunk of the tree. Motifs that resemble various trees or plants are frequently found not only in the column headings of the buildings, but also on the façades and interior decorations (Rian and Sassone, 2014). It can be said that "fan vaults", one of the most important structural elements of churches, which are the symbolic structures of the Middle Ages, were also inspired by the form and structural structure of the tree branches. (Aziz and El Sherif, 2015)

With the coming of the industrial revolution in the 18th century, the nature-inspired movement in architecture also changed and developed in line with the technological advances of the period. Until the industrial period, while the movement inspired by nature generally continued with an analogical approach in line with form and structural pursuits it has developed by spreading to different areas with the production of new building materials and the emergence of new construction techniques. As a result of this development, nature started to be imitated in terms of both form and function (Gertik, 2012). The engineers and architects have benefited from the construction principles of natural formations especially in structural designs. In this regard, Horatio Greenough argued that the principles of designing a skeleton can be learned from the skeletal systems of animals and insects in a theory he put forward in 1851 (Öztoprak, 2008).

It was possible to observe this understanding in the late works of Le Corbusier, one of the pioneers of modern architecture. When speaking about the Ronchamp Chapel in Ronchamp, France in 1954, Corbusier said, "*A crab shell I found on Long Island near New York in 1946 rests on my drawing table. It will be the roof of the chapel…*" (Varlı, 2013). In the same years, Mexican designer Felix Candela started to create products by examining the pressure and breakage resistant structures of seashells and eggs. As seen through the geometric investigations of form in Los Manantiales he also frequently worked with hyperbolic paraboloids found in nature (Bozkurt, 2010). Built in 1962, the TWA airport building, in which American architect Eero Saarinen evoked the concept of flight by imagining the bird form, is among the important examples of nature-inspired architecture. Similarly, Santiago Calatrava has been inspired by the forms and structures of nature both visually and functionally in many of his buildings (Yesilyurt, 2008). The city of arts and sciences building can be cited as one of the examples.

Buckminster Fuller and Frei Otto are also among the important designers who analyze natural forms to create structurally efficient designs and thus design innovative structural systems (Öztoprak, 2008). Otto was not only concerned with what natural structures were, but also how they came together and formed. He conducted multidisciplinary research and experiments on structural efficiency by integrating the principles of biology into the design process within his institute (Institute for Light Weight Structures) in Stuttgart in 1964 (Pasic, 2014). Buckminster Fuller (1895–1983) argued that there is a technology in nature that is both dynamic and functional, and its resulting products light. He said that the optimum efficiency of natural construction contains important clues for man-made structures (Türk, 2018).

Today, architectural design perspectives have changed with the emergence of a new set of problems that have direct effects on nature such as climate change, population growth, unplanned urbanization, pollution and the depletion of natural resources. To adapt to the natural environment, sustainable architectural design strategies have started to be developed that can meet the energy and water requirements in a renewable manner within their own systems. In this sense, energy and water efficiency have become an important design criterion. In this direction, biomimesis has become one of the frequently used areas to solve the sustainability problems of the built environment (Öztoprak, 2008).

In summary, when looking at the history of architecture, it is seen that architectural ideas and practices have an absolute interaction with nature in line with the needs and possibilities of the time. Although the approach of imitating nature in architecture varied according to the dynamics of said times, nature remained the role model for many designers. The movement of learning from nature has gone beyond the formal imitation of nature as a result of the development of technology and research opportunities in the historical process. With the integration of biological information into the design process, imitating nature has gone beyond the metaphorical and analogical approach. The rules that govern natural forms have been used to solve problems in the functioning of architectural structures, and at the same time have extended over many areas such as structure, material, color, structural efficiency, energy efficiency and sustainability. Today, the movement of learning from nature, which unites under the umbrella of biomimesis and cooperates with many branches of science, continues to develop in the field of architecture. In recent years, biomimetic study centers have started to spread in universities all around the world. Some examples are "Biologically Inspired Systems Lab in Sweden, the Centre for Biologically Inspired Designs in Atlanta, and the Centre for Biologically Inspired Materials and Material Systems at Duke University, North Carolina" (Nkandu and Alibaba, 2018). According to Benyus (1997), "*if this learning process continues by spreading in different disciplines, a 'biomimetic revolution' will be experienced in the coming years*". To sum up, it is possible to state that biological data has the potential to create new paradigms in the field of architecture, as in other branches of science and design.

3. Water Harvesting in Built Environments

In the literature, there are different methods of water harvesting in built environments. These methods can be listed as atmospheric water harvesting, seawater harvesting (desalination), groundwater harvesting, and rainwater harvesting.

Atmospheric water (moisture, fog, etc.) harvesting is described as the process where water particles in the air are condensed to obtain water. Various designs and devices have been developed to obtain water with this method. For example, a system called the "foghive" with fog-catching networks was developed in South America by Dr. Cristian Suau (Suau, 2010).

The seawater harvesting method is used to separate the salt in seawater and convert it into fresh water. Although seawater treatment is considered a good water source alternative to obtain potable water, the cost of this technology is not considered as a viable option for all regions and countries that struggle with drought conditions. In addition, it is predicted that this will not be an environmentally friendly method in the long term as the desalination process creates a significant amount of waste accumulation (Bradshaw, 2008).

Groundwater harvesting is one of the methods used in regions where accessible water resources are insufficient. It is not recommended to choose this method in the long run because it is considered disruptive to the existing ecological balance by causing irreversible damages in the natural water cycle. In addition, this method is not economically sustainable as it requires the use of wells and pumps, which are very costly to develop for groundwater discharge (Bradshaw, 2008).

Rainwater harvesting is one of the most common methods to obtain water both in the past and present. According to the World Overview of Conservation Approaches and Technologies Network (WOCAT) database, rainwater harvesting is defined as the "collection and management of rainwater to increase water availability for the continuity of the ecosystem as well as domestic and agricultural use" (Liniger and Studer, 2011). A typical rainwater collection system has 4 main components which are the collection surface, the transport system, the storage system, and the distribution systems. Rainwater is collected from the collection surfaces and transported to the warehouses through a series of gutter systems and redistributed for various uses (Sahin, 2010).

As a result of extensive literature review, it has been observed that water harvesting methods, other than rainwater harvesting, are not applied in built environments today. In recent years, it has been difficult to supply good quality water with the increasing population in cities. As a solution, the approach of collecting and re-using rainwater in urban environments has profoundly increased (Badarnah, 2016). According to Kim et al. (2005), rainwater harvesting is stated as one of the most effective methods to ensure sustainable urban development and restore the natural hydrological cycle. Collecting rainwater has many advantages both economically and environmentally. In addition, in studies conducted in different countries, it has been determined that rainwater harvesting can save water significantly (Julius et al., 2013). For this reason, rainwater harvesting methods are explained in detail in the next section.

3.1. Rainwater Harvesting Methods

There are many rainwater harvesting methods in literature. Depending on the topography, land use, land cover, precipitation and demand parameters each method is specific to the application area. Consisting of a wide range from high cost to low cost, these methods vary from traditional to technologically advanced ones. In the historical process, different rainwater harvesting practices have been carried out in different parts of the world in line with the needs and opportunities of each society, and each culture has created its own traditional rainwater harvesting methods. However, when these traditional rainwater harvesting methods are examined, it has been observed that the same techniques are sometimes referred to by different names in different regions. Sometimes, although they have similar names, they appear to differ completely in practice. As a result, traditional rainwater harvesting techniques have different definitions and classifications, but the terminology used at the regional or international levels has not yet been standardized (Mbua, 2013).

Mostly water tanks, wells, cisterns, special water structures, water channels, artificial ponds or pools are seen in traditional rainwater harvesting methods. When we look at the rainwater harvesting systems used in modern buildings, we can say that traditional rainwater harvesting techniques are adapted to modern systems. The principle of rainwater collection through cisterns plays a particularly important role in the methods used today. As a basic principle, rainwater harvesting is done by collecting rainwater from building surfaces, mostly from roofs, and storing it in various reservoirs. In line with this basic principle, it is possible to see many different concepts for rainwater harvesting.

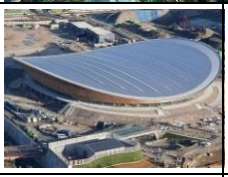
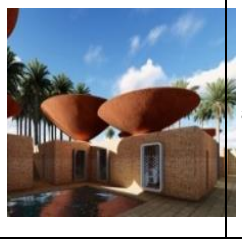
In Table 1 and Table 2, traditional and modern methods of rainwater harvesting are summarized and prominent examples of these methods are presented. Harvesting rainwater through roofs, which is considered one of the traditional methods, is also frequently encountered in modern buildings seen today. While it is understood that the applications for harvesting rainwater through specific water structures occupied an important place in the past, today these applications remain in the background. These traditional practices are now being replaced by modern and technological building designs specially developed for rainwater harvesting. Traditional rainwater harvesting applications, which are carried out through artificial ponds / pools, are used for agricultural purposes, especially in rural areas, and are generally not included in modern building designs. It is also possible to see differences in the purposes and usage areas of traditional and modern rainwater harvesting applications. As can be seen from the studied examples, traditional rainwater harvesting practices are generally carried out for replenishing the drinking water supply and agricultural purposes. In this sense, these methods are used to provide for basic vital needs. When modern practices are considered, environmental concerns come to the forefront and subjects such as water efficiency and water saving are brought to focus rather than vital needs.

Table 1 Traditional Rainwater Harvesting Methods

SAMPLE		METHOD	EXPLANATION	USAGE AREA
Tanka		through roofs	Rainwater is collected from the roof surface and stored in water tanks through a gutter	-Drinking water supply -Small-scale domestic uses
Kund/ Tanka		through special water structures	Rainwater is collected through holes in the tank or through openings on the ground.	-Drinking water supply
Chand Bori		through special water structures	Rainwater is collected from the open surface of the water well with steps and stored at the bottom of the well.	-General uses
Talab		through artificial ponds / pools	Rainwater is collected and stored in an artificial pond.	-Agricultural activities -Domestic uses -Animal husbandry
Berkad		through artificial ponds / pools	In general, on sloping lands, rainwater flow is directed by channels and collected in an artificial pond and stored.	- Domestic uses - Animal husbandry
Khadin		through artificial ponds / pools	Rainwater is collected on the land to be cultivated by directing it through canals or the slope of the land.	- Animal husbandry

Table 2 Modern Rainwater Harvesting Methods

SAMPLE		METHOD	EXPLANATION	USAGE AREA
Heifer İnternational		through roofs	Rainwater is collected from the roof and stored in the water tower that is located on the façade.	-Firefighting systems - WC
Winrock International		through roofs	Rainwater is collected from the roof of the building in the shape of a gull wing and stored in water tanks located in the basement.	- Landscape and garden irrigation works
PhilipMerrill		through roofs	Rainwater is collected from the skillion roofs of the building and stored in the water tanks that are located on the façade.	- Firefighting systems - WC - Cleaning services - Air conditioning systems
PrismaNürnberg		through roofs	Rainwater is collected from the skillion roof of the building and the semi-cylindrical roof and then stored in water tanks in the basement.	- Firefighting systems - Landscape irrigation - Air conditioning systems

The Solaire		through roofs	Rainwater is collected from the terraced roofs of the building and stored in water tanks in the basement.	- Irrigation of green roofs - WC - Cooling systems
Wendell Wyatt Federal Building		through roofs	Rainwater is collected from the one-sided wide canopy added to the roof of the building and stored in water tanks in the basement of the building.	- WC and washbasin - General irrigation - Air conditioning systems
Shangai Tower		through roofs	Rainwater is collected by the spiral parapet of the building.	- Air conditioning systems
The Velodrome		through roof	Rainwater is collected from the hyperbolic parabolic roof of the building and stored in water tanks located at the basement level.	- WC and washbasin
Postdamer Platz Kompleksi		through roof	Rainwater is collected from the roofs of the buildings in the complex and stored in underground water tanks.	- Irrigation of green roofs - Automatic plant irrigation systems in shopping malls - Firefighting systems
Rain Skycraper		special architectural designs	Rainwater is collected by a large funnel on the roof of the building and by the gutters on the façades.	-WC, Bath - Irrigation and cleaning works
BMDesign's Concave Roofs		special architectural designs	Rainwater is collected from the concave roofs of the building and stored between the walls of the building.	- General uses

4. Findings on Nature-Inspired Water Harvest Strategies in Buildings

In the field of architecture, in addition to rainwater harvesting applications, structures and architectural surfaces that can acquire water through condensation or concentration that are inspired by nature have been developed. In this context, below is a review of architectural designs developed through the inspiration of water collection strategies of living creatures.

Las Palmas Water Theatre

Table 3 shows the Las Palmas Water Theater building, inspired by the method of obtaining water of the Namibia Desert Beetle, which lives in arid regions. Moisture harvesting is carried out in the building based on the principles of the Namibian Desert Beetle to obtain water from fog. It contains biomimetic elements in many different design decisions from positioning to material quality. First of all, location selection and positioning decisions for the project were made with a biomimetic approach. The Namibia desert beetle fixes its body in foggy air at an angle of 45 in the direction of the air flow and obtains water by condensing moist air hitting the exoskeleton. Accordingly, the building is located along

an axis in an area where the moist air flow is dense, and an angled façade is placed in line with this axis. Special condensation panels are designed for the façade of the building, referring to the bumps in the exoskeleton of the Namibian desert beetle. Water is obtained from the façade where these panels are located. In this sense, the building has achieved an innovative design by bringing the positioning criterion in water efficient design to the agenda. In addition, it represents an innovation by going beyond the traditional methods and obtaining water through a very specific and specialized façade design.

Namibia University Hydrology Center

The Namibia University Hydrology Center Building was inspired by the Namibian Desert Beetle's principle of obtaining water. Fog harvesting is carried out in the building based on the condensing principle, similar to the method of obtaining water from fog. In line with this principle, it is seen that various biomimetic elements are included in the design decisions of the building. The building stands out with its structural elements specially designed to hold the water in the air. In the design of these elements, the fog basking behavior of the insect in the fog is imitated. The structure is designed and positioned at a certain angle and height to optimally meet the misty air flow. Also, the bumps in the exoskeleton of the Namibia Desert Beetle have a hydrophilic (water absorbing) structure that increases the condensation of the water. This feature has inspired the design of a number of innovative surfaces for the building. Network surfaces supported by special structural elements are designed in the hydrophilic structure. In this direction, the building represents an innovative approach by obtaining water through a specific structure other than traditional methods and with a material proposal that supports water recovery. (Table 4)

Warka Tower

The Warka Tower was inspired by the principles of water supply of spider webs and the Namibian Desert Beetle in Table 5. In the structure, water is obtained based on the condensation principle, similar to the Namibian Desert Beetle's and spider webs' method of obtaining water. The water collection process is done by a network of surfaces within the structure of the building. To obtain water, biomimetic design elements are used especially in terms of materials. It is known that the spider webs have a micro-scaled structure, and the Namibian Desert Beetle has a similarly hilly exoskeleton, and thanks to these surface properties, it has successfully achieved water retention. Based on this, a special 3D network surface is developed for the structure, like the micro-spider web structure. Accordingly, the building represents an innovative and functional approach by presenting an example of a structure that is specialized in the collection of water and by proposing an efficient water retaining surface.

Rain Bellows

The project called Rain Bellows was inspired by the ice flower water storage principle (Table 6). The building stands out with its façade element designed in line with principles like water storage principles of the ice flower plants. The façade element has a movable mechanism that can expand until it is filled with rainwater and does not require additional storage space. In this sense, the building has uncovered an important potential for water storage in buildings with this nature-inspired mechanism.

A Surface Design

Table 7 shows an example of a multi-layered surface design inspired by the water extraction principle of the Namibian Desert Beetle and the water transport principles of the Moloch Lizard. The surface, like the Namibian Desert Beetle, obtains water by the method of condensing the water of damp air. It transmits the acquired water to the interior with pipe systems designed like the capillary channel networks on the skin of the Moloch Lizard. The outermost layer of the surface was designed with a bumps imitating the rugged structure in the exoskeleton of the Namibian Beetle. These artificial domes/mounds/bumps were supported with a hydrophilic material. The lower layer, consisting of a series of capillaries, is planned to release the collected water to indoor spaces on dry or hot days, to contribute to the ambient humidity and increase the comfort of the environment. In this sense, this surface design represents potential building envelope designs by providing a multi-layered surface sample with a specific configuration and material properties in water efficient design.

Table 3 Las Palmas Water Theatre Building inspired by the Namibia Beetle

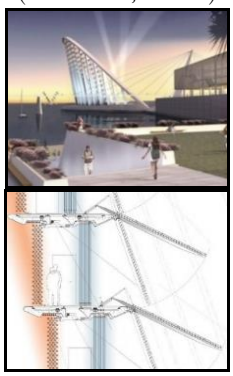
<table>
<tr><td rowspan="3">INSPIRED ORGANISM</td><td rowspan="3">NAMIBIA DESERT BEETLE
  </td><td rowspan="3">FEATURES OF ORGANISM</td><td>Inspirational Feature: Water harvesting</td></tr>
<tr><td>Water Harvesting Method (How):
-The water particles in foggy air condense on the insect's elytra and then canalize into its mouth.</td></tr>
<tr><td>Advanced Biological Properties for Water Harvesting (With What):
-Special Course of Action (fog-basking behavior)
-Morphological Features (Rugged elytra consisting of hydrophilic mounds and hydrophobic grooves)
-Combination of Hydrophilic and Hydrophobic Surfaces</td></tr>
<tr><td colspan="4">BIOMIMETIC DESIGN PROCESS</td></tr>
<tr><td colspan="4">Biomimetic approach</td></tr>
<tr><td colspan="2">Solution Oriented Approach</td><td>Problem Oriented Approach</td><td rowspan="2">Namibian desert beetle, which can obtain and use water in a sustainable fashion, has been investigated to reduce the negative impact on water resources due to water consumption in buildings.</td></tr>
<tr><td colspan="2">-</td><td>+</td></tr>
<tr><td colspan="4">Biomimicry level</td></tr>
<tr><td>Organism Level</td><td>Behavior Level</td><td>Ecosystem Level</td><td rowspan="2">-The elytra of the Namibian beetle is imitated morphologically (organism level)
-Fog-basking behavior developed by the insect for water harvesting is imitated (behavior level)</td></tr>
<tr><td>+</td><td>+</td><td>-</td></tr>
<tr><td rowspan="3">APPLICATION IN ARCHITECTURE</td><td rowspan="3">LAS PALMAS WATER THEATRE
(Las Palmas, SPAIN)
  </td><td rowspan="3">FEATURES OF THE BUILDING</td><td>Feature Transferred to the Structure: Water Harvesting</td></tr>
<tr><td>Water Harvesting Method: Water particles in humid air are collected by condensing through the façade of the building.</td></tr>
<tr><td>Architectural Design Principles for Water Harvesting:
-Special Façade Design (Façade consists of panels specially designed to condense the water in damp air)
-Specific Positioning (The structure is positioned in the direction dominated by the ocean breeze)</td></tr>
<tr><td colspan="4">WATER HARVESTING METHOD</td></tr>
<tr><td>Rainwater Harvesting</td><td>Atmospheric Water Harvesting</td><td>Seawater Harvesting</td><td>Groundwater Harvesting</td></tr>
<tr><td>-</td><td>+</td><td>-</td><td>-</td></tr>
</table>

Table 4 Namibia University Hydraulic Center inspired by the Namibia Beetle

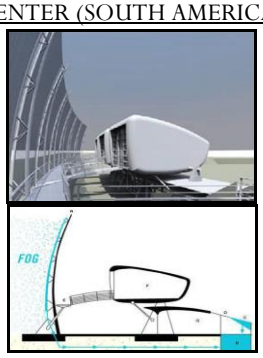
<table>
<tr><td rowspan="3">INSPIRED ORGANISM</td><td rowspan="3">NAMIBIA DESERT BEETLE
  </td><td rowspan="3">FEATURES OF ORGANISM</td><td><u>Inspirational Feature:</u> Water harvesting</td></tr>
<tr><td><u>Water Harvesting Method (How):</u>
-The water particles in the foggy air condense on the insect's elytra and canalize into its mouth.</td></tr>
<tr><td><u>Advanced Biological Properties for Water Harvesting (With What):</u>
<u>-Special Course of Action</u> (fog-basking behavior)
<u>-Morphological Features</u> (Rugged elytra consisting of hydrophilic mounds and hydrophobic grooves)
<u>-Combination of Hydrophilic and Hydrophobic Surfaces</u></td></tr>
<tr><td colspan="4">BIOMIMETIC DESIGN PROCESS</td></tr>
<tr><td colspan="4">Biomimetic approach</td></tr>
<tr><td colspan="2">Solution Oriented Approach
+</td><td>Problem Oriented Approach
-</td><td rowspan="2">Namibian desert beetle, which lives under similar conditions in nature and has solved this problem, has been investigated in order to solve the water access problem of the buildings in water scarce regions.</td></tr>
<tr><td colspan="4">Biomimicry level</td></tr>
<tr><td>Organism Level
+</td><td>Behavior Level
+</td><td>Ecosystem Level
-</td><td>-The elytra of the Namibian beetle is imitated on the basis of form and material (organism level)
-Fog-basking behavior developed by the insect for water harvesting is imitated (behavior level)</td></tr>
<tr><td rowspan="3">APPLICATION IN ARCHITECTURE</td><td rowspan="3">NAMIBIA UNIVERSITY HYDRAULIC CENTER (SOUTH AMERICA)
 
</td><td rowspan="3">FEATURES OF THE BUILDING</td><td><u>Feature Transferred to the Structure:</u>
-Water Harvesting</td></tr>
<tr><td><u>-Water Harvesting Method:</u>
-The water particles in the fog are collected by condensing through a special structure placed in front of the building façade.</td></tr>
<tr><td><u>Architectural Design Decisions for Water Harvesting:</u>
<u>-Special Structural Design</u> (Special structural design that supports water-gathering network surfaces and imitates the angled stance of the Namibian beetle)
<u>-Specific Positioning</u> (The structure is positioned in the direction dominated by the ocean breeze)
<u>-Innovative Material</u> (Special mesh surfaces that are shaped similar to the rugged structure of the elytra to give hydrophilic properties)</td></tr>
<tr><td colspan="4">WATER HARVESTING METHOD</td></tr>
<tr><td>Rainwater Harvesting
-</td><td colspan="2">Atmospheric Water Harvesting
+</td><td>Desalination
-
Groundwater Harvesting
-</td></tr>
</table>

Table 5 Warka Tower İnspired by the Namibia Beetle and Spider Webs

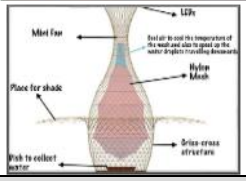
<table>
<tr><td rowspan="3">INSPIRED ORGANISMS</td><td rowspan="3">NAMIBIA DESERT BEETLE
 
SPIDER WEBS
  </td><td rowspan="3">FEATURES OF ORGANISM</td><td>Inspirational Feature: Water harvesting</td></tr>
<tr><td>Water Harvesting Method (How):
-Water in damp air is collected by concentrating on the exoskeleton of the Namibian beetle.
-Water in damp air is collected by concentrating on spider web fibers</td></tr>
<tr><td>Advanced Biological Properties for Water Harvesting (With What):
-Special rugged elytra (Namibian beetle) consisting of hydrophilic mounds and hydrophobic grooves
-Specialized mesh fibers (water harvesting) consisting of hydrophilic knuckles and hydrophobic connections in the micro-scale.</td></tr>
<tr><td colspan="4">*BIOMIMETIC DESIGN PROCESS*</td></tr>
<tr><td colspan="4">*Biomimetic approach*</td></tr>
<tr><td colspan="2">*Solution Oriented Approach*
+</td><td>*Problem Oriented Approach*
-</td><td rowspan="2">-In order to ensure that people living in areas under water shortage have access to clean water, living things that can acquire water with their own methods have been investigated.</td></tr>
<tr><td colspan="4">*Biomimicry level*</td></tr>
<tr><td>*Organism Level*
+</td><td>*Behavior Level*
-</td><td>*Ecosystem Level*
-</td><td>-The hydrophilic structures of the spider web and the exoskeleton of the Namibian beetle are imitated.</td></tr>
<tr><td rowspan="3">APPLICATION IN ARCHITECTURE</td><td rowspan="3">WARKA TOWER
(Ethiopia, EAST AFRICA)
 
  </td><td rowspan="3">FEATURES OF THE BUILDING</td><td>Feature Transferred to the Structure: Water Harvesting</td></tr>
<tr><td>Water Harvesting Method :
-The water particles in the humid air are collected by concentrating on the nylon network surfaces.
-Rainwater is collected directly by the open roof.</td></tr>
<tr><td>Architectural Design Decisions for Water Harvesting:
-Special structural design (modular structure system that supports network surfaces and facilitates the collection of rainwater)
-Innovative material (nylon mesh)</td></tr>
<tr><td colspan="4">*WATER HARVESTING METHOD*</td></tr>
<tr><td>*Rainwater Harvesting*
+</td><td>*Atmospheric Water Harvesting*
+</td><td>*Desalination*
-</td><td>*Groundwater Harvesting*
-</td></tr>
</table>

Table 6 Rain bellows inspired by Ice Flower

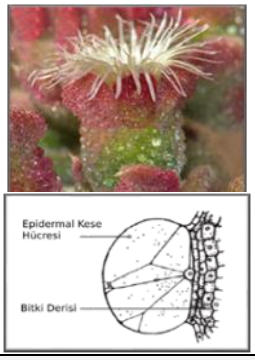
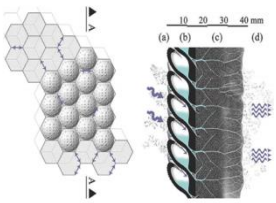
<table>
<tr><td rowspan="3">INSPIRED ORGANISMS</td><td colspan="3">ICE FLOWER
 
</td><td rowspan="3">FEATURES OF ORGANISM</td><td>Inspirational Feature: Water harvesting</td></tr>
<tr><td>Method of Keeping Water (How?):
-Water is stored on the stem of the plant</td></tr>
<tr><td>Advanced Biological Properties for Water Conservation (With What):
• Epidermal sac cells on the plant body that expands and contracts according to the amount of water and stores it.</td></tr>
<tr><td colspan="5">BIOMIMETIC DESIGN PROCESS</td></tr>
<tr><td colspan="5">Biomimetic approach</td></tr>
<tr><td colspan="2">Solution Oriented Approach
-</td><td colspan="2">Problem Oriented Approach
+</td><td>The ability of the ice flower plant to hold water has been an inspiration for water storage areas in buildings.</td></tr>
<tr><td colspan="5">Biomimicry level</td></tr>
<tr><td>Organism Level
+</td><td colspan="2">Behavior Level
+</td><td>Ecosystem Level
-</td><td>The function of the epidermal sac cells in the body of the ice flower is imitated</td></tr>
<tr><td rowspan="3">APPLICATION IN ARCHITECTURE</td><td colspan="3">RAINBELLOWS
(Seattle,USA)
  </td><td rowspan="3">FEATURES OF THE BUILDING</td><td>Feature Transferred to the Structure: Water conservation</td></tr>
<tr><td>Water Preservation Method:
-Rainwater collected through the roof is guided through various channels and stored in storage areas integrated into the façade.</td></tr>
<tr><td>Improved Architectural Design Decisions for Water Conservation:
-Special Façade Element Design (Kinetic front elements that can expand and contract according to the amount of rainwater collected by imitating the flexible epidermal sac cells of the ice flower)</td></tr>
<tr><td colspan="5">WATER HARVESTING METHOD</td></tr>
<tr><td>Rainwater Harvesting
+</td><td>Atmospheric Water Harvesting
-</td><td>Desalination
-</td><td colspan="2">Groundwater Harvesting
-</td></tr>
</table>

Table 7 A surface design inspired by the Namibia Bettle and Moloch Lizard

<table>
<tr><td rowspan="3">INSPIRED ORGANISMS</td><td rowspan="3">Namibia Bettle
 
Moloch Lizard
  </td><td rowspan="3">FEATURES OF ORGANISM</td><td>Inspirational Feature: Water harvesting (Namibian Beetle)-Water transmission (Moloch Lizard)</td></tr>
<tr><td>Method of Keeping Water (How?):
-The water particles in the foggy air condense on the exoskeleton of the Namibian beetle and channel into the mouth of the beetle (water harvesting)
-Water is transported through capillary channel nets in the skin of the Moloch lizard.</td></tr>
<tr><td>Advanced Biological Properties for Water Conservation (With What):
-Special Behavior Form (fog-basking behavior)
-Morphological Properties (Special rugged elytra consisting of hydrophilic mounds and hydrophobic grooves)
-A series of capillaries in the skin that overlap on a micro scale.</td></tr>
<tr><td colspan="4">BIOMIMETIC DESIGN PROCESS</td></tr>
<tr><td colspan="4">Biomimetic approach</td></tr>
<tr><td colspan="2">Solution Oriented Approach
-</td><td>Problem Oriented Approach
+</td><td>Water management strategies of the Namibian beetle and Moloch lizard inspired an effective water surface design</td></tr>
<tr><td colspan="4">Biomimicry level</td></tr>
<tr><td>Organism Level
+</td><td>Behavior Level
+</td><td>Ecosystem Level
-</td><td>-The capillary structure of the skin of the Moloch lizard and the elytra of the Namibian beetle are imitated (organism level)
-Special behavior developed by the insect for water harvesting is imitated (behavior level)</td></tr>
<tr><td rowspan="3">APPLICATION IN ARCHITECTURE</td><td rowspan="3">Surface Design by Kadri and Badarnah (2015) (Concept)
  </td><td rowspan="3">FEATURES OF THE BUILDING</td><td>Feature Transferred to the Structure: Water harvesting and Water transmission</td></tr>
<tr><td>Water Preservation Method:
Water particles in damp air are collected and transported by condensing on the building envelope.</td></tr>
<tr><td>Improved Architectural Design Decisions for Water Conservation:
-Specialized Building Shell Design (the outermost layer of the building shell is designed with a dome, like the exoskeleton of the Namibian beetle. The lower layer is designed by imitating the capillary skin of the Molochlizard to transmit the collected water to the interior spaces and distribute it on the surface)
-Material Selection (hydrophilic material)</td></tr>
<tr><td colspan="4">WATER HARVESTING METHOD</td></tr>
<tr><td>Rainwater Harvesting
-</td><td>Atmospheric Water Harvesting
+</td><td>Desalination
-</td><td>Groundwater Harvesting
-</td></tr>
</table>

5. Evaluation and Conclusion

Within the scope of this article, traditional structures, modern structures and biomimetic designs in the context of "collecting water through buildings" are examined, and the water harvesting methods and architectural elements used in these methods are compared and evaluated (Table 8). In this regard, it has been observed that rainwater harvesting has been adopted as a common strategy within the scope of water harvesting methods. It is seen in the examples that have been examined throughout the study that rainwater harvesting practices contribute significantly to both the elimination of urgent water needs and the reduction of water consumption in modern buildings and traditionally developed water collection structures. It is possible to see rainwater harvesting applications in the water obtaining strategies of biomimetic designs. In addition, atmospheric water harvesting, including fog and moisture harvesting practices, have been brought to the forefront, and ways to obtain maximum water through structures have been investigated. In this sense, it is

predicted that atmospheric water harvesting applications can create an effective water resource, especially in climatic regions where annual rainfall is low or seasonal. In addition, water harvesting strategies of buildings should be suitable for different climate types.

On the other hand, more architectural design elements have been included in the water harvesting process in biomimetic building examples compared to the water harvesting strategies used in traditional and modern buildings. For example, in traditional and modern buildings, water harvesting is generally limited to roofs; however, in biomimetic designs, facades, building shells, structures, walls and various surfaces are utilized. Accordingly, biomimetic designs offer a wider framework for efficient use of water. It also clearly demonstrates the potential of buildings for rainwater harvesting and atmospheric water harvesting.

For example, in the designs inspired by the Namibian desert beetle, it is seen that positioning and material are emphasized. In this direction, it is predicted that the issues of positioning and material use in the structures to be designed in regions with a climate similar to the climatic conditions in which the Namibian desert beetle live will increase the efficiency in water harvesting. In addition, it is thought that extensive research can be made on hydrophobic and hydrophilic materials, which are emphasized in case studies, innovative materials and surfaces can be developed and used in facade designs.

In the design inspired by the ice flower, an innovative approach is put forward for storage areas, which is an important component of water harvesting systems, and kinetic structural elements are highlighted. At this point, it is thought that kinetic building elements can be included in building designs or kinetic building structures can be developed for water harvesting.

From the surface prototype inspired by the Moloch lizard and the Namibian desert beetle, a study has been put forward to show that water harvesting can be done not only through certain architectural elements but also through the building shell, and in this sense, it is thought that progressive building shells can be developed for water harvesting.

In summary, examining nature for the development of water collection methods in built environments has been effective in revealing a variety of potentials, including the potentials for obtaining water from the air. In this context, it is recommended that building design processes be carried out with a multi-disciplinary approach and research in this field. Nature should be examined and investigated as a solution factor. In addition, it is suggested that the information obtained from the research conducted on nature and living organisms are evaluated and transformed into architectural teachings within the framework of biomimetic design to inspire the building design process.

Table 8 An evaluation on water harvesting methods in built environments

Water Harvesting Methods in Built Environments					
Water Harvesting Methods	Architectural Elements Used		Traditional Structures	Modern Structures	Biomimetic Designs
Rainwater Harvesting	Roofs		+	+	+
	Artificial Ponds / Pools		+	+	-
	Facade / Facade Elements		-	+	-
	Special Architectural Designs	Specific Constructions	+	+	+
		Structures	-	-	+
		Surfaces	-	-	-
Atmospheric Water Harvesting	Roofs		-	-	-
	Artificial Ponds / Pools		-	-	-
	Building Envelope		-	-	+
	Facade / Facade Elements		-	-	+
	Special Architectural Designs	Specific Constructions	-	-	+
		Structures	-	-	+
		Surfaces	-	-	+
Seawater Harvesting			-	-	-
Groundwater Harvesting			-	-	-

As a result, in this study, since the number of samples is extremely limited, all samples obtained regardless of climate were examined. Future research can explore climate-oriented solution proposals and further researches are needed to produce effective, and economical prototypes.

Acknowledgments

This article was produced from the thesis named "A biomimetic approach to rainwater harvesting strategies through the use of building" made in the architecture program of Gazi University Graduate School Of Natural And Applied Sciences.

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IJBES

International Journal of Built Environment and Sustainability
Published by Penerbit UTM Press, Universiti Teknologi Malaysia
IJBES 9(3)/2022, 61-73

Strategies to Promote Greenery in Urban Boundary Wall Facades: A Case Study in Residential Areas of Colombo district, Sri Lanka

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ABSTRACT

Understanding the public perceptions towards green infrastructure can be instrumental in identifying effective strategies for greening. This research focuses on the less exploited green boundary walls among the different green infrastructure options. A questionnaire survey was conducted among three hundred twenty-eight residents in residential areas of Colombo district, Sri Lanka, to understand the public perceptions that affect green urban boundary walls. Using Likert scales, participants expressed their perception of benefits and challenges related to greening boundary walls along with socio-economic data. Relaxation effects, improvement of aesthetic appearance, becoming close to nature, and improving air quality were among the highest-rated benefits. Lack of knowledge and time and money requirement was identified as significant challenges. Misconceptions about property damages and nuisance to the owner are demotivators for nearly 38% of the sample as determined by the cluster analysis. Interventions such as providing relevant knowledge on methods of green wall construction and maintenance methods and subsidies can be recommended. Raising awareness through pilot programs and opportunities for experience sharing may motivate people towards greening boundary walls. The study concludes with strategies applicable in motivating residents towards greening their boundary walls.

Article History

Received: *20 January 2022*
Received in revised form: *15 July 2022*
Accepted: *21 August 2022*
Published Online: *31 August 2022*

Keywords:

Facade greenery, Green infrastructure, Green boundary walls, Strategies, challenges

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DOI: 10.11113/ ijbes. v9. n3.934

1. Introduction

1.1 Background

Increasing the urban population in developing countries leads to increasing building footprint at the cost of green areas (Brochu et al., 2022). Lack of green spaces and removal of green spaces are significant issues related to urban densification (Haaland and van den Bosch, 2015), thus calling for an increase in green infrastructure (Jim, 2015; Hall et al., 2012; Chaudhuri and Kumar, 2022). Recent studies highlighted the importance of maintaining equity for greenery in countries of the global south (Rigolon et al., 2018; Elgizawy, 2016)). Mitigation of the urban heat island effect has become an urgent need for Asian countries (Borzino, 2020; Yang and Santamouris, 2018) while some nations around the world are already succeeded in securing reasonable levels of green coverage, some other countries with decreasing

levels of greenery are pressed to find innovative and strategic ways to guarantee safer levels of vegetation in urban areas.
Colombo city, the commercial capital of Sri Lanka, irrespective of its history of being one of the first garden cities, is one of the cities experiencing a decline in green spaces. The green areas in Colombo city have reduced from 31.0 km^2 in 1980 to 5.02 km^2 in 2015. Colombo city's per capita green space was 7.16m^2 in 2015, and it is below the WHO standard level of 8 m^2 per person (Li and Pussella, 2017).

Reduction of urban green spaces due to unplanned urban growth calls for better planning for green spaces. (Senanayake et al., 2013). Li and Pussella (2017) suggest that efforts to increase green spaces in Colombo should focus on smaller administration units. High dense space scared urban areas like Colombo and should look for innovative green infrastructures such as green walls and green roofs to increase green spaces. Green buffers, instrumented through urban planning regulations, have been proposed to core parts of Colombo under Megapolis regulations (Jayaweera et al., 2018). Colombo has joined the trend of constructing green walls, increasingly appearing in clients' requirements (De Silva et al., 2021). As highlighted by the above publications, and in the context of scarce land plots and the suggestion to focus on smaller administrative units, Colombo's effort to increase greener should focus on vertical greening at the household level. According to Rathnasiri et al. (2021), only 15% of the Sri Lankan participants who do gardening practice vertical gardening. This shows a substantial unutilized potential for increasing vertical greenery for Colombo. It further calls for careful effort at the hand of urban planners to increase urban greenery based on a proper understanding of motivators and barriers for greening as well as effective interventions for such.
Research studies from other countries give evidence for attempts to understand citizen perceptions about green infrastructures in urban areas to support the process of increasing urban greenery (Tsantopoulos et al., 2018; Jim and Chen, 2006). Tsantopoulos et al., (2018) proposed some strategies to improve urban greenery in Athens in Greece by understanding people perceptions about benefits, challenges, interventions, and sources of information related to green infrastructure.

The research reported here also attempted to study people perception of one such resident maintained vertical greening option: the green road facades of roadside boundary walls. Citizen perception of greening boundary walls was explicitly understood in terms of benefits and challenges in order to identify effective strategies towards increasing greenery in boundary wall facades.

1.2 Literature review

1.2.1 Multiple Options Of Green Walls As Green Infrastructure

The increase of green space can be materialized through different forms of green infrastructure. Tzoulas et al. (2007), after reviewing previous research on green infrastructure, identified eight options: green roofs; urban parks; green corridors; encapsulated countryside; derelict land; housing green space and domestic gardens; churchyards, cemeteries, and school grounds; open standing and running water. Focusing on green infrastructure at the household level, Tsantopoulos et al. (2018) identified the options such as green roofs, green walls, and green balconies. Historically, green walls, living walls, and green roofs have been used at the building level as passive techniques which adopt the natural cooling mechanism. While the green roofs have been actively promoted in many areas, adoption of the green walls is happening slowly (Jim, 2015). The potential of green walls or vertical green systems remains high in the context of space availability lesser plant requirements. However, this potential has not been fully exploited (Radić, et al., 2019).

A range of options is available for adopting green walls. A green wall may be constructed as a living wall or a green façade (Papadopoulou, 2013), which may not be fixed to a wall or building façade (Francis and Lorimer, 2011). Further, these can be varied according to the growing method, supporting structure, location, the material employed for construction and type of vegetation (Dunnett and Kingsbury, 2008). Jim (2015), based on his review of published materials and applications, has presented his classification based on three factors: growth form, training/ substrate system, and substrate. Based on the observations of existing green facades in Western Province, Sri Lanka, Madushanka et al., (2019), identified 12 configurations of green boundary walls which citizens successfully adopted.

1.2.2 Benefits of green walls and other green infrastructure as motivators for greening

A large mass of literature focusing on different green infrastructure options has been built over the last decades, highlighting multiple motivators behind introducing green to urban areas. People install green infrastructure to receive various benefits. Akreim and Suzer (2018), reviewed 32 studies and identified 26 factors that motivate green buildings. They have classified these factors into environmental, economic, and social motivators. Sheweka and Magdy, (2011) also, classified benefits of living walls into the same three categories. Radić et al. (2019), who reviewed the benefits, identified thermal performance, air pollution, noise pollution, hydrological, social, visual, educational, habitat, and economic benefits. These can also be categorized as environmental, social, and economic benefits. The benefits of green walls and other green infrastructure are thus discussed below by classifying them into environmental, economic, social, personal, aesthetic, and psychological benefits. In the absence of much research on green boundary walls, the benefits arising from green walls and other green infrastructure are reported here.

Peck et al. (1999) have comprehensively reviewed a series of qualitative and quantitative studies on green roofs and green walls to identify a range of benefits. As reviewed by those authors, the environmental benefits of green walls included improved air quality, climate change mitigation, temperature regulation, insulation of buildings, moderation of urban heat island effect, CO_2 and O_2 exchange, stormwater exchange, water filtration, and sound insulation. Oberndorfer et al. (2007) and Teotónio et al., (2021) also suggested other benefits, including increasing biodiversity, noise reduction, and mitigating the urban heat island effect. The environmental benefits through green spaces Mitigation of climate change by sequestering, carbon emissions

and reduction in air pollution are benefits of urban greening (Ramaiah and Avtar, 2019).

Green plants reduce air pollution by taking up gaseous pollutants through leaf stomata and convert to acids and other chemicals (Dennis et al., 1987). Green walls can improve air quality by controlling air movement and especially the movement of dust and dirt particles (Peck et al., 1999). Greenery plays a significant role in maintaining atmospheric carbon dioxide balance by absorbing carbon dioxide for photosynthesis and releasing oxygen. Thermal comfort by greenery results from the evapotranspiration cooling and shading effect of green plants. Plants absorb water from roots, and a large portion of them again is released into the atmosphere as vapours. This process absorbs surrounding heat energy resulting in cooler conditions (Shashua-Bar, et al., 2011; Gates, 1968). An experimental study done in Colomobo, found that *Sansevieria trifasciata* has a temperature reduction potential of up to 2.3ºC (Jayasundara et al., 2017). A technical review using literature and case studies conducted to build a greener London has highlighted that green roofs can bring some improvements. These include the thermal performance of buildings, reducing the urban heat island effect, absorbing rainfall, enhancing biodiversity, providing residents' amenities, and improving the appearance (Greater London Authority, 2008). Green walls have a sound-absorbing impact (Azkorra et al., 2015). Veisten et al., (2012) estimated that a green wall with a height of 9.2 m could reduce the noise level by 4.1 dB.

Green infrastructure and green walls can bring economic benefits by increasing property values, reducing energy requirements in the associated building while becoming a food source, as presented following literature. Economic benefits include increased property value due to aesthetic quality (Peck et al., 1999). Energy savings for winter heating and summer cooling and the increase of durability of building facades can be considered personal economic benefits (Rosasco, 2018). Vertical green layers can enhance building performance creating an air layer between the building envelope and green layer (Perini et al., 2011) and reducing the 50% of energy requirement for air conditioning in the Mediterranean climate (Mazzali et al., 2012). The green wall concept can be used for urban agriculture to produce high-quality fruits and vegetables in a limited space available in urban areas (Papadopoulou, 2013). Since some of the intangible benefits of green infrastructures, such as those generated by biodiversity, don't have a formal market, researchers have attempted to evaluate those based on non-marketed valuation techniques (Collins et al., 2017). Gao and Asami (2007) have applied hedonic pricing to evaluate green walls, and they have found that an increase in greenery would increase land price 1.4% in Tokyo 2.7% in Kitakyushu of Japan.

Increase environmental quality by reducing greenhouse gases, heat island phenomena reduction, better air quality due to abatement of pollution indoor and outdoor comfort improvement and increase of biodiversity will result from green walls. These would be social benefits since the beneficiaries are humans in society (Rosasco, 2018).

The psychological and aesthetic benefits of urban greenery have been extensively studied by researchers in environmental psychology, especially in the 20th century. White and Gatersleben (2011) have summarized the key trends associated with urban greenery. They suggested that those areas with vegetation and nature are perceived as more positive than those without. Further, they highlighted that natural and vegetated regions have higher preferences than built areas. At the same time, they are perceived as more aesthetically beautiful and evoke more positive emotions while having more restorative effects. Green roofs improve visual and aesthetic appearance in urban areas (Fernandez-Cañero et al., 2013). Buildings vegetated with certain types of vegetations appeared to be aesthetically pleasing and restorative than those without vegetation (White and Gatersleben, 2011). However, the authors also presented another argument that some of the generalizations from landscape research may have validity issues when applied to natural residential settings where the resident perception may vary if their houses vary from a standard house. A study done in Germany on people perception about roadside greenery revealed the presence of positive perceptions related to "Plants are important for the quality of life", "nature in the city", "it lifts the spirit", "aesthetic value", "wellbeing" and without plants everything grey and ugly. Roadside greeneries enhance the bonds with nature (Weber et al., 2014). According to Tsantopoulos et al. (2018), for people in Athens in Greece, the most important benefit from constructing green infrastructure is the improvement of aesthetic properties and improvement of quality of life of tenants.

1.2.3 Challenges And Demotivators For Green Walls And Other Green Infrastructure

Challenges faced in installing and maintaining green infrastructure may keep the residents from adopting such. As detailed in the studies presented below, these problems include lack of knowledge related to installation, possible plant species, and maintenance is the main challenge. Costs at various stages, issues such as insects and diseases, or the time commitments for installation and maintenance are among others. Limited knowledge of officials and developers responsible for city planning, barrier issues in cost and unfamiliarity, and lack of incentives cause to limit the vertical greening systems in Texas (House, 2009). Past failures, the absence of design guidelines, and limited local expertise on the green roof are the main obstacles in implementing the vertical greening system (Zahir et al., 2014). A study in Cairo, Egypt, revealed that people who preferred vertical green infrastructures were more familiar with the system. The study showed that people's main concerns are maintenance, insects, installation cost, and irrigation. They are also concerned about the lack of technical understanding on plant selection and orientation, soil stabilization, impact on building envelope while worrying about maintenance problems such as falling of leaves. According to (Koraim and Elkhateeb, 2017) prior knowledge can affect on residents' concerns related to greenery.
A study by Papadopoulou, (2013) reveals people consider construction and maintenance cost, lack of knowledge, problems with irrigation, mould and moisture problems, damage to the wall, salt accumulation, attraction of insects, and excessive pollen as challenges for greenwalls.

1.2.4 Interventions And Incentives To Encourage Green Walls And Other Green Infrastructure

Different forms of interventions such as providing subsidies, can increase green infrastructure. Government interventions and

incentives as well as contributions in the form of money, tax reductions support for installations, may encourage more green infrastructure as described in the studies below.

A study in Germany revealed that most people believed roadside greeneries are planted either by municipal action or by private initiatives, which indicates the need for interventions at the municipal level or as private initiatives (Weber et al., 2014). Amsterdam, Netherlands, and Shanghai, China are two examples. Residents of Amsterdam can apply for a subsidy of 50 €/m² up to a maximum of 50% of the total installation costs. A maximum of 20,000€ assistance were to be awarded for each project. The Shanghai Municipal Afforestation and City Appearance and Environmental Sanitation Administration has introduced a subsidy for the total green area of their city (Papadopoulou, 2013).

The studies mentioned above on green infrastructure provide evidence on how the residents perceive benefits and challenges. It is necessary to consider citizens' views and attitudes when planning cities integrated with vertical greenery systems through urban planning strategies (Tsantopoulos et al., 2018; Jim and Chen, 2006). In the absence of a comprehensive study on resident perception on green facades of Colombo, this study aims to explore views of people about roadside green facades. It includes benefits arising from the roadside green facades, challenges people to face when and after installation. Further, to support greening initiatives, effective and applicable strategies in Sri Lanka would be proposed based on the perceptions identified in the study.

2. Methodology

2.1 Study Area

Colombo district is the commercial capital and most densely populated district of Sri Lanka. Several high dense residential areas within the district were selected to carry out this study which included Rathmalana, Dehiwala, Mt. lavinia, Kesbawa, Piliyandala, Maharagama, Moratuwa, Malabe, Kaduwela, Kotte and Homagama. Data collection was done by using a structured questionnaire (Balram and Dragićević, 2005). Using a random sampling approach, research data was collected through a google form. Three hundred twenty-eight (328) questionnaires were collected from participants of the areas mentioned above of the Colombo district.

Questions related to socio-economic characteristics and whether they have a green wall, perceived cost and time to construct and maintain green walls, were raised in Section A. In Section B, the public perception on greening the boundary walls was evaluated along with two facets, namely perceptions towards benefits of green walls and challenges of adopting green walls. A set of representative variables was first identified for each of these facets based on a pilot study conducted using a qualitative approach. This set was further enriched with relevant variables identified from the above literature review especially based on the study of Tsantopoulos et al. (2018). The variables were presented to the participants in the form of Likert scale-based statements, and the participants rated each statement for the degree of agreement. As an example, data for benefits arising from the construction of a green boundary wall was obtained by getting them to evaluate the benefit variables on a 5-point Likert scale of 1 (do not agree as a benefit) to 5 (strongly agree as a benefit).

2.2 Data Analysis Approach

Data of Section A on socio-economic factors, perceived cost and time requirements and presence of green boundary wall were analyzed using descriptive statistics. The representative variables for both benefits and challenges were first analyzed using descriptive statistics to identify trends of resident perception for green boundary walls. Two distinct factor analyses were conducted to find out underlying factors which represent the relationships among benefits and challenges. K modes clustering method was used to identify different clusters within the sample based on perceived challenges for adopting green walls. All analyses were carried out in R statistical software package.

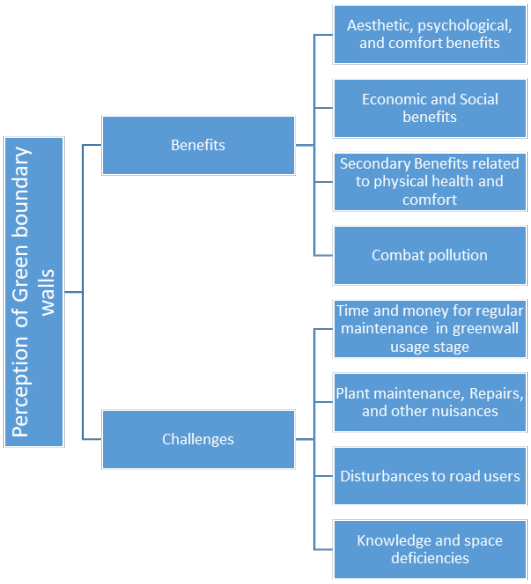

Figure 1 Underlying factors for benefits and challenges of public perception towards green boundary walls

3 Results and Discussion

3.1 Sample demographic characteristics and presence of green boundary wall

The study sample consisted of 328 participants, 51% males and 49% females. Care was taken to have participants representing different age groups, income levels and education levels. Only 15% of the participants of this study had a green boundary wall in their houses.

3.2 Benefits from green boundary walls

The percentage of people agreeing on the benefits is nearly 90% for most benefit variables (Table 1). All the variables had their mean values above 3.50, while many exceeded 4.00. With Likert scale value 3 indicating the neutral opinion, these values indicated participants agreed to the benefits of green walls.

Among the benefits, a higher level of agreement was observed for, "Seeing green make me relaxed" (4.58), "Improve the aesthetic of property" (4.49), "I can feel close to nature" (4.47), "Improve the air quality/purifies air" (4.46), "Growing plants is good for health" (4.41), and "Improves thermal comfort" (4.40). All the first 11 variables had a mean score above 4 and proved that participants strongly agree with the multiple benefits of façade greening. The remaining ten variables still showed mean values greater than 3.50, indicating participant agreement for those. The least values of these were "Safeguard wall against weather" (3.60), "Reduction of energy requirement" (3.59), "Sources of food" (3.58) which were related to material benefits.

The factor analysis revealed four important factors that explain 60.79% of the total variance (a-Cronbach=0.925; Keiser-Meyer-Olkin = 0.923; χ^2 =3239.978; df=210; $p<0.001$). As detailed in Table 2, four major factors were identified as deterministic factors for benefits. The first factor was named as "aesthetic, psychological, and comfort benefits". This had a higher loading from variables, I can feel close to nature; seeing green make me relaxed; Improve the air quality/ Purifies air; Growing plants is good for health; Effective use of available limited space; Enhance the image of the area; hiding artificial elements; improve the aesthetic of property and improve thermal comfort.

Table 1 . Level of the agreement for the perceived benefits arising from green boundary walls

		Percentage of participants expressing different opinions		
	Mean	Agree	Neutral	Disagree
Seeing green make me relaxed	4.49	92	4	4
Improve the aesthetic of property	4.48	93	4	3
I can feel close to nature	4.46	92	5	3
Improve the air quality / Purifies air	4.45	92	5	3
Growing plants is good for health	4.42	90	7	3
Improve thermal comfort	4.39	91	5	4
Effective use of available limited space	4.39	92	6	2
Biodiversity enhancement	4.26	88	7	4
Enhance the image of the area	4.22	84	12	5
Hiding artificial elements	4.19	87	8	5
Improve the microclimate	4.11	83	11	6
Reduction of dust and vehicle smoke	4.10	82	9	9
Creation of shade	4.02	77	13	10
Improve the quality of life of tenants	3.89	71	19	10
Help me to be physically active	3.8	68	22	10
Increase the property value	3.69	62	26	12
Creation of a setting to have a social interactions	3.62	57	30	12
Reduction of energy requirement	3.58	58	27	15
Safeguard wall against weather	3.58	60	24	16
Reduction of noise pollution	3.57	57	28	15
Source of food	3.57	57	31	13

Table 2. Rotated component matrix for value variables related to benefits

	Factor			
	Aesthetic, psychological, comfort, benefits	Economic and social benefits	Secondary Benefits related to physical health and comfort	Combat pollution
I can feel close to nature	0.816			
Seeing green make me relaxed	0.809			
Improve the air quality / Purifies air	0.772			
Growing plants is good for health	0.710			
Effective use of available limited space	0.697			
Enhance the image of the area	0.687			
Hiding artificial elements	0.655			
Improve the aesthetics of the property	0.628			
Improve thermal comfort	0.564			
Improve the quality of life of tenants		0.781		
Increase the property value		0.685		
Reduction of energy requirement		0.596		
Creation of a setting to have social interactions		0.580		
Source of food			0.788	
Safeguard wall against weather			0.616	
Creation of shade			0.561	
Help me to be physically active			0.532	
Reduction of noise pollution				0.833
Reduction of dust and vehicle smoke				0.713
Percentage of variance explained by the component	26.6	13.2	10	9.8
Cumulative percentage explained by the component	26.6	39.8	49.8	59.6

The second identified factor was "Economic and social benefits". This was loaded from the variables Improve the quality of life of tenants; Increase the property value; Reduction of energy requirement and Creation of settings to have social interactions. The third factor was "Secondary Benefits related to physical health and comfort". It was loaded by the variables Sources of food; Safeguard wall against the weather; Creation of shade and Help me to be physically active. The fourth factor is named "Combat pollution" with the higher loading of variables "Reduction of noise pollution" and "Reduction of dust and vehicle smoke". Consistent observations can be done for outcomes of factor analysis, whereby the first factor related to Aesthetic and Psychological benefits explained higher variance than the fourth factor on combatting pollution.

Similar observations have been made by Tsantopoulos et al. (2018), in a study on green infrastructure in Greece. Accordingly, people have recognized aesthetic value, improvement of tenants' quality of life, and leisure areas as significant benefits of green roofs. On the other hand, interest in financial investment, suitable space for environmental education increase the building value, and biodiversity enhancement were perceived as less important (Tsantopoulos et al., 2018). De Silva et al., (2021), who studied six vegetated building facades in Colombo and their Contribution to Environmental Sustainability concluded that such green walls have achieved aesthetic aspects and provided psychological benefit.

Irrespective of higher appreciation levels of benefits of green walls, the aforementioned statistics on green wall presence in Colombo (15%), indicates the presence of some other factors which inhibits people from adopting green walls. Therefore, challenges associated with the creation and maintenance of green walls may lead to lower levels of green wall adaption was studied next.

3.3 Challenges For Installation And Maintenance Of Green Boundary Walls

According to the results on perceived challenges shown in Table 3, the agreement levels reveal that except for a few challenge variables, the participants' perceptions of challenges varied across the sample.

As per the results on agreement levels, most participants perceived Initial cost as a challenge to have a green wall. The variables which had higher agreement levels across the sample were "Lack of knowledge about construction and planting methods" (3.73), "Lack of knowledge about suitable plants" (mean 3.69), "Requires time for maintenance/pruning/shaping" (3.62), "Requires money and time for maintenance" (3.53). These variables in total, describe challenges related to knowledge gaps for construction and time and monetary demands for maintenance.

People may be receptive to advise on construction and maintenance and to receive monetary or material subsidies such as plants. The Residents of Amsterdam, Netherlands, has been provided with the incentives of receiving subsidies for initial construction (Papadopoulou, 2013), which shows their desire to receive direct financial support. Interventions in indirect support such as property tax reduction are less familiar instruments in Sri Lanka where direct interventions such as plants and fertilizer. However, indirect support such as property tax reduction is less familiar in Sri Lanka and may not be effective since the property tax for houses remains at significantly lower levels.

Table 4 gives the results of the Factor analysis for challenges. The Factor Analysis with Varimax rotation of factorial axis to variables related to challenges revealed four important factors giving an approximately equal contribution to explaining a total variance of 53.79%. (a-Cronbach=0.863; Kaiser-Meyer-Olkin = 0.816.; χ^2 =2495.754; df=210; $p<0.001$).

The first factor identified was "Demand for time and money for regular maintenance in green wall usage stage". It was loaded from the variables, require money for agrochemicals and fertilizer; Requires money and time for maintenance; Requires time for application of agrochemicals and fertilizer, and Requires time for maintenance/pruning/shaping. "Fear of nuisances to the owner" was identified as the second factor which had higher loading from Damages to the wall; Problems with regular replanting; The presence of insects; Blocks daylights; Limitations by powerlines and require frequent watering. The third identified factor was "Disturbances to road users" which was loaded from variables Disturbance to pedestrians; Disturbance to the road; Disturbance by fallen leaves and another part. "Knowledge and space deficiencies" was identified as the fourth factor. It was loaded through variables Lack of knowledge about suitable plants; Lack of knowledge about construction and planting methods, and Limited space for planting. The underlying components behind the perceived benefits and challenges towards installing green boundary walls are summarized in Figure 1.

Stakeholders for green roof establishment have identified four types of barriers: Lack of knowledge and awareness, Lack of incentives for implementation, cost-based barriers, and technical issues and risks associated with uncertainty (Peck et al., 1999). Tian et al., (2012) have identified a shortage of knowledge, Lack of interest shown by public entities, and ineffectual institution and legacy of the government as challenges for making Hong Kong greener. The present study also showed similar results on perceived challenges. Thus, irrespective of the type of green infrastructure, challenges related to knowledge gaps and technical issues are common for establishing urban greenery.

Table 3: Level of the agreement for the perceived challenges arising from green boundary walls

		Percentage of participants expressing different opinions		
	Mean	Agree	Neutral	Disagree
Lack of knowledge about construction and planting methods	3.72	70	16	14
Lack of knowledge about suitable plants	3.69	68	18	14
Requires time for maintenance/pruning/shaping	3.65	67	19	14
Requires money and time for maintenance	3.54	62	23	15
Requires money for agrochemicals and fertilizer	3.5	60	23	17
Requires time for application of agrochemicals and fertilizer	3.44	56	25	19
Presence of insects	3.44	57	22	21
Initial cost (only for greening an already constructed wall)	3.41	53	30	18
Require regular watering	3.28	51	25	24
No time for making a green wall	3.26	50	24	27
Limited space for planting	3.23	48	24	28
Damages to the wall	3.19	44	28	28
Problems with regular replanting	3.13	42	29	29
Hiding place for intruders	2.99	34	33	33
Disturbance by fallen leaves and other parts	2.96	37	25	37
Limitations by powerlines	2.93	34	33	34
Damages to the pipes	2.77	27	32	41
Blocks daylights	2.64	23	29	48
Disturbance to the pedestrians	2.52	22	24	54
Disturbance to the road	2.43	18	26	57
Looks ugly	1.87	10	13	77

Table 4. Rotated component matrix for Challenges for green boundary walls

	Component			
	Time and money for regular maintenance in green wall usage stage	Plant maintenance, Repairs, and other nuisances	Disturbances to road users	Knowledge and space deficiencies
Requires money for agrochemicals and fertilizer	0.898			
Requires money and time for maintenance	0.862			
Requires time for application of agrochemicals and fertilizer	0.853			
Requires time for maintenance/pruning/shaping	0.566			
A hiding place for intruders				
No time for making a green wall				
Damages to the wall		0.643		
Problems with regular replanting		0.631		
Presence of insects		0.628		
Blocks daylights		0.620		
Limitations by powerlines		0.610		
Require regular watering		0.596		
Damages to the pipes				
Disturbance to the pedestrians			0.867	
Disturbance to the road			0.855	
Looks ugly			0.655	
Disturbance by fallen leaves and other parts			0.459	
Lack of knowledge about suitable plants				0.848
Lack of knowledge about construction and planting methods				0.823
Limited space for planting				0.549
Initial cost (only for greening an already constructed wall)				
Percentage of variance explained by component	15.8	13.4	13.2	11.2
Cumulative percentage explained by component	15.8	29.2	42.4	53.6

Table 5 : Cluster modes identified with K-modes clustering

	Cluster		
	1	2	3
Cluster size	29%	38%	33%
Initial cost (only for greening an already constructed wall)	4	4	3
Lack of knowledge about suitable plants	4	4	4
Lack of knowledge about construction and planting methods	4	4	4
Limited space for planting	4	4	3
No time for making a green wall	4	4	3
Requires time for maintenance/pruning/shaping	4	4	3
Requires time for application of agrochemicals and fertilizer	4	4	3
Requires money for agrochemicals and fertilizer	4	4	3
Requires money and time for maintenance	4	4	3
Hiding place for intruders	2	4	3
Disturbance to the road	2	3	1
Disturbance to the pedestrians	2	3	1
Disturbance by fallen leaves and other parts	2	4	3
Presence of insects	2	4	4
Looks ugly	1	1	1
Problems with regular replanting	2	4	3
Damages to the pipes	2	4	3
Damages to the wall	2	4	3
Require regular watering	2	4	3
Blocks daylights	2	4	3
Limitations by powerlines	2	4	3
Note: Cell values denote the mode value of the perceived challenge			

Table 6. Perceived money and time required for construction and maintenance of green wall among participants of different clusters

Challenge cluster		The perceived initial cost for construction of a green wall (LKR)	Perceived monthly maintenance cost of a green wall (LKR)	Perceived time required for construction of a green wall (Hours)	Perceived time required for maintenance of a green wall (Hours per month)	Greenwell ownership within the cluster	Size of cluster
1	Mean	36902	3361	25	24	22%	29%
2	Mean	37323	2727	39	16	10%	38%
3	Mean	50825	2468	25	19	12%	33%
1	Minimum	2000	500	1	1		
2	Minimum	2000	50	1	1		
3	Minimum	2000	100	1	2		
1	Maximum	300000	50000	365	200		
2	Maximum	500000	10000	1000	90		
3	Maximum	500000	12000	240	192		
	Estimated cost *	37000	1630				
*Cost estimated (using standard rates) for cost associated with green wall (for a 6m long 2m high wall with climber support fence)							

In the presence of variations in agreement levels of perceived challenges, the possible existence of distinct user groups within the sample was explored through cluster analysis. Three distinct clusters were identified, and their perception profile can be understood in Table 5. Accordingly, people belonging to Cluster 1 placed a higher emphasis on the challenges related to Lack of time, money and knowledge. However, they neither perceived green walls as a nuisance for themselves and road users nor worried about the potential of property damages due to green walls. This cluster is nearly 29% of the sample.

People of Cluster 2 also identified Lack of time, money and knowledge as the challenges. In addition to those, they perceived green walls might damage the property or become a nuisance within their property. Further, they are neutral about the possible disturbances to the other road users. Except for Lack of knowledge about green wall constructions and plants, members of Cluster 3 take many challenges as neutral. People of cluster 3 appears to be passive/ or unconcerned about having a green wall.

Table 6 details the perceived money and time required for constructing and maintaining green walls among participants of different clusters. Further, an estimation of the cost of construction and maintaining a typical green wall was done for comparison purposes. In terms of the initial cost of construction of a green wall, members of Clusters 1 and 2 have mean values closer to each and the estimated cost value. However, members of cluster 3 perceived this need of higher investment in comparison to other clusters and the estimated cost. All three clusters have a perceived maintenance cost that is higher than the estimated maintenance cost. Further, the perceived time for maintenance for all clusters remains in the range of 30 to 45 minutes per day.

The percentage of members of cluster 1 owning a green wall was 22%, which is a notably higher value compared to the other two clusters.

3.4 Strategic Implications Of The Study To Promote Green Boundary Walls

Based on the findings of this study, the following strategies focusing on the public can be recommended to increase green facades in Colombo and similar areas.

- Knowledge on construction methods of green walls and planting such as different optional configurations should be easily available for residents who are considering incorporating façade greenery. Further, the details about the method and cost of construction and sample drawings would be helpful to install such configurations. Also making ready-made/ easy to install options available either directly or through landscape service providers may also be effective.
- Effort and money spent on maintenance may be holding people back from greening the boundary walls. Enhanced knowledge and technology on easy maintenance methods, especially for automating the plant nutrient and water level monitoring and delivery, and market availability of such devices can be proposed to overcome challenges related to maintenance.
- The residents should be educated with knowledge on how to plant and maintain a green façade what kind of fertilizers should be applied at which intervals. An online database providing the above information for potential species could be proposed.
- Subsidies for agriculture has been effective in Sri Lanka. Similarly, subsidies in the form of money, plants and fertilizer could be provided to those who adopt green walls.
- Local authorities can adopt options such as the provision of support to construct walls. Also, free or discounted distribution plants, fertilizers and agrochemicals can be recommended. Financial subsidies may also be effective, and the data on estimated costs can be referred to in deciding the values of such subsidies.
- Further interventions such as pilot programs can be introduced at local authority level with the support of volunteers youth groups. Such programs could be structured based on an understanding of the three user group clusters identified above.

Members of cluster 1 should be the first group to be motivated through a pilot program and the focus of such a program could be to improve the knowledge on practical implementation.

Those of cluster 2 have perceived additional challenges in terms of misconceptions on property damages and maintenance requirements in addition to the challenges perceived by cluster 1 members. Thus the interventions for this cluster should additionally focus on improving the awareness on above-mentioned misconceptions. Sharing the experience of green wall owners using multiple means could be effective in this regard.

Members of clusters 1 and 2 in total amount to 67% of the sample and the above measures would be able to motivate a substantial majority.

While the outcomes of the study directly apply to Colombo, other developing countries in the South Asian region with the same tropical climate may be able to use this knowledge to improve their urban greenery through boundary wall greening.

4 Conclusions

Proper understanding of public opinion is vital to encourage urban greening through green walls. Such knowledge will pave the way for better decision-making by policymakers, urban planners, and related business owners leading to more effective outcomes from greening for Colombo and similar places.

The present study showed only a marginal number of residents (15%) already have green in their boundary walls. These findings indicate a significant opportunity for greening within the remaining population. The outcomes revealed that residents place a higher value on intangible benefits such as aesthetic appearance, feeling relaxed and less weight on tangible benefits such as the source of food or energy savings.

Participants perceived Lack of knowledge of construction and planting methods of green walls as challenges. They also perceived the time and money spent on maintenance as a challenge. Three distinct clusters can be identified based on the

way of perceiving challenges. Support to overcome challenges such as Lack of knowledge and time and money requirement may effectively move the members of first cluster to adopt greenery in their boundary walls. Experience sharing sessions can be recommended to encourage members of the second cluster along with support measures provided to first cluster members. Members of the third cluster are passive over adopting green walls, hence, motivating them towards green wall adoption will be more challenging. The strategies applicable to promote green walls are proposed based on the study results.

Acknowledgements

This research was funded by the university research grant number ASP/01/RE/ENG/2017/44 from the University of Sri Jayewardenepura, Sri Lanka.

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