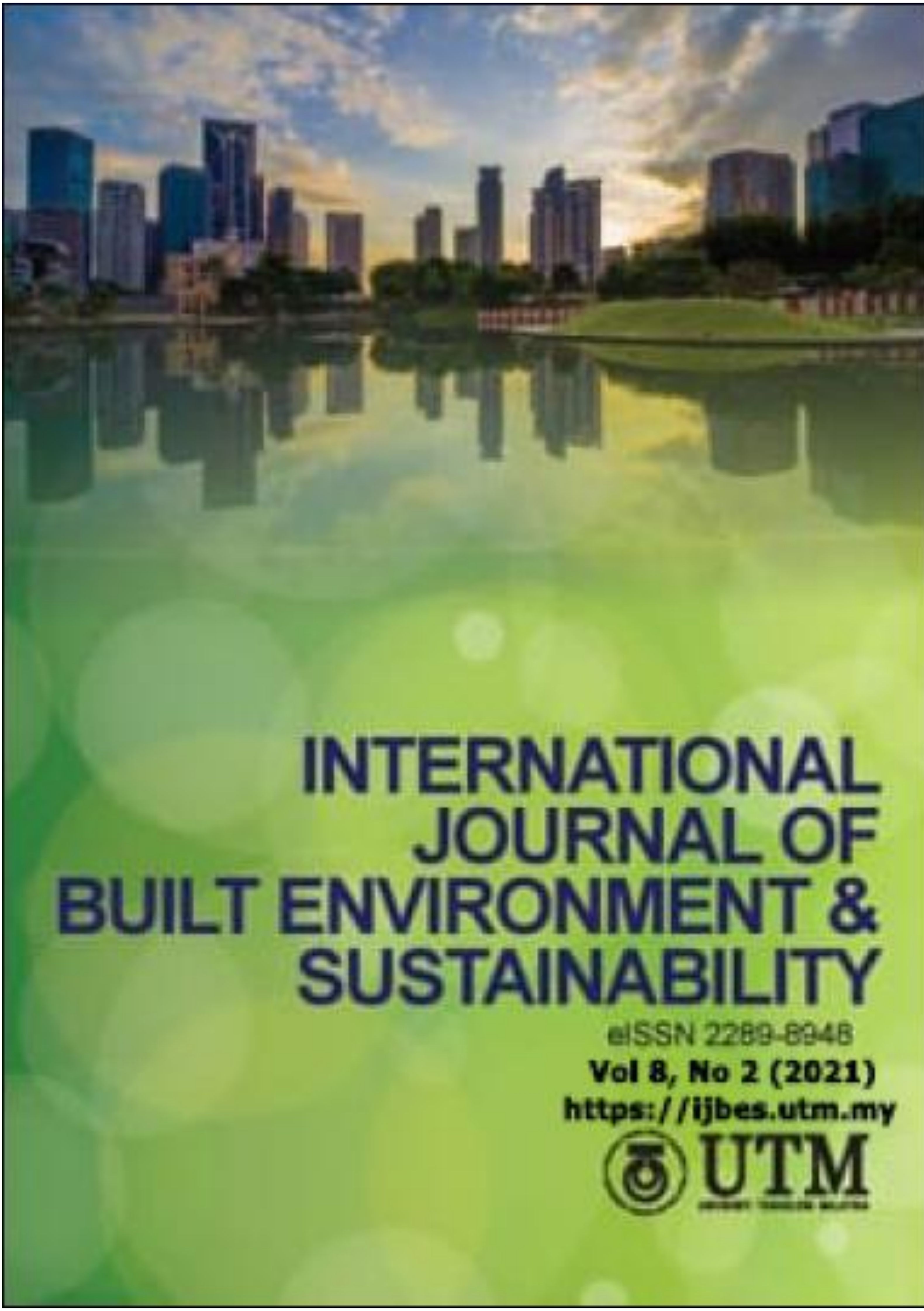
INTERNATIONAL
JOURNAL OF
BUILT ENVIRONMENT &
SUSTAINABILITY
eISSN 2289-8948
Vol 8, No 2 (2021)
https://ijbes.utm.my
UTM

IJBES
International Journal of Built Environment and Sustainability

Mail Address:
International Journal of Built Environment and Sustainability
Faculty of Built Environment and Surveying
Universiti Teknologi Malaysia
81310, Johor Bahru, Malaysia
Telephone: +60-7-5537382
Email: ijbes@utm.my

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

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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

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Vol. 8, No. 2, 2021

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IJBES

International Journal of Built Environment and Sustainability
Published by Penerbit UTM Press, Universiti Teknologi Malaysia
IJBES 8(2)/2021, 1-9

Identifying the Influential Factors Enriching the Experiences of Visitors of Touristic Religious Sites: The Case Study of Al-Khandaq Battle Site

Mohamed Saleh Amer
Urban and Regional Planning Program, Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia 81310 UTM Johor Bahru, Johor

Abdullah Saeed Karban and Abdulrahman Abdulaziz Majrashi
Department of Islamic Architecture, College of Engineering and Islamic Architecture, Umm Al Qura, Mecca

Mohammad Rafee Majid and Abba Saleh
Urban and Regional Planning Program, Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia 81310 UTM Johor Bahru, Johor

ABSTRACT

Enriching visitors' experiences at religious, historical sites (RHS) is getting more attention than before. This research aims to identify and investigate the influential factors enriching the visitors' experience at such a site, using Al-Khandaq battle site as the case study. Forty-two respondents were interviewed at the site and NVivo 12 pro software was used to code and analyze the responses. The study explored tourist motivations, expectations, and perceptions as the guiding constructs in detailed qualitative analysis. Foremost, learning, reliving the experience of the events of the battle, and Islamic values were the primary motivation to the historic site visitation. Next, findings reveal the extent to which tourists' expectations can be met through the availability of an open museum, accessibility, and the spatial and experiential simulation of the ancient Al-Khandaq path. Lastly, the need to reconstruct the historical site in spatial planning and experiential dimensions formed the main thrust of the element of visitors' perception. Based on the foregoing, the study recommends that Al-Khandaq site should be developed traditionally as an open museum, displaying both religious and historical elements of the battle with emphasis on the visual connection to the Prophet's mosque.

Article History

Received : *12 September 2020*
Received in revised form : *17 March 2021*
Accepted : *18 March 2021*
Published Online : *30 April 2021*

Keywords:

Visitors Experiences; Religious Historical Sites; Al-Khandaq Battle; Tourists Perception; Tourist Motivation Values

Corresponding Author Contact:

Saleh1983@graduate.utm.my

DOI: 10.11113/ijbes.v8.n2.703

1. Introduction

Travel is essential for economic, social, and religious activities and tourism resulting from travel plays a significant role in countries' prosperity (Baggio, 2008; Frias *et al.*, 2015). Many countries aim to support their economies by enriching tourists' experiences to attract more visitors and repeats from satisfied visitors. Enriching the tourist experience is positively related to improving tourist satisfaction and revisit intentions (Chen *et al.*, 2020; Al-Ghamdi *et al.*, 2021)**.** Tourism also integrates a wide range of stakeholders (Costa & Baggio, 2009; Frias *et al.*, 2015)**.** Budeanu (2007) and Moscardo & Murphy (2014) suggest that tourism is a product that aims to fulfill tourist needs; therefore, it has been studied from providers and consumers (tourists) point of view.

In this regard, enriching the tourist experience will benefit all stakeholders. Identifying some basic concepts such as tourist destination, tourism product, and point of interest is essential. Tourist destinations are tourist attractions that refer to a set of economic, cultural, and social events complemented by a set of supported infrastructures (Cohen *et al.*, 2014). The complexity of tourism attraction can be reflected through a focus on the process of tourists' decisions. However, not enough research has been conducted on developing tourism attractions based on these decisions. Cohen *et al.* (2014) reviewed several studies about tourist behavior in the process of decision-making, and they suggest that tourists' decision process takes place independent of other consumption decisions. The tourists' decisions can only be elicited through less-structured methodologies involving narrative accounts of actions and activities (Zhang *et al*., 2020). Therefore, several have suggested conducting more studies on tourists' decisions.

Much of the tourism research appears to rest on the assumption that tourists' decisions are previously planned (Hyde & Lawson, 2003; Bargeman & Poel, 2006). As most existing research on tourists' decisions assume previously planned decisions, their decisions and their implications for enriching tourists' experiences are in urgent need of research. Therefore, this study investigates the influential factors on enriching visitor experiences of touristic religious sites.

The Kingdom of Saudi Arabia is blessed with many of the distinctive historical religious sites associated with events of the biography of the Prophet Mohamed (PBUH). However, many of these sites are not adequately included among the visiting places. For example, given the numerous positive contributions of Al-Khandaq battle as highlighted in both the religion and history of Islam, the site where the battle took place is however, not substantially captured in the list of the preferred sites by many.

This study's main objective is to identify the influential factors that enrich the tourists' experience at religious, historical sites by investigating tourists' motivations, expectations, and perceptions of Al-Khandaq battle site. The investigation of these factors helps identify the key issues influencing tourists' decisions to visit religious, historical sites in Saudi Arabia, particularly around Makkah and Madinah cities.

Many researchers investigated various factors that influence tourists' decisions, which in turn helps enrich their visiting experiences at war heritage sites (Alabau-Montoya & Ruiz-Molina, 2020) and touristic religious sites (Correia & Kozak, 2016; Hassani & Moghavvemi, 2019; Juhanda, 2019). Previous studies show that three dominant factors influencing tourists' decisions: motivations, expectations, and perceptions. This study reviews the definitional issues for each factor for the essential contemporary factors impacting tourists' experience.

Visitors Motivations

Motivation is an essential factor in marketing decisions and environmental developments. Therefore, academics, researchers, and developers give great attention to understanding visitors' motivation (Correia & Kozak, 2016; Giddy & Webb, 2018; McIntosh & Thyne, 2005; Paker & Vural, 2016). Motivation refers to an individual's psychological and biological needs that drive a person's behavior and activities (Cohen *et al.*, 2014; Eccles & Wigfield, 2002; Yawson *et al.*, 2009). Due to the importance of motivation, several studies have developed several theories or models to explain the concept of motivation (Cohen *et al*., 2014). For example, in 1997, Gnoth precisely differentiates between motives and motivations, where motives refer to the persons permeant activities, recurring on a cyclical basis (behaviorist approach), and motivations refer to preferences of a specific object (cognitivist approach) (Gnoth, 1997). In contrast, McCabe (2001) suggested that a visitor's motivation is characterized by a combination of behaviorist and cognitivist approaches (McCabe, 2001).

However, to date, there is no general agreement about the concept of motivation, and scholars still view the two concepts of motivation as one (Cohen et al., 2014). The push-pull is a simple and intuitive approach that is most commonly applied for explaining motivations to profile visitors (Said & Maryono, 2018). Visitors are pushed by their needs and pulled by destination characteristics (Battour *et al.*, 2017). This process is influenced by several factors such as involvement, perception, expectation, and emotion (Battour *et al.*, 2017; Pestana *et al.*, 2019; Said & Maryono, 2018). Most studies that discuss theories of visitors' motivations were either conceptual or limited in scope and sample size (Battour *et al*., 2017; Fernández-Morales *et al.*, 2016; Juhanda, 2019; McCabe, 2001; Said & Maryono, 2018). Researchers in tourism have also been adopting the motivation theories with four structural factors, including personal seeking, intrapersonal seeking, personal escape, and intrapersonal escape. These factors function as a salient intrinsic for tourism motivational behavior (Cohen *et al.*, 2014; Eccles & Wigfield, 2002; Lai, 2011).

However, the relationship between motivation and visitor's behavior, such as expectation and perception, has been conceptualized and validated (Cohen *et al.*, 2014). On the other hand, some studies focus on the formation of motivation, such as values, in order to understand what motivates visitors (Eccles & Wigfield, 2002; Karban *et al.*, 2017; Rosyada *et al.*, 2018). The relationships between motivation and values and affective constructs such as expectation and perception remain the cornerstone of developing tourism activities and locations (Zakariya *et al*., 2020).

Visitors Expectations

Understanding consumer and visitor expectations play a vital role in satisfying their desires (de Rojas & Camarero, 2008). Expectation refers to consumers' predictive needs and what consumers feel, wish or perceive to get from the provider (Cohen *et al.*, 2014; Pons *et al.*, 2016). In other words, the expectation is what the consumer wants to get. Also, consumer expectations represent the quality anticipated by customers when assessing service and product attributes (Allen, 2016; de Rojas & Camarero, 2008). Expectations can, therefore, be of different types, such as outcomes, predictive, ideal, and experience-based expectations (Cohen *et al*., 2014). All these types are somehow intertwined with each other and are widely applied in tourism. Therefore, the researchers will use some of them as an approach to understanding the visitors' expectations for the Al-Khandaq battle.

For instance, outcomes expectation refers to the estimation of outcomes when assessing a given behavior (Cohen *et al.*, 2014), while predictive expectations are the consumer's prediction about what they perceive to get based on their actions or behaviors (Thai, 2015; Zeithaml **et al.**, 1993). Thus, expectations may be fulfilled or unfulfilled or exceeded what is expected, influencing visitor satisfaction and enriches their experience. Therefore, the expectancy theory can be considered to positively enrich the visitor experience, which meets or exceeds visitors' expectations (Hassani & Moghavvemi, 2019; Lunenburg, 2011; Rahman, 2014).

Notable omissions in tourist literature is the investigation of the consistency of visitor expectations over time by analyzing the service, which is met and influenced by visitor demographics, which has also been discussed in this paper.

Visitors Perceptions

Perception refers to what consumers expect or imagine. It is usually shaped or generated by familiarity, experience, values, and motivations (Cohen *et al.*, 2014; Correia & Kozak, 2016; Kala, 2008). According to the perception theory taken from cognitive psychology, work on customer preferences attempts to examine cognitive elements in the perceptual phase, often at the cost of affective elements, without proper recognition of the interplay between cognitive and affective aspects (Bian & Moutinho, 2015; Dimanche & Havitz, 1995; Poor, 2014; Rahman, 2014).

Variances of perceptions contribute to differences in cognitive or behavioral motivational values; a core consequence for tourism is that beliefs such as motivation and actions are vital to creating tourist interest, the identity of destination and quality of service. Destination perception appears to be a significant area of study in perceptions-related tourism and customer behavior research (AlsInI *et al.*, 2019; Qurashi, 2018; Rahman, 2014; Stylidis *et al.*, 2014). In addition, the quality of perceived services is considered an essential factor in understanding visitor perception in tourism research (Cohen *et al.*, 2014).

Thus, the researchers can differentiate between visitors expected and perceived quality. Recently, several studies in heritage and religious tourism, perceptions research in tourism often focus on examining ethical, historical, and religious perceptions of visitors (Griffin & Raj, 2017; Juhanda, 2019; Raj & Bozonelos, 2015). For example, Alsini *et al.* (2019) concentrate on tourists' perceptions of religious tourism in Saudi Arabia. The impacts of Islamic life and beliefs, provided services, destination quality, and Religious tourist loyalty are factors that could exploit event attributes to form positive consumer perceptions (Alsini *et al.*, 2019).

However, various studies indicate that understanding and considering visitor perceptions would contribute to better social, political, environmental, technological, and service-related issues (Al-Ghamdi *et al.*, 2021; Cohen *et al.*, 2014)). Therefore, this research seeks to understand the perception of Al-Khandaq battle visitors to provide a proper environment and services that exceed their expectations.

Heritage and Religious Tourism

Heritage and religious tourism refer to tourism services or locations that provide historical, cultural, and heritage experiences that are mostly rooted in religious sources. The concern of studying religious heritage tourism stems from the importance of this type of tourism to provide visitors' needs and expectations and the importance of these visitors to the local economy. According to Chandler & Costello (2002), the importance of heritage tourism stems from the visitors' revenues to the local economy. Thus, visitors to historical sites are considered very important to the tourism and recreation industry (Chandler & Costello, 2002; Griffin & Raj, 2017), as these visitors to historical and religious sites tend to vary somewhat from visitors to new cities or nature (Li & McKercher, 2016; Sharpley, 2018).

Visitors of historical and religious sites are also more likely to participate in passive recreation activities such as worshipping, welfare practicing, sightseeing, learning, wildlife watching, and relaxing (Ahmed, 1992; Chandler & Costello, 2002; Mujtaba, 2016; Karban *et al.*, 2018) Juhanda, 2019). As Chandler & Costello (2002) reported, historic sites' visitors are mostly older people who tend to spend more money and are more likely to use different sources to gather information about trip planning and destination selection.

2. Methodology

2.1 Description of Study Area

The study area is Al-Madinah Al-Munawwarah, located in the Eastern Part of Al Hijaz Region in the northwestern part of Saudi Arabia at latitude 24.28 06°E and longitude 39.36 6°N. The city is about 150 km away from Yanbu city on the Red Sea coast to the west. The latter is the sea gate for the visitors of the city. Al-Madinah Al-Munawwarah is 400 km away from Jeddah, the main port, and 980 km away from Riyadh, the capital of the Kingdom (Figure 1). It is located in a hot tropical region and is influenced by the Mediterranean region in the north and the south's tropical season region. Madinah is surrounded mostly by mountains and its height above sea level is between (590-620 meters). The Medina area is about 589 square kilometers, of which 99 square kilometers are occupied by the urban area (Bob et al., 2016).

Al-Madinah Al-Munawwarah is considered the second most important Islamic city after Holy Makkah. Its importance is derived from the presence of the Prophet's Mosque; Al-Madinah is also one of the holy cities that non-Muslims are not allowed to visit. Al-Madinah occupies a natural hillside basin more than 600 meters above sea level. The city is surrounded by a group of volcanic mountains, except for its northern sides.

The Battle of Al-Khandaq is considered one of the most important events of the Prophet's biography, which embodies the most important meanings of patience and sacrifice. The site is filled with lessons and sermons; its events are glossy pages, which are passed on from generation to generation (Figure 1).

The victory in the hearts of Muslims is linked to the location in which it occurred. The trench area is one of the legitimate places to visit and features Al-Fateh Mosque, from which Prophet Mohammed, (PBUH) called for victory over various groups. Today, it is called the seven mosques area. One of the most critical landmarks, it contains a small group of mosques whose exact number is six, not seven; however, it is famous due to the addition of the Qiblatan Mosque within these mosques, because whoever visits it also visits that mosque on the same trip, bringing the total number to seven.

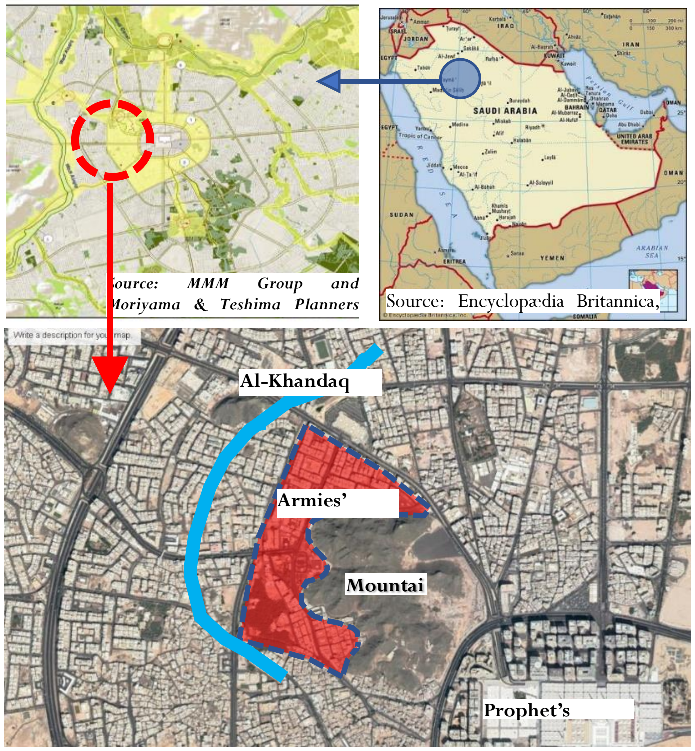


Figure 1 Location of Al-khandaq Battle in Saudi Arabia (Source: Google Earth December 2019)

2.2 Data Collection

People's motivations, experiences, and perceptions are the central core of this paper. In this regard, the researchers have conducted semi-structured interviews to get the visitors' perceptions. As argued by many (e.g., Cobbinah & Aboagye, 2017; Wehrmann, 2012), semi-structured interview conversations create an opportunity for researchers to examine the phenomenon under investigation in detail, thus presenting sufficient flexibility in addressing various dimensions of the research. Interviews involved 42 persons from several countries, including Saudi Arabia, Yamen, Egypt, Jordan, Nigeria, as well as Malaysia. The interviews were conducted by the five authors of this research from Egypt, Saudi Arabia, Malaysia and Nigeria. The interviews were collected during the fieldwork from 2nd to 22nd December 2019. They were guided by a list of open questions that focus on the perception about the site of the battle and the values that motivate them to visit Al-Khandaq site and what they expect to see if they will explore the site after the development. Participants were interviewed using the face-to-face approach, which clarifies the purpose and objectives of the research and galvanizes their interest and relevant responses. A checklist of questions guided the interviews. It also integrated some semi-structured interviews with investigating questions (Al Jarah et al., 2019).

A pilot study has been conducted from 18th to 28th November 2019. The authors of this research administered the interview to all participants, in which an initial semi-structured interview was carried out with ten people to gauge their understanding of the questions. The feedback was essential to develop the questions before the meetings with all participants was carried out. Two questions have been developed regarding the frequency of visiting the seven mosques site and Al-Khandaq battle area in order to investigate the reliability of the results. During the interviews, the answers and discussions were recorded in a notebook (Wahyudi, 2017).

2.3 Data Analysis

The interviews were conducted in Arabic and English languages. Thus, the obtained data were transcribed and documented according to the respondents. The interview conversations were analyzed using NVivo 12 pro software (NVivo qualitative data analysis software) to generate themes and categories and ensure that the interviews' findings reflected the respondents' perspectives. Efficacy and reliability were ensured by arranging and contrasting the results from all respondents. According to (Cobbinah & Aboagye, 2017), this process is useful in addressing gaps and inconsistencies that occur in the data analysis process.

3. Results and Discussion

Interviews involved 42 participants from six countries, namely Saudi Arabia, Yamen, Egypt, Jordan, Nigeria, as well as Malaysia. The respondents' ages ranged from 20 to 55 years old. The male represented 81% and the rest were female. Foremost, the study reveals that only 40% of respondents had visited the Al-Khandaq battle site before. Some of the respondents have misperceptions or incorrect information about the battle location. For example, when the researcher asked a respondent about the location of the battle, he said: "It is located far away from the prophet's (PBUH) Mosque, I mean out of the city boundary."

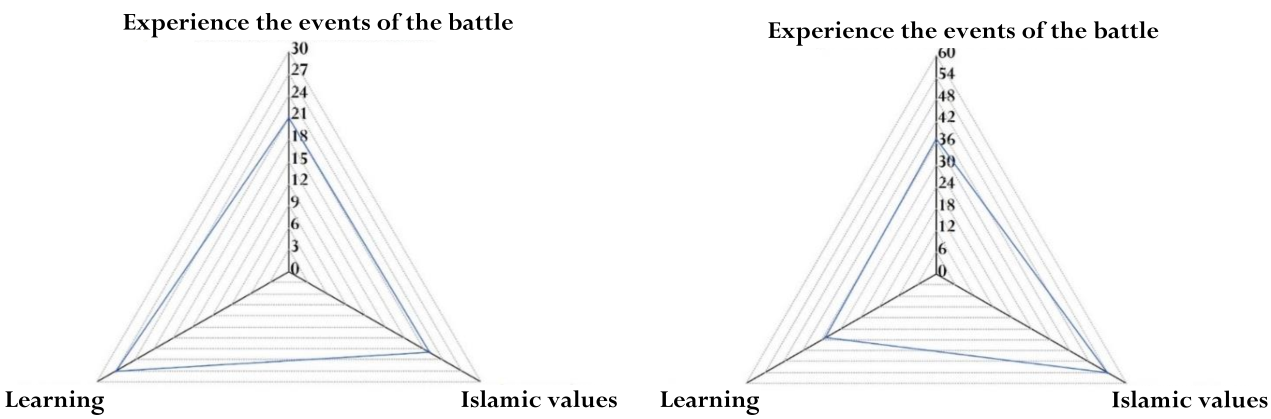
Some of the respondents who claimed they had visited Al Khandaq site could not identify the battle site, and some of them could not distinguish between Al-Khandaq and another battle named Uhud located in the north of Al-Haram.

On the other hand, 57% of the respondents stated that they had previously visited the Seven Mosques' site. This implies that several participants do not know the location of Al-Khandaq battle site, as well as the history of the Seven Mosques, which is located in the center of Al-Khandaq battle site.

The respondents refer to the three following reasons for their not visiting the site of Al-Khandaq battle: the lack of arranged tours to this place, the inadequacy of signages leading to this site, and outright ignorance of the location.

3.1 *The Motivation To Visit The Site*

In this part, the primary intent is to address the first objective, and to achieve that, the following research question was posed: "What motivates you to visit the battle site?". In view of this, (Figure 2-a) shows that a total of 70 codes were created from the answers. From the analysis of the coding reference in NVivo, 38.6% of respondents were of the view that learning purpose was the main reason behind the visit. For example, one of the interviewees reported that "learning through exploration is to move from fiction and stories to reality." A further 31.4% and 30% were of the view that experiencing the events of the battle, and Islamic values, respectively, were the main motivations to their visiting the site. On the other hand, using the words coded analysis tool, the Islamic values got the highest priority with 42.9%, followed by experiencing the events of the battle with 29.4%, and finally, learning purposes with 27.8% (see Figure 2-b).



(a) Results of coding references analysis **(b)** Results of words coded analysis

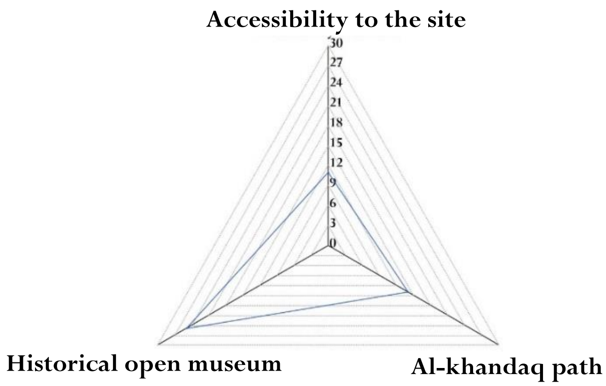
Figure 2 Visitors' motivations to visit the site

From the previous results, learning purpose code ranked first based on code references, whereas Islamic values got the highest level on word coded test, which means the interviewees gave much explanation on the importance of Islamic values. There is no conflict between the results from both tests, as people are concerned about visiting the site in order to acquire more knowledge in terms of Islamic perspectives. This is a significant finding in understanding what motivates people to visit Al-Khandaq battle site.

3.2 *Visitors Expectations*

This section tries to identify the expectation of the visitors to the site. The following question was designed, "What would you expect to see there?". Given this, Figure 3-a illustrates that a total of 50 codes were generated from the visitors' responses. Among them, 50% were expecting that the site would have contained a historical museum. One of the visitors pointed out that "I expect an open museum showing events of the foray, the tents of the polytheists' army, and the types of weapons have been used in the battle." A significant 28% expected the body of Al-Khandaq path, and the rest (22%) highlighted the accessibility to the site from the Prophet Mosque. Using words coded analysis has corroborated similar trends of the open historical museum, which scored 57.6% followed by the accessibility to the site with 27.1%, then Al-Khandaq path with the lowest rate of 15.2% (see Figure 3-b).

The historical open museum code has taken a significant proportion (i.e.50%) of the code words from the visitors' respondents. They suggest developing the site as an open-air museum reflecting the real actions of the battle flow as they studied in books. Even though the path of Al-Khandaq is considered a vital part of the museum, from the interviewees' point of view, they shed light on it and emphasized on the need for it to be reconstructed. Accessibility to the site is the third expectation of the visitors. Considering their answers, especially those who did not visit the site, they said they did not know that the site is nearby AL-haram, as no signage offered guidance to the site. It is worth noting that many of those who had visited the seven mosques did not realize that the location is the Al-Khandaq battle site. Besides, they had to walk through low-quality residential areas and cross some not walk-friendly roads to reach the site. The foregoing's lateral imports are that the primary desire to learn more about the battle's religious history can be achieved by transforming the site into an open museum.



(a) Results of coding references analysis

(b) Results of words coded analysis

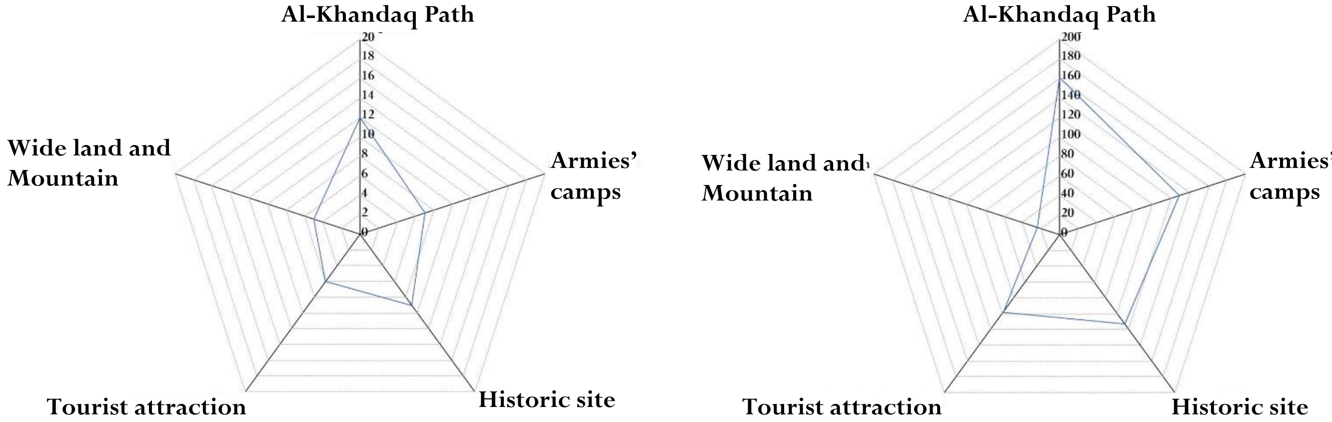
Figure 3 The visitors' expectation about the site

3.3 Visitors Perceptions

This part aims to understand the visitors' perceptions of the proper way to rehabilitate the site. The question was designed as thus: "What is your perception of the ideal way to develop the site?" The results from the analysis of the coding references show that (see Figure 4-a) most visitors thought Al-Khandaq Path needed to be dug up again. This factor scored 30.8% out of the total codes. One of the interviewees said: "I would like to see the body of the trench, as it is a crevice in the ground of great length and width that horses cannot easily cross." The next factor, which weighted 23.1%, is the historical site, as the visitors emphasized that the importance of the pattern of the site should be developed traditionally to reflect the spirit of the battle. Then, the Army Camps scored 17.9% of visitor interest, as they were keen to see the exact spots of the Muslims' tents as well as the non-Muslims' camp. The fourth factor is the tourist attractions, with 15.4%. The respondents mentioned the importance of tourist attractions services (e.g., souvenirs markets, hotels, and traditional cuisines)—lastly, the vast land and Mountain with 12.8%. The interviewees underlined the significance of paving the battleground and the role of the Mountain, which was used to shield the Muslim armies back.

There is some modification of the results noticed when using the words coded analysis. Figure 4-b displays that the Al-Khandaq path still has priority with 30.7%, whereas the army camps were the second element with 24.6%. Finally, 21.5%, 18.7, 4.6% were of the view that historical sites, tourist attractions, and vast land and Mountain, respectively, were significant.

The figure shows that the most significant components of the open museum consist of three main sections. The first one is the Al-Khandaq path, which should be developed as it used to be during the prophet era. Second, army camps for both Muslims and nun-Muslims follow a separate route to the tents. Third, the border of the battle site, including the Mountain situated on the opposite side of the Al-Khandaq path, played an essential role in the battle's Muslim army strategy. Next, the tourist attraction spots should be included as they are considered a vital component for attractive destinations. Finally, all these developments should have unique characteristics by involving the historical and traditional dimensions in planning and design levels.



(a) Results of coding references analysis

(b) Results of words coded analysis

Figure 4 The visitors' perception of the site development

4. Conclusion

Regarding the research aim and objective, which are to identify and investigate the influential factors enriching the tourists' experience at Religious Historical Sites (RHS), the findings and conclusions asserted that the visitors to the religious and historical places, specifically Al-Khandaq battle site, are motivated by three significant factors, which are learning purposes, Islamic values, and the need to experience the events of the battle. It was found that three significant factors enriched the Visitors' experience when they visited the RHS. Through their expectations, as the site witnessed many significant events since the earliest years of Islam, the site development plan should propose the elements reflecting the spirit of the place, utilizing the physical path of the Al-Khandaq, open museum with secure access to the site from the prophet's mosque. The visitors also acknowledge that the site has the potential to become an attractive tourist religious place in the Al-Madinah tourist attraction map. It is one of a kind, which has the characteristic of describing a critical period of Islamic history. According to the interviewees' perception, the battle site should be appropriately developed to reflect the experiences of preparing the battle and action during the battle and the implications of the outcome to enrich the visitors' experiences no matter where they come from and their languages. Building the actual body of Al-Khandaq alongside the camps of both the Muslims and non-Muslims considering the site boundary, which includes the Mountain behind the Muslim camp, could be useful in reproducing the place's memory. The connection between the site and Al-haram should also be developed and paved with traditional and local landscape elements connected with tourist attractions.

Lastly, these research findings fill the knowledge gap in developing tourism attraction sites based on the tourists' decisions in Al-Madinah and all the RHS.

Acknowledgments

The authors would like to thank the Deanship of Scientific Research and Prince Khalid Al-Faisal Chair for Developing Makkah Al-Mukarramah and the Holy Places at Umm Al-Qura University (project # DSRUQU.PKC-42-10) for the logistics and financial support.

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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 8(2)/2021, 11-22

Comfortable Liveable Space: Shipping Container and Bamboo as Sustainable Building Materials in Equatorial Climate Perspective?

Adi Ainurzaman Jamaludin
Environmental Science and Management Programme, Institute of Biological Sciences, Faculty of Science, Universiti Malaya, 50603 Kuala Lumpur.

Zul Ilham
Environmental Science and Management Programme, Institute of Biological Sciences, Faculty of Science, Universiti Malaya, 50603 Kuala Lumpur.

Wan Abd Al Qadr Imad Wan-Mohtar
Functional Omics and Bioprocess Development Laboratory, Institute of Biological Sciences, Faculty of Science, Universiti Malaya, 50603 Kuala Lumpur.

Sarina Abdul Halim-Lim
Faculty of Food Science and Technology, Universiti Putra Malaysia, 43400 Serdang, Selangor.

Hazreena Hussein
Department of Architecture, Faculty of Built Environment, Universiti Malaya, 50603 Kuala Lumpur.

ABSTRACT

The development of liveable space made from shipping containers becomes a trend even in Malaysia with the hot and humid climate persisting throughout the year. For sustaining the indoor comfort, building insulation is well adapted to increase thermal resistance and reduce the dependency on the mechanical cooling systems. The prospective of a shipping container as an efficient construction material and bamboo as a sustainable insulation material is well documented but basic information on the internal environment that has an impact on a person, particularly risk potential towards sick building syndrome (SBS) has been absent. Therefore, the measurements of both indoor and outdoor temperatures, relative humidity and CO_2 concentration with two different conditions were done by using different sets of data loggers for at least 70 days under each condition. The first condition is a bare unit of the shipping container and followed by the installation of untreated bamboo as insulation for the second condition. This research reveals that high temperatures were recorded up to 40°C in both conditions and untreated bamboo as insulation increased the relative humidity levels up to the maximum, 100%. The mean values of CO_2 concentration are in the range of 1,869 ppm to 2,938 ppm and they reach up to 5,000 ppm at the most of the intervals, indicating a significant contribution to SBS. The condition of the equatorial climate denies the compatibility of the shipping container to be used as the building material of liveable space. The quality and treatment of the bamboo must be the ultimate priority.

Article History

Received : *02 November 2020*
Received in revised form : *10 February 2021*
Accepted : *18 February 2021*
Published Online : *30 April 2021*

Keywords:

Bamboo, Comfort, Insulation, Shipping Container, Sick Building Syndrome

Corresponding Author Contact:

adiainurzaman@um.edu.my

DOI: 10.11113/ijbes.v8.n2.728

1. Introduction

The use and the transformation of a shipping container as a liveable space have grown drastically all around the world. It is not limited to residential and commercial structures but extended to various kinds of buildings and functions including school buildings, studios, shops, mobile museums, bank branches, medical buildings, pharmacies, sleeping rooms, cultural centers, malls and public restrooms (Radwan, 2015). The surplus of shipping containers due to the imbalanced trade of western-Asian countries that lowered their price and the lack of affordable housing for students in the city of Amsterdam urged the conversion of a shipping container into 1,000 units of student housing (Uittenbroek and Macht, 2009). The very high embodied energy of the shipping container encourages the recycling process to maintain ecological sensitivity (Vijayalaxmi, 2010).

In natural disaster areas, the shipping container has become an interim house for the homeless (Hong, 2017). The need for this sustainable temporary house is expected to increase due to the increasing severity of natural disasters resulting in the large number of displaced peoples, an increase in the number of climate refugees as a result of a changing climate and the inability of developing countries to provide sufficient infrastructure to keep pace with their rapid population growth (Perrucci et al., 2016). A study done by Zhang et al. (2014), found that the success of shipping container temporary housing projects relate to the flexibility in ownership, and reuse, while the sitting arrangement is significant with key social factor, in addition to robust pre-disaster planning by authorities, taking into account the varying characteristics of different types of disasters.

The characteristics of a shipping container which is high structural strength, easily recycled and reused with a wide range of sources make it a great material in the construction of liveable space (Sun et al., 2017). As-built with stringent standards of design and size, it brings the advantages of modularity, ease of transport and assembly (Pena and Schuzer, 2012). According to Oloto and Adebayo (2012), the shipping container is able to withstand the stacking of nine fully laden containers and extreme weather conditions. The construction time and cost can be reduced due to unnecessary additional resources, planning and maintenance either for initial construction or further expansion (Radwan, 2015). Thus, the shipping container is a mark of construction efficiency, affordability, economy, mobility and sustainability (Buchmeier et al., 2010; Martinez-Garcia, 2014). In the long term, it gives an impact on the real estate industry when the container-housing trend will likely continue to gain momentum due to the increasing demand for affordable houses (Martinez-Garcia, 2014).

The shipping containers are made of steel and were designed to improve the quality and efficiency of naval vehicular in the 1950s (Levinson, 2016). The structural compositions of the shipping container are container base with cross member and plywood flooring, door assembly, rear-end frame, top-side rail with side panel assembly, front-end frame and roof panel (Radwan, 2015; Ismail et al., 2015). The main function is for shipping goods and to store products. The most common size of shipping containers are 20', 40', 20' High Cube (HC), 40' HC and 45' HC with 2.4m of width, and in the range between 2.4m and 2.9m of heights (Bernardo et al., 2013; ISO 688:1995). The 20' HC container is always a preferred choice for construction building due to its greater strength, lower price and ideal clear ceiling height of 2.4m that provides a space for hiding the ductwork, plumbing and electricity (Ismail et al., 2015).

The use of shipping containers in building industries is well accepted in Malaysia with the growth of container-style hotels, especially at tourist attraction places outside the city area (Adreena, 2017; Alaniazul, 2016; KL Now, 2016). By staying in this new concept of hotels, it gives a unique experience while people can enjoy the tranquillity of the countryside and the beauty of nature. In order to sustain the indoor comfort, a mechanical cooling system is required due to Malaysia's climatic conditions that are hot-humid throughout the year (Ahmad, 2008). As located in the equatorial climate region, high temperature and relative humidity are recorded throughout the year with heavy rainfall, especially during the changes of monsoon. Air conditioning systems are fully utilised, which increase the electricity usage and extend the effect of global warming. This situation is getting worse as the shipping container is mainly made of steel, which has high heat conductivity and without sufficient insulation; it is prone to condensation (Botes, 2013). Thus, insulation is a necessity to avoid heat for sustaining the comfort level with the minimum usage of energy for the mechanical cooling system. Furthermore, it can prevent noise, fire, pollution and any invasion by threatening creatures like poisonous animals (Wagner, 2017).

Building insulation is an effective way of energy conservation by increasing the thermal resistance of the building envelope, and it is classified according to the heat exchange properties, form, and composition (Aditya et al., 2017). Conventionally, building insulation is obtained from petrochemicals or natural sources processed with high energy consumption (Asdrubali et al., 2015). There are six common insulation materials in Malaysia, namely rock wool, fiberglass, urethane, fiberglass urethane, perlite, and extruded polystyrene (Basrawi et al., 2013). Due to the movement on environmental-friendly buildings, there are several feasibility studies on agricultural and industrial by-products as new sustainable insulation materials (Asdrubali et al., 2015; Volf et al., 2015; Chuen et al., 2015). These are also contributed by the need for maximising energy saving, for low material cost, easy manufacture and application in the building structure (Reif et al., 2016; Moghimi et al., 2013).

Bamboo is one of the fastest-growing plants, which makes it ideal as a sustainable construction material (Bal et al., 2010). Jusoh et al. (2013) showed two species of bamboo which are Akar bamboo (*Dendracalamus pendulus*) and Semantan bamboo (*Gigantochloa scortechinii*) with low thermal conductivity. A similar result is also reported by using *Guadua velutina* and with low thermal diffusivity, it is possible to combine with other materials as insulation (Gallegos–Villela et al., 2016). By not referring to specific species, two lines of bamboo as multilayer wall is convenient as a material construction with a U-Value of 1.4 W/m^2K and three layers is recommended to mitigate the presence of thermal bridges with a U-Value of 0.67 W/m^2K

(Bruges et al., 2018). Fiberboards from bamboo fibers and protein-based bone glues have shown a great potential for buildings thermal insulation with a thermal conductivity below 0.082 $Wm^{-1}K^{-1}$ (Nguyen et al., 2018). As compared to wood-based shear walls, the thermal insulation performance of bamboo shear walls is slightly lower, demonstrating their feasible substitution in common practice (Wang et al., 2018). The benefits of bamboo, especially in the construction of affordable structures are well documented by Nwoke and Ugwuishiwu (2011).

From the safety and health perspective, indoor air quality has been highlighted as one of the main aspects that contribute to SBS under building-related factors (Wijerathne et al., 2012). Snow et al. (2019) showed substantial links exist between the prevalence of SBS and elevation of indoor CO_2 concentrations. As stated by Apte et al. (2000), the indoor CO_2 concentration is approximately the surrogate for indoor concentrations of other occupant-generated pollutants and the ventilation rate per occupant. By keeping CO_2 concentrations below 1,000 ppm, it is able to improve the occupants' task performance (Hong et al., 2018).

SBS is a situation where the occupants of a building experience acute health or comfort-related effects that seem to be linked directly to the time spent in the building (Joshi, 2008). Six factors are related to increasing the prevalence of SBS, which are personal factors, job category, type of work, psychosocial factors, building factors and building-related factors (Skov et al., 1990; Burge, 2004; Crook and Burton, 2010). According to Wijerathne et al. (2012), personal, psychosocial and building-related factors are the most common affecting factors leading to SBS. The signs and symptoms of SBS comprise a group of unclear aetiology divided into mucous membrane symptoms related to the eyes, nose, and throat; dry skin; together with what are often called general symptoms of headache and lethargy (Burge, 2004; Fisk et al., 2009). Joshi (2008) listed cough, chest pain, shortness of breath on mild exertion, edema, palpitations, nosebleeds, cancers, pregnancy problems, miscarriages, extrinsic allergic alveolitis, Legionnaire's disease, humidifier fever, pneumonia, and occupational asthma as the signs and symptoms of SBS specifically to the building-related factors.

There is a lack of studies on the effectiveness of bamboo as insulation for liveable space constructed from shipping containers. The internal condition of shipping containers that are exposed to high temperatures and humidity of the equatorial climate is undefined to be referred to as a baseline. To date, an engineered solution to the problem that is low-cost, quick to construct, environmentally and socially sustainable, that takes into account the needs of the occupant, and accounts for local climatic conditions has yet to be found (Perrucci et al., 2016). Thus, this research aims to examine the indoor and outdoor conditions of a shipping container by focusing on two basic parameters, which are temperature and relative humidity. The measurements were carried out simultaneously before and after the installation of untreated bamboo functioning as insulation. The carbon dioxide (CO_2) level was also observed but it is limited inside the shipping container. According to Jaber et al. (2017), temperatures and indoor CO_2 levels within buildings play a crucial role for occupant performance particularly cognitive performance regarding all mental activities including thinking, reasoning and remembering. The findings from this research reveal the suitability of shipping containers to be utilised as a liveable space and bamboo as an insulator, especially in the equatorial climate region. In the long term, they contribute to the efficient use of electricity due to the low thermal loads for sustaining the comfort level while minimising the air contamination.

2. Methodology

The research was conducted in a closed 20' shipping container and painted with basic white colour without any ventilation to minimise any other factors that would affect the measurements of temperature (°C), relative humidity (%) and CO_2 concentration (ppm). The Onset Hobo MX CO_2 logger was located in the middle of a shipping container by using a tripod. This data logger is using a non-dispersive infrared (NDIR) self-calibration CO_2 sensor technology with integrated temperature and RH sensors. Thus, erroneous results can be avoided while keeping the operating and maintenance cost to a minimum (Onset, 2017).

Outside the shipping containers, the measurement only involves the temperature (°C) and relative humidity (%) due to the restricted capability of equipment. Onset Hobo Micro Station H21-002 data logger that is connected to the sensor covered by the solar radiation shield was used by fixing it at one steel pole. As shown in Figure 1, all data loggers and sensors were fixed at 1.10m above the floor as the typical human body level (Jamaludin et al., 2017).

Figure 1 The arrangement of equipment for both inside and outside the shipping container

The measurements were done two times with different conditions at least for 70 days for each condition. The first condition is a bare unit of the shipping container (BUSC) and the second condition is installed with untreated bamboo as insulation at all sidewall panels, end wall panel, roof panel, and door assembly (IUBSC) as shown in Figure 2. In both conditions, there is no modification done for the flooring that is covered with plywood.

(a)

(b)

Figure 2 The arrangement of (a) bare unit of shipping container – BUSC, (b) shipping container installed with untreated bamboo as insulation – IUBSC

The data loggers were set to cover a 24-hour measurement with a one-hour interval due to the uniformity of Malaysia's climatic conditions throughout the year and it has distinguishable differences caused by the day and night factor (Ahmad, 2008; Jamaludin et al., 2017; Dahlan et al., 2009).

As the measurement of both conditions (BUSC & IUBSC) was not done concurrently, the effectiveness of bamboo as insulation for liveable space constructed from shipping containers was recognised based on the difference values of temperature and relative humidity between inside and outside of the shipping container according to the daily pattern or 24 hours' average profile. Further statistical analyses were carried out by using a statistical computer software package to determine the difference of measurements of situations which are, between the inside and outside of the shipping container and between two conditions (BUSC & IUBSC), as well as the CO_2 concentration between a bare unit of the shipping container and shipping container that is insulated by untreated bamboo.

3. Results and Discussion

3.1 Temperature and Relative Humidity

The measured temperature and relative humidity values for indoor and outdoor under both conditions (BUSC & IUBSC) are presented in Figure 3 and 4. The measurement covered a 24-hour with a one-hour interval from Day 1 until Day 70. In a bare unit of a shipping container (BUSC), the recorded indoor temperatures are in a range of between 18.72°C and 42.24°C. A smaller range can be observed at the outside when minimum and maximum values are 19.51°C and 36.12°C, respectively.

The measured values for indoor relative humidity are in the range of between 56.65% and 90.12%, while outdoor has a margin of 42.50% to 100%. With the installation of untreated bamboo as insulation (IUBSC), the maximum indoor relative humidity values can exceed 100%. The smaller range was observed as the minimum value was 92.06%. Comparatively, there was a bigger range at the outside as minimum and maximum values were 45.40% and 100%. With regard to the temperature, the minimum and maximum temperature values were 18.72°C and 40.80°C for the inside, while 18.79°C and 35.93°C were for the outside of the shipping container.

The difference between the measured temperature and relative humidity values according to the daily pattern or 24 hours' average profile between the inside and outside of the shipping container concerning both conditions (BUSC & IUBSC) is visualised in Figure 5 and 6. Extracted from Figure 4 and 5, the minimum and maximum values with differences according to time are presented in Table 1.

The installation of bamboo as insulation contributes to the reduction of the temperature inside the shipping container. The differences between minimum and maximum values are getting lesser as compared to the values measured inside a bare unit of a shipping container (BUSC). On average, the maximum value exceeds 35°C at 1 pm, while 31°C has been recorded at the outside a bare unit of a shipping container. The difference exceeds 4°C at 2 pm. With regard to the second condition (IUBSC), both indoor and outdoor show a similar value which is 30°C at 3 pm with 2.5°C of maximum difference at 8 pm. By looking at the outdoor relative humidity, the values are constant between 68% and 99% throughout the research. For indoor, the relative humidity values are influenced by temperature as the increased temperature can decrease the relative humidity values. Remarkably, a substantial difference of up to 30% was obtained on the second condition due to high minimum and maximum values that reached 99% although in the afternoon.

Referring to Table 2, further statistical analysis shows that there is a significant difference of two measured parameters; temperature ($t = -19.006$, $df = 1{,}701$, $p < .05$) and relative humidity ($t = 34.495$, $df = 1{,}701$, $p < .05$), between the indoor and outdoor of a bare unit of shipping container (BUSC).

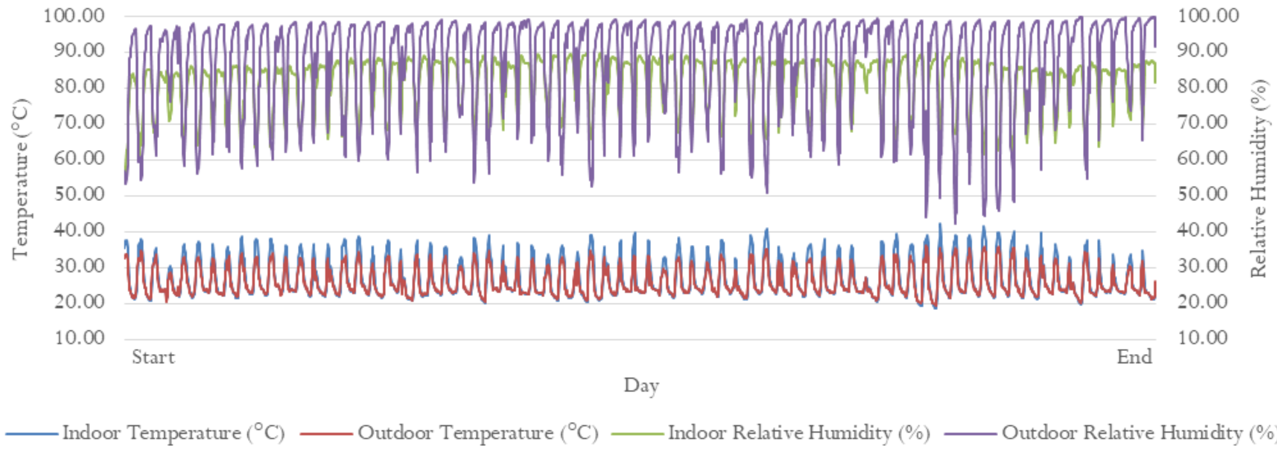


Figure 3 The measured indoor and outdoor temperature and relative humidity values of the bare unit of shipping container

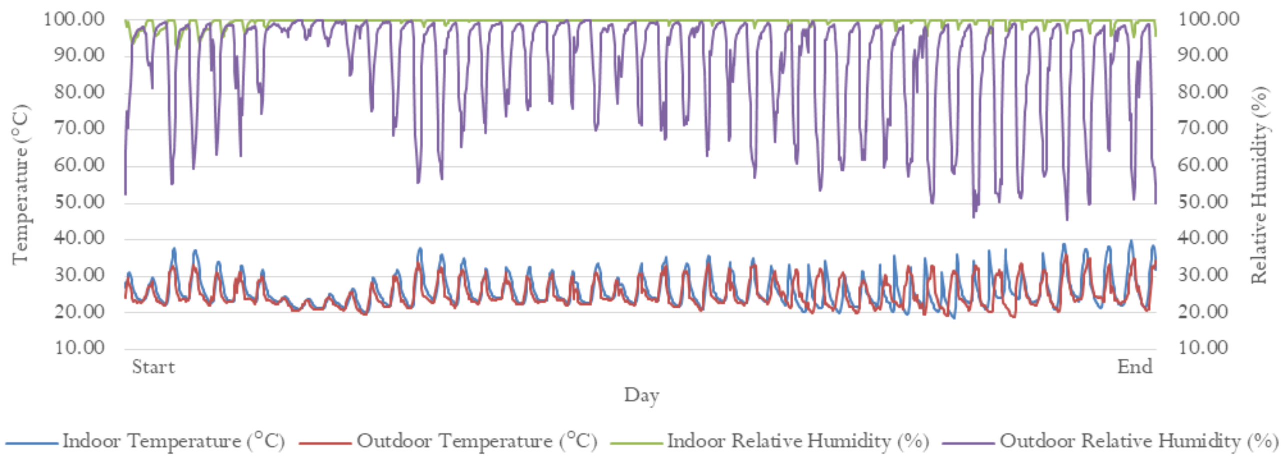
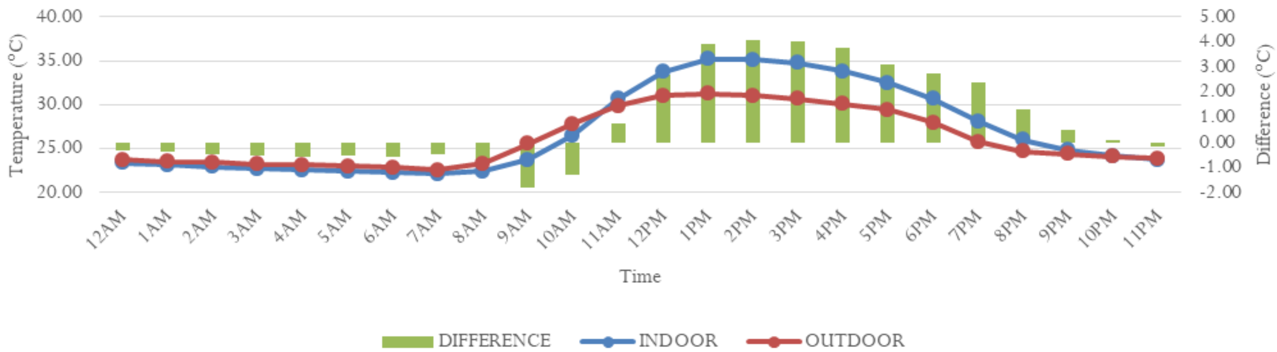


Figure 4 The measured indoor and outdoor temperature and relative humidity values of the shipping container installed with untreated bamboo as insulation

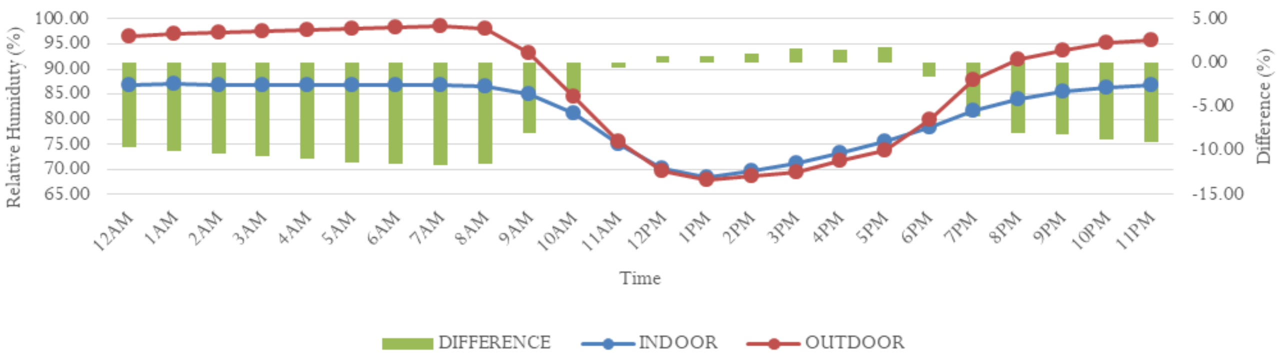
Similar result was also obtained for the second condition (IUBSC) with a significant difference of temperature ($t = -8.464$, $df = 1{,}108$, $p < .05$) and relative humidity ($t = -26.845$, $df = 1{,}108$, $p < .05$).

High-temperature values were recorded up to 40°C in both conditions, a bare unit of a shipping container (BUSC) and with the installation of untreated bamboo as insulation (IUBSC). The installation of untreated bamboo pushes relative humidity values to the maximum exceeding 100%. With this humidity level, the bamboo begins to decay as the highest strength occurred in environments with the humidity level in the range of 60 to 80% and the level significantly dropped thereafter (Askarinejad et al., 2015). The decay process was accelerated as some of the bamboos are probably immature when they were harvested, which indirectly affects the strength of the bamboo. The optimum maturity period of bamboo is about three to four years to provide optimum strength (Sekhar and Bhartari, 1960). Through periodic observation, the decay process is getting faster with the absence of any treatment to the bamboo that is used as insulation in this research. As reported by Bruges et al. (2018), it is necessary to apply some treatments to the bamboo for waterproofing, fire resistance and avoiding the presence of animals that can damage it.

Comparatively, the findings on the daily pattern or 24 hours' average profile are out of the comfort ranges that have been lined up either by global or local authorities. American Society of Heating, Refrigerating and Air Conditioning Engineers - ASHRAE has set the temperature and relative humidity in the range of 23°C to 25°C and 20% to 60%, while Standards and Industrial Research Institute of Malaysia – SIRIM MS 1525 in the range of 22 to 26°C and 30 to 70% respectively (Jamaludin et al., 2017). The daily pattern is also not acceptable to any range of comfort for Malaysians as reported by AbdulRahman (1997) and Zain-Ahmed et al. (2004) who give a range of 23.4 to 28°C of temperature and 54 to 76 % of relative humidity. Hidayat and Munardi (2018) found that commercial facilities using a shipping container are less convenient for humans and animals especially cats and dogs as a standard recommendation for temperature and relative humidity indicated by American Veterinary Medical Association (AVMA) is in the range of between 15.5 to and 26.6°C and between 30 and 70%, respectively.

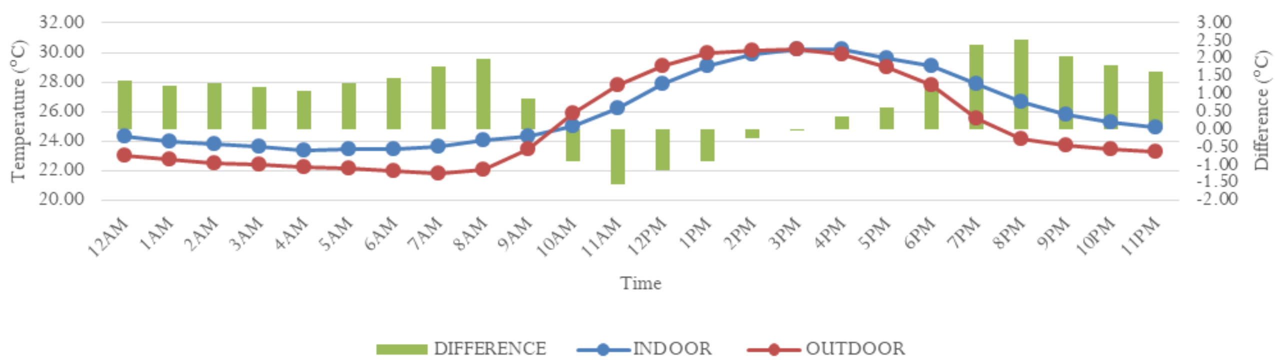


(a)

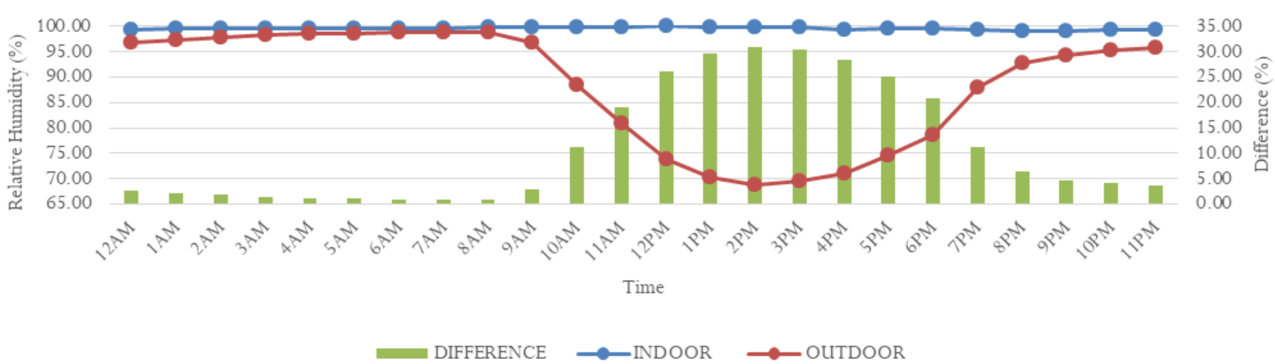


(b)

Figure 5 The daily pattern of indoor and outdoor (a) temperature, (b) relative humidity of the bare unit of shipping container (BUSC)



(a)



(b)

Figure 6 The daily pattern of indoor and outdoor (a) temperature, (b) relative humidity of the shipping container installed with untreated bamboo as insulation (IUBSC)

Table 1 The minimum and maximum values of temperature and relative humidity according to different conditions - bare unit of shipping container (BUSC) and shipping container installed with untreated bamboo as insulation (IUBSC)

		Condition			
		Bare unit (BUSC)		**Installed with untreated bamboo as insulation** (IUBSC)	
		Temperature (°C)	**Relative Humidity (%)**	**Temperature (°C)**	**Relative Humidity (%)**
Indoor	Min	22.15 (7am)	68.53 (1pm)	23.35 (4am)	99.10 (9pm)
	Max	35.18 (1pm)	86.95 (1am)	30.22 (3pm)	99.98 (12pm & 1pm)
Outdoor	Min	22.61 (7am)	67.78 (1pm)	21.84 (7am)	68.89 (2pm)
	Max	31.24 (1pm)	98.45 (7am)	30.25 (3pm)	98.96 (8am)
Difference	Min	-1.83 (9am)	-11.67 (7am)	-1.57 (11am)	0.82 (8am)
	Max	4.09 (2pm)	1.81 (5pm)	2.53 (8pm)	31.06 (2pm)

Table 2 Paired samples statistical analysis of indoor-outdoor temperature and relative humidity values of two different conditions - bare unit of shipping container (BUSC) and shipping container installed with untreated bamboo as insulation (IUBSC)

	Paired Differences					**t**	**df**	**Sig. (2-tailed)**
	Mean	**Std. Deviation**	**Std. Error Mean**	**95% Confidence Interval of the Difference**				
				Lower	**Upper**			
IndoorTempSC - OutdoorTempSC	-.88799	1.92755	.04672	-.97963	-.79635	-19.006	1701	.000
IndoorRHSC - OutdoorRHSC	6.00261	7.17905	.17402	5.66131	6.34392	34.495	1701	.000
IndoorTempSC+Bamboo - OutdoorTempSC+Bamboo	-.88240	3.47160	.10425	-1.08694	-.67785	-8.464	1108	.000
IndoorRHSC+Bamboo - OutdoorRHSC+Bamboo	-11.23748	13.94028	.41861	-12.05883	-10.41613	-26.845	1108	.000

The daily pattern is also not acceptable to any range of comfort for Malaysians as reported by AbdulRahman (1997) and Zain-Ahmed et al. (2004) who give a range of 23.4 to 28°C of temperature and 54 to 76 % of relative humidity. Hidayat and Munardi (2018) found that commercial facilities using a shipping container are less convenient for humans and animals especially cats and dogs as a standard recommendation for temperature and relative humidity indicated by American Veterinary Medical Association (AVMA) is in the range of between 15.5 to and 26.6°C and between 30 and 70%, respectively.

Therefore, the effectiveness of shipping containers as liveable space in providing a comfortable indoor environment, particularly in the hot-humid tropics is not very convincing due to its lack of compatibility with the local climate conditions (Ismail et al., 2015). According to Wagner (2017), the building's thermo-profile shot during typical Malaysia overcast conditions shows that the outside temperature of the roof will increase up to 65°C and it is taking too much time to get rid of the heatwave. This situation is getting worse as the physical features of the shipping container are made of steel. Special attention should be paid to improve both the thermal resistance and hygro-thermal capacity of the envelope due to overheating risk and more humidity issues (Shen et al., 2020). Insulation plays an important role in converting the shipping container into habitual space although Kamarazaly et al. (2017) found container construction is feasible in Malaysia. Brandt (2011) highlighted that R-value should be in line with a climatic condition as the interior of a shipping container gains extremely high temperature in summer, and vice versa during winter. Adequate insulation satisfies the thermal performance of housing units built with shipping containers (Adenaike, 2018). It should be refurbished not only by installing appropriate layers of insulation for controlling thermal, acoustic and fire protection, but also by equipping it with suitable vapor barriers, internal fittings and finishes that suit the local climate (Robinson et al., 2011).

Despite being regarded as one of the sustainable or green architectural alternatives that can provide low carbon footprint buildings, the ISO shipping containers in buildings consume higher energy (per square metre) and releases more carbon dioxide as compared to traditional buildings (Olivares, 2010). The overall contributions of the whole life cycle impacts with regard to six life cycle environmental impacts (LCEI) category indicators; cumulative energy demand (CED), water use, solid waste, global warming potential (GWP), acidification potential, and eutrophication potential, have increased significantly if the design life of a building is increased to 100 years (Islam et al., 2016).

To achieve sustainable shipping container homes, the most effective strategy is the use of green roofs and green walls as energy consumption is reduced by 13.5% compared to the courtyard which reduces the total energy consumption by 3.6% (Taleb et al., 2019).

3.2 Carbon Dioxide (CO_2)

The mean daily CO_2 concentration values in a bare unit of shipping (BUSC) container varied from 440 ppm to 540 ppm, as shown in Figure 7. The recorded values are in the range of between 296 ppm and 661 ppm. By looking at the daily pattern, the mean value of CO_2 concentrations reaches a peak at 8 am and starts to decrease until 3 pm. It gradually increases at 4 pm afterward. A different situation was recognised in a shipping container that was insulated with untreated bamboo. The mean daily CO_2 concentration values varied from 1,869 ppm to 2,938 ppm as shown in Figure 8.

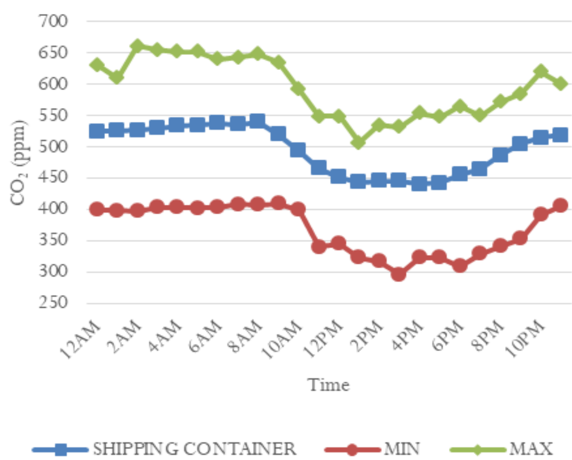


Figure 7 The daily pattern of CO_2 concentration with minimum and maximum values in a bare unit of the shipping container (BUSC)

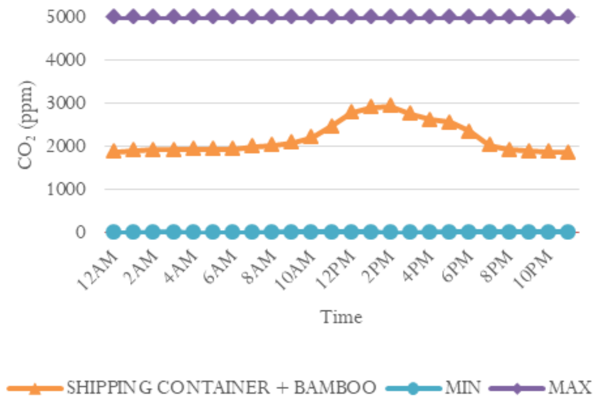


Figure 8 The daily pattern of CO_2 concentration with minimum and maximum values in a shipping container with bamboo as insulation (IUBSC).

The minimum and the maximum recorded values were too extreme, exceeding 5,000 ppm which is beyond the capability of the data logger. The average value reached its highest point at 2 pm and declined subsequently.

As shown in Table 3, there was a significant difference ($t = -25.538$, $df = 1,107$, $p < .05$) of CO_2 concentration values inside the bare unit of the shipping container (BUSC) and shipping container installed with untreated bamboo as insulation (IUBSC). The use of untreated bamboo as insulation drastically contributes to the Sick Building Syndromes (SBS) by shifting the indoor liveable space made from shipping containers into space under unhealthy conditions.

The maximum CO_2 concentration occupational limits set by the developed countries is 5,000 ppm, while the Japan Society for Occupational Health sets the stringent maximum value at 1,500 ppm (Onset, 2017).

Table 3 Paired samples statistical analysis of CO_2 concentration

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
CO_2SC - CO_2SCBamboo	-1664.644	2169.708	65.183	-1792.540	-1536.749	-25.538	1107	.000

According to the Department of Occupational Safety and Health (2010), 1,000 ppm is the ceiling limit that shall not be exceeded at any time. The maximum CO_2 concentration occupational limits set by the developed countries is 5,000 ppm, while the Japan Society for Occupational Health sets the stringent maximum value at 1,500 ppm (Onset, 2017). According to the Department of Occupational Safety and Health (2010), 1,000 ppm is the ceiling limit that shall not be exceeded at any time. Headaches, sleepiness, stagnant, stale, stuffy air, poor concentration, loss of attention, increased heart rate and slight nausea are the potential health problems when the concentration level of CO_2 is in the range of 2,000 to 5,000 ppm (Wisconsin Department of Health Services, 2018). With the CO_2 concentration level exceeding 5,000 ppm, it indicates unusual air conditions where high levels of other gases could also present and the toxicity of oxygen deprivation could occur (Bonino, 2016).

Concerning the untreated bamboo as insulation, it must be waterproof and should not be susceptible to mould or fungi (Joshi, 2008). The mould can spread in buildings as the fungus experiences additional water events, while the colonies remain viable long after a water source has been removed and it remains toxic over extended periods (Straus, 2009). According to Sun et al. (2013), mould has a significant risk factor for nose irritation. Humidity should be measured more often indoors as high air humidity is related to more SBS symptoms (Smedje et al., 2017).

Even the recorded values in a bare unit of the shipping container (BUSC) are within the indoor range target of the CO_2 hazard scale; which is in the range of 600 ppm to 1,000 ppm, so further attention is crucial. According to the European Standard (EN 13779, 2007), this range is classified as moderate indoor air quality. Exposure to CO_2 levels greater than 800 ppm makes the occupants likely to report more eye irritation or upper respiratory symptoms (Tsai et al., 2012). The consequences include a lower rate of productivity, tiredness and distracted decision-making (Ghaffarianhoseini et al., 2018). As reported by Jaber et al. (2017), decreasing CO_2 levels from 1,800 ppm and/or 1,000 ppm to 600 ppm significantly improved the performance of adult female students in a memory and attention task.

The prevalence of several SBS symptoms can be significantly reduced by increasing the ventilation rates per person (Erdmann et al., 2002). According to Adenaike (2018), the aspect of volumetric air changes becomes more relevant if the units are occupied by several people to reduce the heat generated by human metabolism and moisture from respiration by an individual. The improvement of ventilation systems with a proper design and an efficient room layout is the key strategy to address the issues of SBS (Ghaffarianhoseini et al., 2018). With the adaptation of natural ventilation, the prevalence of SBS symptoms is less as compared to air-conditioned buildings or buildings with simple mechanical ventilation (Seppanen and Fisk, 2002). The recycling of air in rooms is one of the main causes of SBS (Jafari et al., 2015). The fresh air is required to supply air for respiration, as well as to dilute carbon dioxide and other contaminants (Rostron, 2008). The airflow rate of 5 cubic feet per minute (CFM) per person in a standard office environment and up to 15 CFM in smoking areas or areas adjacent to manufacturing or warehousing areas are recommended by American Society of Heating, Refrigerating and Air-Conditioning Engineers (Heinkel, 2016).

Well-treated bamboos as insulation and perfect ventilation are not the ultimate accomplishment in developing liveable space made from the recycled shipping container. Other contributing factors need high consideration as mentioned earlier, including personal factors, job category, type of work, psychosocial factors, building factors, and building-related factors. It is impossible to provide one environment that suits a large proportion of the population due to the diverse individuals' requirements for indoor air quality. The development of SBS becomes prominent to the individuals who are unable to adapt to, or alter the surrounding environments (Burge, 2004). However, it is believed that the ability to handle indoor air quality issues becomes key to a healthy, comfortable and sustainable environment.

4. Conclusion

From the sustainability perspective, the shipping container is not applicable to be used as a building material to build a liveable space due to the incompatibility with the hot and humid conditions of the equatorial climate. Conversely, there is a potential in bamboo as insulation but it needs a holistic attention on the quality aspect. Only matured bamboos should be used with an appropriate treatment to extend the life span and allowing them to perform as good insulation.

The range of 18°C to 42°C of temperature and 56% to 100% of relative humidity values were recorded in both conditions, which are in a bare unit of the shipping container (BUSC) and with the installation of untreated bamboo as insulation (IUBSC). These values force the full utilisation of the mechanical cooling system in the future to sustain the comfort level that indirectly increases the carbon footprint through the higher usage of electricity. Referring to the 24 hours' average profile, higher indoor temperature values were recorded up to 35°C in a bare unit of the shipping container (BUSC) as compared to the outdoor. The maximum difference exceeds 4°C. Meanwhile, untreated bamboo as insulation (IUBSC) is able to reduce indoor temperature and make it equivalent to the outdoor, which is 30°C. There are some differences in a certain hour but with a smaller maximum value, 2.5°C. The decaying process of untreated bamboo forces the relative humidity values to the maximum, 100%. Statistically, there are significant differences in the temperature and relative humidity values between the indoor and outdoor of the shipping container in both conditions. A significant difference in CO_2 concentration levels was also discovered inside the shipping container before and after the installation of untreated bamboo as insulation. In a bare unit of the shipping container (BUSC), the mean daily CO_2 concentration values varied from 440 ppm to 540 ppm and exceeded 661 ppm as a maximum recorded value. With the insulation made from the bamboo (IUBSC), the mean values were in the range of 1,869 ppm to 2,938 ppm. Remarkably, the concentration of CO_2 levels reached up to 5,000 ppm at the most intervals especially during the early days after the installation. Concerning Sick Building Syndrome (SBS), there is no direct contribution by the shipping container (BUSC) as compared to the addition of untreated bamboo as insulation (IUBSC) that indicates a significant contribution to SBS.

To evaluate the potential of the shipping container and bamboo as a sustainable construction material in a rigorous manner, further research should be done by using data loggers that are able to record a higher level of concentration with various parameters of indoor and outdoor air quality. This also includes thermal comfort parameters which are air temperature, relative humidity, air speed and mean radiant temperature. If possible, all the measurements should be done concurrently for a longer period with multiple replicates to get comprehensive findings. Different treatments to bamboo are required to enhance the quality and reduce the risk of SBS while maintaining sustainability features. The natural ventilation aspect should be included to minimise the energy usage for sustaining the comfort level of liveable space made from the shipping container, especially in the equatorial climate region.

Acknowledgements

The authors would like to thank Pusat Penyelidikan Bioteknologi Glami Lemi, Universiti Malaya (PPBGL UM), which located at Jelebu, Negeri Sembilan for their permission to carry out the research within their premises. This work was financially supported by Institut Pengurusan dan Pemantauan Penyelidikan (IPPP), Universiti Malaya under BKP Grant (BK010-2015).

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IJBES

International Journal of Built Environment and Sustainability
Published by Penerbit UTM Press, Universiti Teknologi Malaysia
IJBES 8(2)/2021, 23-33

An Indicator-Based Approach for Micro-Scale Assessment of Physical Flood Vulnerability of Individual Buildings

Ismaila Usman Kaoje
Tropical Map Research Group, Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia

Muhammad Zulkarnain Abdul Rahman, Tze Huey Tam and Mohd Radhie Mohd Salleh
Tropical Map Research Group, Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia

Nurul Hazrina Idris
Geoscience and Digital Earth Centre, Research Institute for Sustainability and Environment, Universiti Teknologi Malaysia, 81310, UTM Johor Bahru ,Johor, Malaysia

Abdullah Hisam Omar
Geomatic Innovation Research Group (GIG), Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia

ABSTRACT

The current trends of floods event in many countries are alarming. Hence, managing flood and the associated risk are crucial in order to reduce the loss and to be well prepared for the combined impact of urbanization and climate changes. The best approach to manage flood activities is a risk-based approach, where the vulnerability of elements at risk is reduced to a minimum. There is a significant number of studies that use an indicator-based approach for flood vulnerability assessment with focus on the macro-scale. However, this paper assesses physical flood vulnerability of buildings at micro-scale using an indicator-based method in Kota Bharu, Malaysia. The region is one of the most flood affected regions in Malaysia. Micro-scale vulnerability assessment considers damages for individual buildings at risk, rather than in aggraded manner. In this study, the methodology adopted involve the use of 1D-2D SOBEK flood modelling, the selection and weightage of indicators, development of spatial based building index and, production of building vulnerability maps. The findings demonstrate the physical pattern of flood vulnerability of buildings at a micro-scale. The approach can assist in flood management planning and risk mitigation at a local scale.

Article History

Received : *09 September 2020*
Received in revised form : *11 March 2021*
Accepted : *18 March 2021*
Published Online : *30 April 2021*

Keywords:

Flood, physical Vulnerability, indicators, buildings

Corresponding Author Contact:

usman.kaoje@graduate.utm.my

DOI: 10.11113/ijbes.v8.n2.700

1. Introduction

Globally, flooding is the most destructive event in terms of collective and expected annual loss (Najibi and Devineni, 2018). In recent years, a risk-based approach has been proven to be beneficial in managing flood-related problems (Romali *et al.*, 2018). The term risk in a natural disaster is defined as "the combination of the probability of hazard occurrences and its (vulnerability) potential consequences" (Ayala *et al.*, 2020). Flood hazard is the context of this study. Therefore, flood risk is a measure of the statistical probability of flooding combined with its adverse consequences (DID, 2015). A risk is considered to be the elements of hazard, exposure and vulnerability, where the combination of these provides a better estimate of expected damages related to flood risk (Nasiri *et al.*, 2016). Similarly, flood risk is analyzed through the main components of risk: hazard, exposure, and vulnerability. In comparison to other types of natural hazard, "flood risk assessment" suffers inequality in the level of development among the three components, where hazard and exposure studies and assessments are more developed and advanced while vulnerability assessment and analysis are inadequately developed (UNISDR, 2017). Similarly, in Malaysia, most of the flood risk studies are on flood hazard modelling with little or no information on vulnerability level (Wahab and Muhamad Ludin, 2018; Zakaria *et al*., 2017).

In day-to-day use of language, the term "vulnerability" is understood as the inability of elements to endure the effects of hazard or hostile environments (Ciurean *et al*., 2013). Within disaster research, the concept of vulnerability keeps on developing from time to time. Likewise, there are various attempts to define and explain the meaning of "vulnerability" (Balica *et al*., 2013; Liew *et al*., 2019; Nasiri *et al*., 2016). It is understood that the definition of vulnerability depends on the goal and nature of the scientific study to be conducted. Although, there is an agreement between the disaster risk management researchers' that "vulnerability is the root cause of disasters" (Ibrahim, 2017), however, in this study, the adopted vulnerability definition is that of UNESCO-IHE (2012) where "vulnerability is the extent of harm", which will occur under certain conditions of hazard, exposure and susceptibility. Figure 1 shows how the three mentioned factors of vulnerability interact with each other.

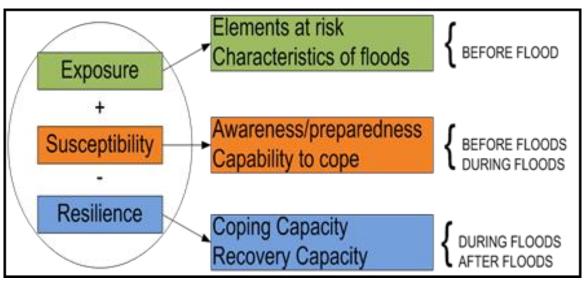

Figure 1 Vulnerability components (UNESCO-IHE 2012)

Likewise, there are several vulnerability assessment approaches (methods) which are different in their vulnerability description, methodology and theoretical framework (Nasiri *et al*., 2016). However, the three most common approaches used in assessing flood vulnerability by most studies are vulnerability matrices, vulnerability curves, and, vulnerability indicator-based method, with each having some strength and weaknesses (Papathoma-Köhle *et al*., 2017). The strength of Indicator-Based Method (IBM) to summarize the complexity and multidimensionality issues to gauge the level of vulnerability makes it more suitable for assessing the variables that influence the flood vulnerability of an element at risk. In Malaysia, significant number of studies use indicator-based approach for flood vulnerability assessment (Liew *et al*., 2019; Hadi *et al*., 2017; Ibrahim 2017; Lee *et al*., 2018; Nasiri *et al*., 2018). However, these studies focus more on macro-scale approaches and less on micro-scale approaches. Therefore, there is a need to develop an indicator-based method to address flood vulnerability at a micro-scale, especially when considering the primary goal of national flood risk assessments and mapping in Malaysia is an effort towards providing the country's non-structural solutions to support the structural measures (Zakaria *et al*., 2017).

Recently, there are attempts to study the physical vulnerability of buildings to flood (Mazzorana *et al*., 2014). Also, significant number of studies have argued that flood vulnerability assessment studies should focus on the identification and evaluation of variables that influence the vulnerability of specific element at risk (Liew *et al*., 2019; Papathoma-Köhle, 2016; Connelly *et al*., 2015). Unlike social vulnerability, assessing the physical vulnerability of all kind of hazard using Indicator-Base Method (IBM) is only in its infancy stage (Papathoma-Köhle *et al*., 2017). Indicator-based assessment is used to evaluate different factors of vulnerability as variables, namely exposure factors, susceptibility characteristics and resilience characteristics (Mulok *et al*., 2019); where "exposure" is seen as the predisposition of a system to be disrupted by a hazard because of its location in an area of hazard influence. Susceptibility is the likelihood or probability of harmed at times of hazardous floods. Resilience is the ability of an element to return to its normal capacity after being affected by flooding or the capacity of an element to survive a disaster by maintaining a significant level of strength of its physical components (UNESCO-IHE 2012).

Mostly the result from indicator-based vulnerability assessment produces vulnerability index, in this case, Flood Vulnerability Index and Flood Vulnerability Maps, which involves sequential stages, including the selection of indicators, their normalization, weighting and aggregation to a final index. However, the objective of this paper is to assess the physical flood vulnerability of buildings, using an indicator-based vulnerability method in Bandar Kota Bharu sub-district. The result is useful in flood management planning and risk mitigation. From the previous record, most of the events of the extreme floods recorded in Malaysia are in the east coast of the Malaysian peninsular (Alias *et al*., 2016), mostly on the present-day state of Kelantan with Kota Bharu as one of the most affected areas.

The Indicator-based Method (IBM) measures indicators (variables) which represent characteristic of an element at risk that makes it unable to withstand the effects of a hazard, such as flooding (Müller *et al*., 2011). The result is indices that can be represented on maps, and the representation is known as the vulnerability index. Among the physical structures at risk of floods, buildings are the most critical element at risk, and their vulnerability assessment and mapping require data and information from many sources (Papathoma-Köhle *et al*., 2017). In order to represent the flood vulnerability of buildings on the map, flood vulnerability needs to be assessed and modelled for each building rather than in an aggregated manner (Custer and Nishijima, 2015). In Malaysia, there are limited researches on flood risk and vulnerability assessment at micro-scale. However, the objective of this paper is to introduce and demonstrate the practical approach for micro-scale flood vulnerability assessment of buildings using an indicator-based method. In December 2014 the Kota Bharu is affected by an extreme flood event resulting in several losses of life and properties. To prepare and prevent the future occurrences of such disasters, it becomes necessary to develop models and approaches for assessing flood vulnerability that can reduce flood consequences.

2. Description of the Study Area

The study area is Bandar Kota Bharu, located in Kelantan State of Malaysia. The city is located in the north-eastern region of Peninsular Malaysia. The district of Kota Bharu covers an area of approximately 409 km², with a total population of 314,964 in 2010

(Hua, 2015). It is located at latitudes 4°40'N to 6°12'N and longitudes 101°20'E to 102°20'E. Kota Bharu consists of seventeen sub-districts (Bandar Kota Bharu, Kadok, Limbat, Salor, Badang, Kemumin, Panji, Kota Bharu, Sering, Kota, Kubang Kerian, Banggu, Pendek, Pendek, Peringat, Beta and Ketereh) as depicted in Figure 2. Bandar Kota Bharu serves as the royal seat and the state capital of Kelantan. About 90% of Kota Bharu relief is between 2 to 10 meters above sea level, with relatively flat surfaces of overlying unconsolidated alluvial and depositional terrain of marine sediments. The entire Kota Bharu is situated in the Kelantan River Basin, which represents typical floodplains and basins that are prone to annual monsoon floods in Malaysia (Khan *et al.*, 2014). Kelantan River constitutes the primary hydrological pattern of Kota Bharu, which contributed to shaping its terrain with many minor streams flowing into Kelantan River. According to Khan *et al.*, (2014), the geographical characteristics of Khota Bharu, unplanned urbanization and proximity to the South China Sea make it is extremely vulnerable to monsoon floods every year. The unprecedented flooding of December 2014/January 2015 triggered by monsoon rains, has been described as one of the worst natural floods in the history of Kelantan with Kota Bharu and Kuala Krai as the most affected districts (Alias *et al.*, 2016)

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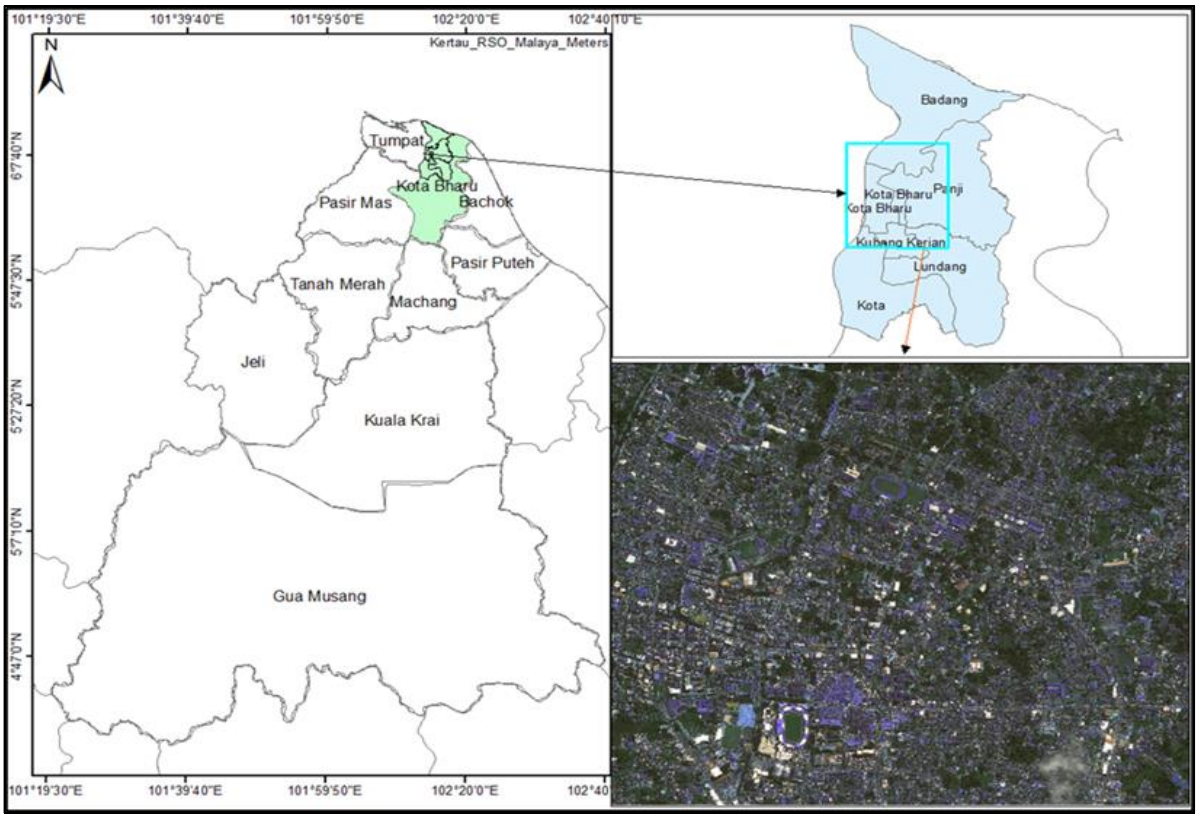

Figure 2 Location map of the study area in Kota Bharu

3. Methodology

The flow of methodology for assessing physical flood vulnerability of buildings is shown in Figure 3. The methodology involved 3 main stages which include 1-2D SOBEK flood modelling, selection and weighting of indicators, and building flood vulnerability computation and mapping.

3.1 1D-2D SOBEK Flood Modelling

Flood vulnerability is site-specific and hazards dependent (de Brito *et al.*, 2017). Therefore, the first step adopted in this study is 1-2D SOBEK flood modelling for the mapping of flood hazard. It involves data collection, pre-processing of data, model schematization, flood simulation and generation of flood depth maps. It is important to establish the fact that for a building to be vulnerable to flood hazard, it has to be exposed to the hazard (Grahn and Nyberg, 2017). Therefore, flood hazard assessment and modelling are significant in order to define the level of flood exposure and vulnerability indicators that are related to hazard intensity such as flood depth, inundation, velocity and duration.

3.1.1 Data Acquisition

The required data for SOBEK flood modelling are Digital Terrain Model (DTM), hydrographs of inflow and outflow boundaries, land-use/land-cover information, stream network geometry and river cross-sections. The DTM data is acquired from LiDAR, which have 3-meter spatial resolution and is obtained from geoinformatics department, UTM. For the hydrographs, hydrological data is

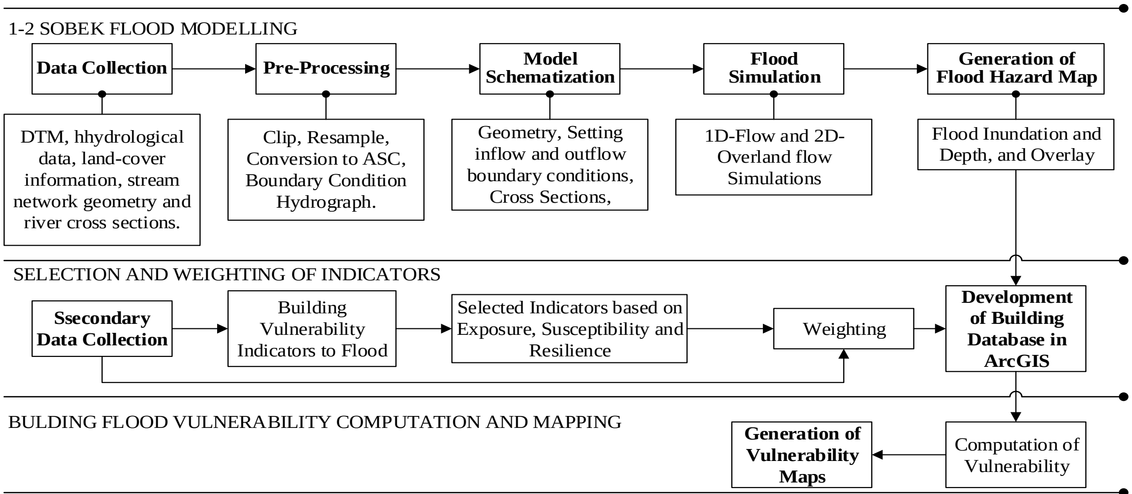

Figure 3 Flowchart of Methodology

obtained from the DID Sg. Kelantan hydrological station. The data consist of an hourly water level and streamflow discharge from 1 December 2014 to 1 January 2015. Furthermore, in order to conduct a realistic flood simulation, a detailed land-use map in shapefile ArcGIS format is used to estimate Manning's n value for input into SOBEK. For the computation of 1D model stream network, geometry and cross-sections are used as input.

3.1.2 Pre-Processing

The 3 meter LiDAR DTM is resampled to 90 meters spatial resolution for the input into the model schematization. This is necessary in order to reduce the simulation time. Extensive computation time is a major limitation in SOBEK 2D hydrodynamic modelling (Vanderkimpen *et al.*, 2008). Likewise, the land-use map is converted into raster Manning's file, and the

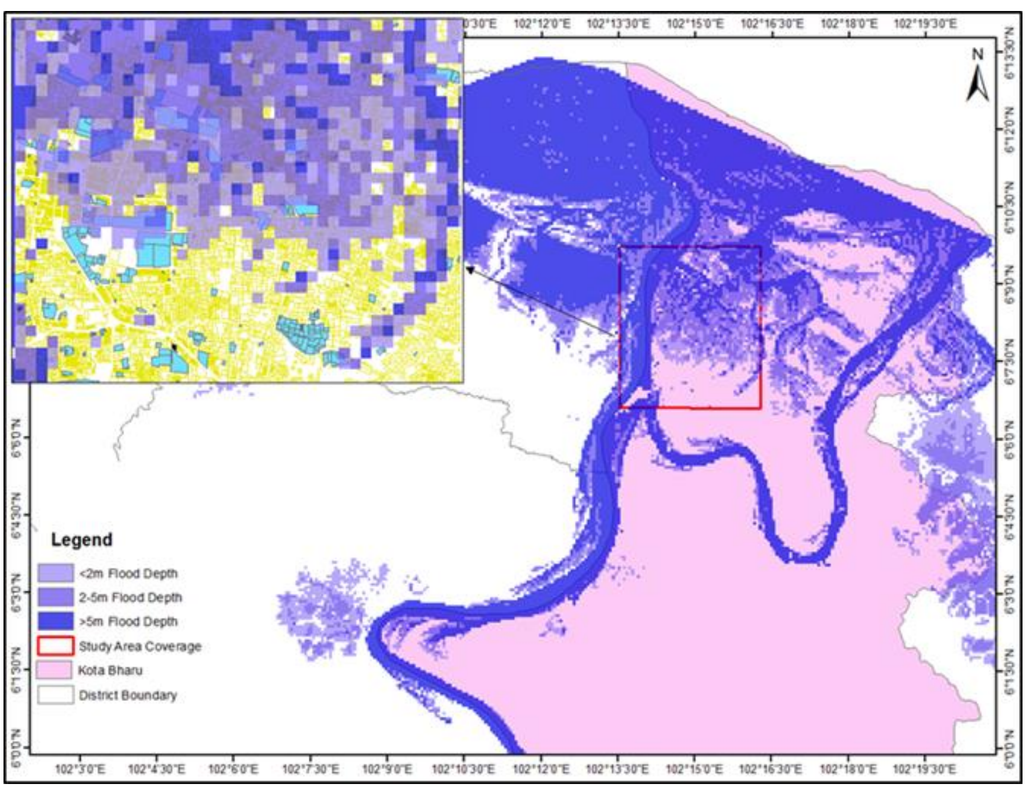

Figure 4 Generated flood inundation and depth map

spatial resolution of the DTM is used. The Manning's value used in this study for land-use classes is depicted in Table 1.

Table 1 Manning's *n* value of land-use (Maruti *et al*., 2018)

Land-Used Class	Manning's *n*
Water Bodies	0.033
Forest	0.3
Rubber	0.15
Paddy	0.2
Oil Palm	0.25
Built-up Area	0.8
Others Agriculture	0.2
Cleared Land	0.01

3.1.3 Model Schematization

This stage allows geometric data to be inserted into SOBEK using a network editor interface called NETTER. For the inflow and outflow boundary conditions. The hourly discharge hydrograph is selected for the upstream condition while the water level is selected for the downstream condition. The selected targeted to capture and simulated the December 2014 flood event in Kota Bharu, since the data is captured in real-time. Similarly, at this stage, both the DTM and Manning's raster files are inserted in SOBEK. Likewise, Sg. Kelantan geometry is digitized, and the cross-sections are added to the river network.

3.1.4 Flood Simulation and Generation of Flood Hazard Map

Using the model schematization, 1Dflow and overland flow are simulated. It simulated flood scenario in December 2014, where most of the Kota Bharu district is inundated by floodwater. This study mainly focuses on Kota Bharu urban center, but the entire Kota Bharu district is covered making the model a near real-life scenario. From the simulated results, the vital parameter of interest (i.e. flood inundation depth) is extracted. Therefore, the obtained model output is the floodwater inundation depth. The model output is exported into ArcGIS (see Figure 4) for further analysis.

Figure 5 Extraction of element-at-risk from satellite imagery using heads-up digitizing

The result is used to define buildings flood exposure of buildings in this study area.

3.2 Selection and Weighting of Indicators

The procedure used in identifying flood vulnerability indicators of buildings and their weight beins with the secondary data collection method; review of relevant literature is carried out in the scope of this research. A range of widely-accepted physical vulnerability indicators that are relevant to building flood vulnerability assessment are compiled together with their weight. However, due to the study limitations, this research selected the following indicators (it considered sufficient) as identified in Table 2 to demonstrate the vulnerability mapping capacity using IBM. The indicators are selected based on the three components of vulnerability; exposure, susceptibility and resilience. Each of the selected indicators are classified into different categories, with each category having a different vulnerability value. However, information on flood insurance and flood warning system are not sufficient therefore they are given 0 weight.

Table 2 Building indicators for flood vulnerability

Indicators	Score	Categories	Weight	Weight
Exposure:				
Floodwater depth	**0.3**	>3m 1.1-3m 0.5-1m <0.5m	1 0.75 0.5 0.25	(Ghazali and Osman, 2019)
Proximity to river	**0.1**	<20m 20-40m 40-80m >80m	1 0.75 0.5 0.25	(Kappes *et al.*, 2012)
Susceptibility				
Building materials	**0.3**	Wood Mix-material Unreinforced Reinforced	1 0.75 0.5 0.25	(Usman Kaoje et al, 2020)
Number of storeys	**0.3**	1 storey 2 storeys 3 storey >3 storey	1 0.75 0.5 0.25	(Ayala et al., 2020)
Resilience				
Insurance	**0.0**	Yes No	0 1	(Balaca, 2013)
Warning System	**0.0**	Yes No	0 1	(Balaca, 2013)

3.3 Development of Kota Bharu Building Footprint Database

Buildings footprints (polygons database) were derived from satellite data (world-view satellite imagery), land-use data, and street-view from google earth pro. First, the satellite imagery was used to manually digitize buildings footprint using the heads-up Digitizing method (see Figure 5). It involves visualizing the satellite imagery on a computer screen and then traces the points, lines and polygons using digitizing tools. Likewise, some building footprint were acquired during the field study using the ArcGIS Collector application at the same time, also their attribute. At this stage, each of the building footprints was assigned a feature number to maintain consistency during further processing. Google earth-pro is used in assigning building attribute (number of floors and construction material) to buildings that are not covered during the field study. The digitized polygon's projection was converted into a WGS-1984, a format recognized by the google earth pro application. Then they were directly imported into the application for the identification of their attribute (indicator category). Each building can be directly viewed using a street-view. From their building characteristics, information that is selected as indicators are assigned to each building. At this stage, weight of indicator categories are entered into the database. For proximity to river, a buffer tool in ArcGIS is used to measure buildings distances from the river. For floodwater depth, information obtained from flood modelling (see Section 3.1) was used.

3.4 Building Flood Vulnerability Computation and Mapping

From the final weight of indicators, an index value is assigned to each building using a flood vulnerability index equation adopted from the study of Kappes *et al.*, (2012). The approach uses a weighted linear combination method, an analytical method used in handling Multi-Criteria Decision Making (MCDM). Each indicator is assigned a weight based on its importance. The higher the score, the more significant an indicator is to the analysis. The computation is done by using Equation 1:

$$F - VI = \sum_{1}^{m} w_m * I_m \quad \text{(Eq 1)}$$

Where, $F - VI$ = flood vulnerability index, w_m = propriety score of indicator, I_m = indicator-category weight. The vulnerability index constructed here shows that buildings considered with high vulnerability will suffer more damage during flood occurrence. The building vulnerability is computed according to the model shown in Figure 6. The model is based on Papathoma Tsunami Vulnerability Assessment (PTVA) model (Dall'Osso et al., 2016; Papathoma-Kohle et al., 2019; Kappes *et al.*, 2012)

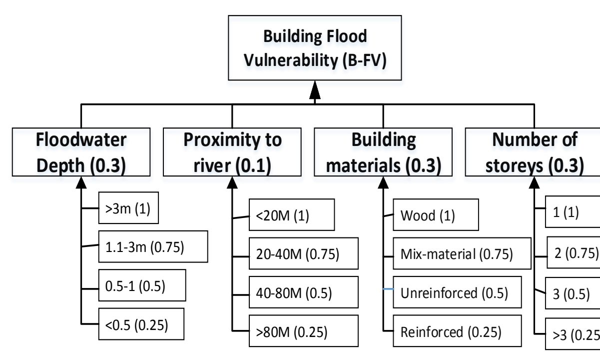

Figure 6 The vulnerability index computation model

4. Result and Discussion

The choice of variables used in the vulnerability analysis and their classification is very important (Ibrahim, 2017). In this study,

Table 3 Description of building flood vulnerability indicators

Indicators	Categories	Description
Exposure:		
Flood water depth.	>3m 1.1-3m 0.5-1 <0.5	At less than 0.5m flood depth, buildings are expected to stay dry during flooding. At flood depth of 0.5-1m; the ground floor is expected to be covered which may affect buildings, but less damage is expected. At 1-2m: The ground floor of buildings can be flooded and the people have to be evacuated or move to the other floors. Flood depth at 2-5m: the single storey buildings and the first floor of other buildings will be covered by flood water. At this stage, there is a high possibility of building collapse. At more than 5m flood depth, buildings with less than two storeys will be completely inundated by flood water and they have to be evacuation.
Proximity to river.	<20m. 20-40m. 40-80m. >80m.	The distance to a river can determine whether the building will be undercut by a fast eroding stream that can lead to collapse of buildings.
Susceptibility		
Building materials.	Wood/Light weight Mix-material construction Unreinforced masonry Reinforced masonry.	Different types of building materials behave differently under flood water saturation. Therefore, different level of vulnerability. It is expected that metal and concrete building are more resilient to flooding than wood constructed buildings and buildings constructed with mix-materials of both wood and concrete.
Number of storeys.	1 storey 2 storeys 3 storey >3 storey	More than one storey building offers vertical evacuation opportunity during flood disaster. It allows people and their properties to be move to upper floors of the building and also for evacuation.
Resilience		
Flood insurance.	Yes. No.	Flood insurance is used for flood recovery after flood event and it covers a dwelling for losses sustained by water damage from flood.
Warning System.	Yes. No.	Availability of flood warning service, whereby those at risk can be provided with a reliable information on what and when to expect flooding so they can be adequately prepared.

building vulnerability indicators are selected based on their significance in causing flooding in the study area. The sub-categories of flood depth indicator are extracted from the SOBEK flood modelling. Among the exposure indicators, flood depth is the most significant (Ouma and Tateishi, 2014). Furthermore, the study of Kappes *et al*. (2012) highlighted the significance of the influence of building surrounding to flood vulnerability, which may play an important role by offering protection from a range of hazards. However, Table 3 described the behaviours of the building indicators for flood vulnerability.

4.1 Spatial Distribution of Flood Vulnerability Indicators in Kota Bharu

As depicted in Figure 7, each indicator's spatial pattern is shown separately—map "A" of Figure 7 depicted buildings exposure to flood depth. Flood depth is an essential indicator among all the selected indicators. Without the impact of water depth, no damage is generated. An indication of how damaging floodwaters can depend on their depth. Map "B" represent buildings proximity to a river where flood is originated. Overflow of water bodies during the flood occurrence makes the adjacent area much more vulnerable and influences the water velocity as well (Maruti et al., 2018). Map "C" represent the spatial distribution of buildings based on their construction material and type. Lastly, map "D" shows the spatial distribution of buildings based on their number of floors. Custer and Nishijima (2015) suggest that the number of storeys are among the most vital indicators for building flood vulnerability. Likewise, if we acknowledge building structures as engineering structures. The foundation strength is a direct function of building weight, and building with more floors is expected to have more weight, making it difficult to wash away by floodwater.

4.2 Composite map Based on Integration of all indicators

Furthermore, a composite index map is necessary, where the collection of all indicators is combined to represent the overall flood vulnerability. Figure 8 shows the aggregated vulnerability results in a map with vulnerability values assigned to each building block based on vulnerability designations modified from Balica et al. (2013). The description of the rank designation of the vulnerability index is depicted in Table 4. The vulnerability map is derived using the vulnerability indicators after Figure 7. Since the 2014 flood event is a 100-year flood event (Alias et al., 2016), the simulated flood hazard map is also considered a 100-year hazard model. During a flood event, buildings with higher vulnerability rating are expected to suffer more damage. As a result, they should be evacuated when high intensity (100-year) flooding is forecasted. The flood damage description assignment to the vulnerability index is probably difficult in the index-based flood vulnerability assessment. However, since the primary purpose of the flood vulnerability index is to assess flood vulnerability index value to buildings in relation to vulnerability indicators, the generated index value of between 0 and 1 is divided into five using an equal distance, and the assigned index classes (Very Low, Low, Moderately, High, Very High) are based on standardized vulnerability indices (Balica et al., 2013).

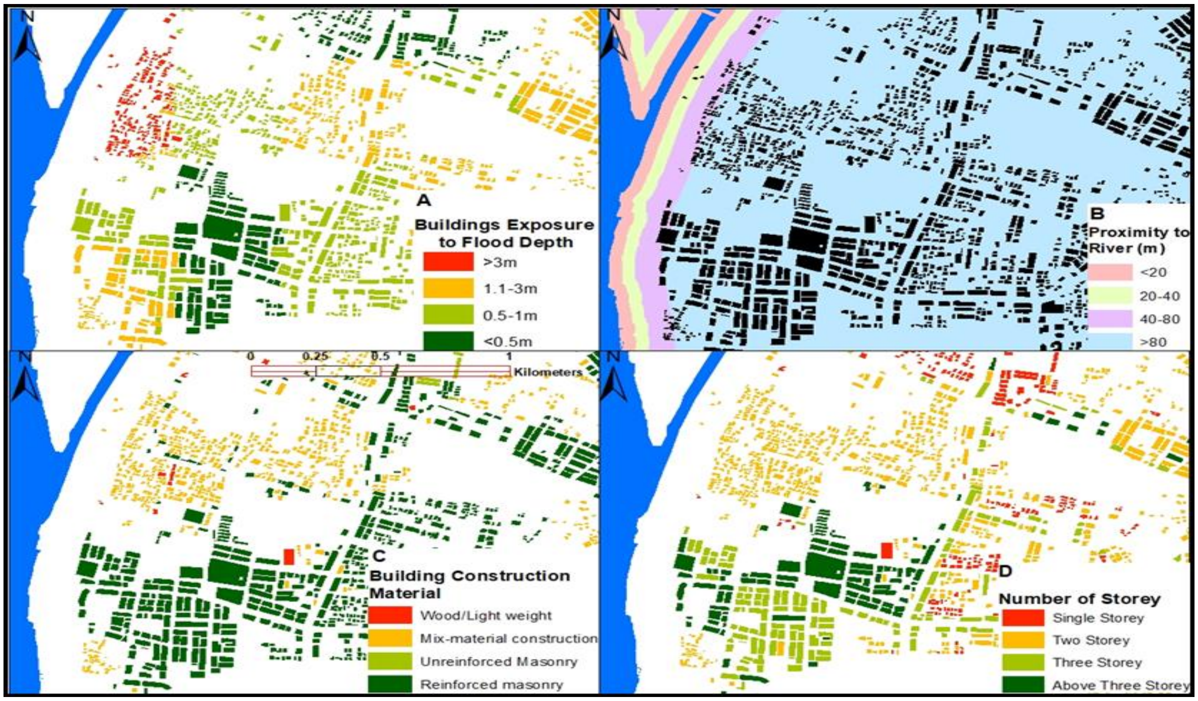

Figure 7 Spatial representation of building according to indicators categories (A) Flood depth, (B) Proximity to river, (C) building construction materials, (D) Number of floors

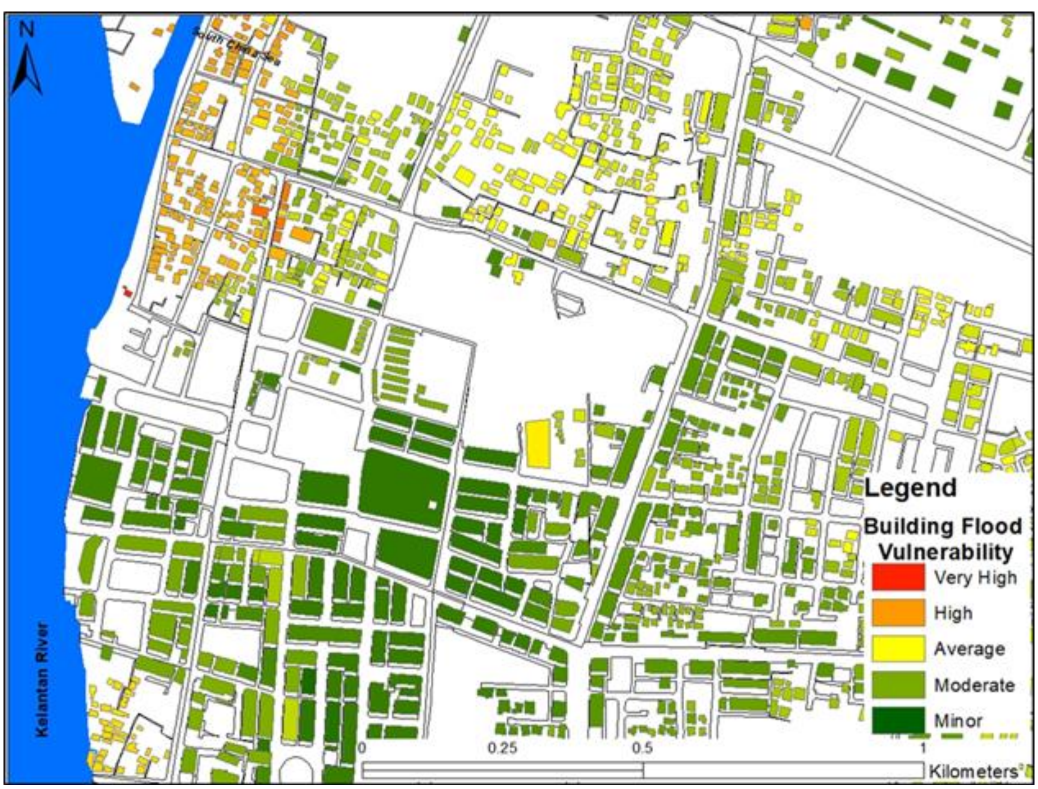

Figure 8 Spatial distribution of flood vulnerability in Kota Bharu

Table 4 Flood Vulnerability Designations (Modified from Balica *et al*., 2013)

Designation	Index Value	Description
Minor Vulnerability	0.00 – 0.20	Minimal vulnerability to floods, no property will be damaged, elements recover fast.
Moderate vulnerability	0.21 - 0.40	The element is vulnerable to flood, but the recovery process is fast due to the high resilience measures, damage to the infrastructure is minimal. If a flood occurs, the damages are not high, so small vulnerability.
Average Vulnerability	0.41 - 0.60	The element is vulnerable to floods, small amount of damage may be observing, the element can recover after flood water drains with a minimal damage. Average resilience measures.
High Vulnerability	0.61 - 0.80	The element is vulnerable to floods, significant amount of damage may be observing and properties may be lost, recovery process is slow, low resilience.
Very high vulnerability	0.81 - 1	The element is very vulnerable to floods, and it can experience total collapse or wash away by the floodwater.

5. Conclusion

This paper adopted the UNESCO-IHE definition of vulnerability. It carried out a flood vulnerability assessment of Bandar Kota Bharu buildings using the Papathoma-Kohle framework for physical vulnerability assessment. The study mapped the spatial distribution of flood vulnerability to explore the vulnerability of buildings. The flood vulnerability index of buildings presented in this study provides a scale of criticalities for individual buildings that will be severely affected at the occurrence of 100-year flood events. There is a difference between flood event and flood disaster. Small flood event occurrences in Kota Bharu is like an annual event. For an event to be seen as a disaster, it has to overpower the local coping capacities. Flooding at a 100-year event is seen as a great disaster and can cause widespread devastation. In anticipation of a flood disaster, the flood vulnerability index model can be utilized to prevent significant losses. Likewise, the current study demonstrates the ability of the indicator-based method (IBM) approach to identify individual infrastructures at high risk based on their vulnerability category. It also demonstrated the integration of the IBM approach with GIS by giving a clear visualization of building spatial vulnerability. This approach can help decision-makers in disaster management to make informed decisions, for instance, developing a spatial database for identifying buildings that need to be evacuated during flood disaster or in anticipation of high magnitude flooding. Such as in this study, buildings identified within the class of very-high vulnerable to floods can experience total collapse or wash away by the floodwater. As such, in planning flood evacuation, they require more attention. For future research, it is recommended to consider other necessary indicators that is location dependent as to empower the ability of spatial model in modelling vulnerability aspect.

Acknowledgements

Thanks to Universiti Teknologi Malaysia for support under the grant: Q.J130000.2527.17H76, and to Department Irrigation Drainage Malaysia for providing hydrological data. We thank the department of Geoinformatics, Faculty of Built Environment and Surveying, UTM for elevation data geometric data.

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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 8(2)/2021, 35-48

Indoor Thermal Environment of Various Semi-Enclosed Atrium Configurations of Institutional Building in Tropical Climate

Wardah Fatimah Mohammad Yusoff
Department of Architecture and Built Environment, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia.

ABSTRACT

The consideration of local climate is essential for the application of atrium in building. Different strategies and approaches in atrium configuration are required for different climates in ensuring its effectiveness. Nevertheless, the final aim is still similar which is to provide a comfortable environment for the users. Hence, this study was executed to examine the effects of top and side configurations on the indoor thermal environment of semi-enclosed atrium in the tropical climate. The methodologies involved field measurement and questionnaire survey. The field measurements were executed at two different configurations of semi-enclosed atriums in the tropical climate of Malaysia. Meanwhile, the questionnaire surveys were executed simultaneously with the field measurements in obtaining the users' thermal sensation and satisfaction. The findings indicated that the top configuration had more influence to the indoor thermal environment compared to the side configuration as it determined the amount of solar heat penetration into the atrium area. Meanwhile, the side configuration influenced the air velocity inside the atrium. The Faculty of Engineering and Built Environment's atrium that has opaque top finishes was found to have the average indoor operative temperature of less than 30 °C throughout the day, though the average outdoor air temperature was more than 30 °C. It also had more hours with neutral thermal sensation felt by the users compared to the Faculty of Economics and Management's atrium that has transparent materials for the top finishes. The study is useful in guiding the selection of appropriate strategy for an atrium in tropical climate.

Article History

Received : *27 September 2020*
Received in revised form : *05 March 2021*
Accepted : *07 March 2021*
Published Online : *30 April 2021*

Keywords:

Atrium, Configurations, Indoor thermal environment, Tropical climate

Corresponding Author Contact:

wardahyusoff@ukm.edu.my

DOI: 10.11113/ijbes.v8.n2.710

1. Introduction

In building, atrium is known as a top-lit internal space that has several storeys surround it (Curl, 2006). The numerous functions and benefits of atrium in the social and environmental aspects have made this strategy is widely applied in various building typologies such as the office, institutional and commercial buildings. One of the social benefits of atrium is an area for organizing events, socializing and gathering (Hung, 2003). The ample area provided by an atrium, as well as its location in building which is normally at the front or centre, has made it as a focal point and a node. In addition, the spaces or rooms around it have also made an atrium as a strategic place for activities and events. Besides that, an atrium may also become a starting point in distributing the circulation within the building (Adams et al., 2010).

Besides social benefits, an atrium also provides many environmental benefits if the strategy is appropriate for the climatic condition where it is situated. The environmental benefits of atrium have been widely studied, and the aspects are various such as the daylighting strategy (Sharples and Lash, 2007; Jorgensen et al., 2012; Ghasemi et al., 2015; Huang et al., 2015; Acosta et al., 2018; Song, 2007; Mohsenin & Hu, 2015) the ventilation strategy (Acred and Hunt, 2014; Yusoff et al., 2019), the energy usage (Wang et al., 2017; Aldawoud & Clark, 2008; Vethanayagam & Abu-Hijleh, 2019), and the indoor thermal environment (Abdullah and Wang, 2012; Chu et al., 2017; Abdullah, Meng, Zhao, & Wang, 2009; Hussain & Oosthuizen, 2012; Hussain & Oosthuizen, 2013; Lu et al., 2019; Taleghani, Tenpierik, & van den Dobbelsteen, 2014).

Due to its various social and environmental benefits, the application of atrium is not restricted to certain climatic condition. The application of atrium in tropical climate of Malaysia is also very wide. It is applied in various building typologies such as the commercial, institutional and office buildings. Nevertheless, different climatic condition requires different approach in the atrium application to ensure the environmental benefits are achieved. Hence, it is important to understand the appropriate strategy for a particular climatic condition. Otherwise, instead of providing environmental benefits, the atrium may become a liability to the building, such as increasing the energy usage, as well as the maintenance and operational costs.

The application of atrium at commercial and office buildings is common. There are already many studies conducted for the atrium at such building typologies such as the studies by Ghasemi et al. (2015), Huang et al. (2015), Mohsenin and Hu (2015), Yusoff et al. (2019), Wang et al. (2017), Abdullah and Wang (2012), Abdullah et al. (2009), Asfour (2020) and many others. However, the study of atrium at institutional building is still lacking, though the application of it in such building is mushrooming nowadays. Hence, two atriums that are located at the institutional building which is National University of Malaysia (UKM) were selected for this study. They were selected due to the different atrium characters though located within similar institution and having similar functions. Details of these two atriums are elaborated in the methodology section.

1.1 Atrium Configuration

There are four generic forms of atrium which are categorized by the location in building. They are the centralized, attached, semi-enclosed and linear forms (Hung and Chow, 2001), as shown in Figure 1.

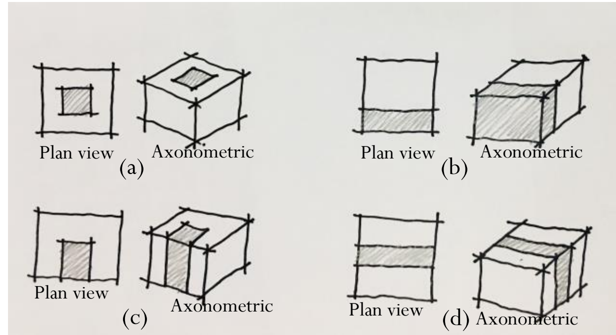


Figure 1 The four generic forms of atrium, which are a) centralized, b) attached, c) semi-enclosed, and d) linear

Each atrium has its own configuration, depending on its connection with the adjacent spaces within the building. The location and configuration of an atrium have significant effect to the indoor environmental condition of the atrium space. The study by Aldawoud (2013) indicated that the energy usage for a narrow and elongated rectangular atrium was higher than a square shaped atrium.

Besides location, the environmental strategy can also be considered to classify an atrium. In general, the atrium can be classified into two, namely the fully enclosed atrium and the semi-enclosed atrium. This classification is based on the daylighting and natural ventilation strategies. The semi-enclosed atrium is an atrium that has openings whether at the facade or roof, which allow for air exchange between the indoor and outdoor. The ventilation mode that is normally applied at the semi-enclosed atrium is either fully naturally ventilated or hybrid, which is by incorporating a mechanical fan. It is different from the fully enclosed atrium, which is normally air-conditioned. The indoor environmental effects provided by the fully-enclosed atrium and semi-enclosed atrium are also different. The former strategy provides greenhouse effect, which is favorable by cold and temperate climates, whilst the latter offers chimney effect, which is appropriate for tropical climate.

In term of the daylighting strategy, the amount of daylight into the atrium area is determined by the building massing and orientation, as well as the openings such as skylight, void and window (Asfour, 2020). An atrium can be either top-lit, side-lit or both. The top-lit atrium normally uses transparent or translucent roof material that enables certain amount of daylight penetration. Such example is the utilization of skylight at the roof of the atrium. Nevertheless, the ratio of the skylight or glazing area impacts the heating and cooling loads of the atrium area (Aldawoud & Clark, 2008; Tabesh & Sertyesilisik, 2016). Excessive glazing is inappropriate for hot climate as it increases the amount of heat gain, which subsequently escalates the indoor air temperature (Asfour, 2020). In addition, a multi-storey atrium with top glazing that is located in hot and humid climate will also suffer a high air temperature stratification at the highest level (Abdullah et al., 2009).

In summary, by combining the ventilation and daylighting strategies, the atrium can be classified into four categories which are fully enclosed top-lit, fully enclosed side-lit, semi-enclosed top-lit and semi-enclosed side-lit. All these strategies have different effects to the indoor environmental condition of atrium. Nevertheless, the semi-enclosed side-lit atrium was found to provide better indoor thermal comfort than the other atrium strategies for tropical climate (Abdullah and Wang, 2012). Though Abdullah and Wang (2012) had already investigated the thermal comfort in semi-enclosed side-lit and top-lit atriums, the methodology used was numerical simulation only. There was no survey executed on the actual thermal sensation felt by the users of the atriums. Similarly, other studies of the indoor thermal comfort in atrium which are by Hussain and Oosthuizen (2012), Hussain and Oosthuizen (2013), Abdullah et al. (2009), Chu et al. (2017), Lu et al.(2019), and Taleghani et al. (2014) also did not execute field survey on the actual users' thermal sensation. Hence, this paper intends to examine the effects of top and side configurations on the indoor thermal environment of semi-enclosed atrium using the field measurement and questionnaire survey methods. The findings from this study take into account the actual users' thermal sensation and satisfaction of the atrium's indoor environmental condition.

2. Methodology

Two research methods were utilized for this study namely the field measurement and the questionnaire survey. The field measurement was executed with the purpose of obtaining the outdoor and indoor environmental data of the selected atriums. The environmental data of the field measurement were used to calculate the indoor operative temperature and the predicted indoor comfort temperature. Meanwhile, the questionnaire survey was conducted concurrent with the field measurement, with the purpose of deriving the users' thermal sensation and satisfaction regarding the indoor thermal environment of the selected atriums.

2.1 Building Selection

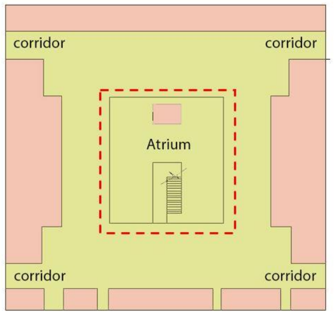
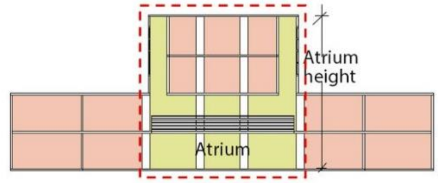
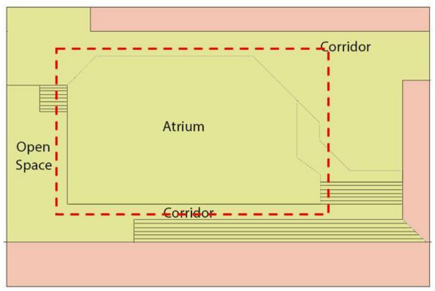
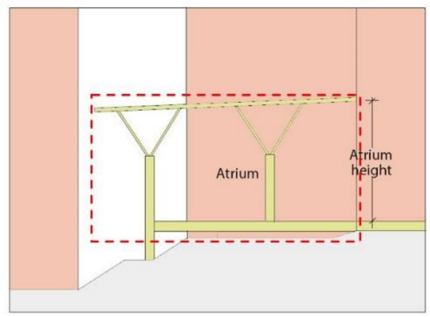
Two institutional buildings with different configurations of atriums had been selected for this study. Though the atriums' configurations are different but they have similarity, in which both of them are classified as semi-enclosed and centralized atrium. The two institutional buildings are Faculty of Engineering and Built Environment (FKAB), and Faculty of Economics and Management (FEP) of National University of Malaysia (UKM). The atriums of those buildings serve the similar purpose which is as communal area for socializing and gathering. In addition, the events or activities held at the atriums are also for the academic purposes such as educational talk and exhibition. Those buildings are located within the main campus of National University of Malaysia. The distances between those buildings are approximately 2.6 km from each other (Figure 2).

Figure 2 The locations of the selected buildings (GoogleMap, 2020)

The atrium at FKAB has the area of 159.3 m2 (Table 1). There are many rooms and spaces that surround the atrium, which function as laboratories and offices. There are also corridors that connect the atrium with the outdoor. Besides being as passageway, the corridors also allow the outdoor air to flow into the atrium. The atrium has a total height of 12 m from the ground level (Table 1). However, the 12 m height includes the spaces like vertical shafts that are located at the sides of the atrium. On the other hand, the height of the centre of the atrium is only 6 meter from the ground level. The penetration of daylight into the atrium is via the glass louvers that are located at the vertical shafts. Nevertheless, the artificial lightings are still installed at the spaces and corridors around the atrium due to the low lighting level at the areas especially during the cloudy days. Besides daylighting, the glass louvers also allow for natural ventilation, especially the stack effect ventilation due to their heights from the ground level.

The FEP's atrium is similar to FKAB's atrium which it is also surrounded by other spaces and rooms. However, the floor area of the atrium is larger than the FKAB's atrium, which is 343.4 m2 (Table 1). In contrary to the FKAB's atrium, there is one side of the FEP's atrium that is adjacent to a small courtyard. Nevertheless, the other sides are similar to the FKAB's atrium which are adjacent to rooms. The atrium is also naturally ventilated via the corridors that link the atrium with the outdoor. Nevertheless, the ventilation in the atrium is also aided by mechanical fans. These ceiling fans function only when there is a large crowd at the atrium due to event. In comparison to the FKAB's atrium, the FEP's atrium has lower height which is 5.8 m from the ground level (Table 1).

Table 1 Simple Layout Plans and Cross Sectional Views of the Selected Atriums

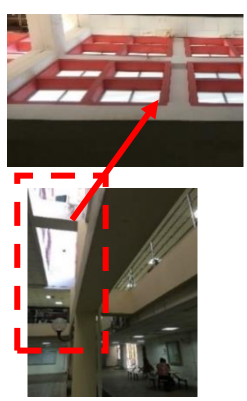
<table>
<tr><th>Atrium</th><th>Simple Layout Plan</th><th>Simple Cross Sectional View</th><th>Area / Height</th></tr>
<tr><td>FKAB</td><td>
</td><td>
</td><td>Area: 159.3m2
Height : 12m</td></tr>
<tr><td>FEP</td><td>
</td><td>
</td><td>Area: 343.4m2
Height : 5.8m</td></tr>
</table>

Note: The atrium area is indicated by the red dashed lines.

2.2 *Top and Side Configurations of Selected Atriums*

Table 2 shows the top and side configurations of the atriums. The top configurations of the atriums are dissimilar in term of the design and materials. Meanwhile, the side configurations are different in term of the surrounded spaces, the amount and locations of the openings, as well as the locations of corridors that function as the air flow paths.

Table 2 Top and Side Configurations of the Atriums

Atrium	Top Configuration	Side Configuration	Description
FKAB			Top: -The ceiling is finished with gypsum boards. Side: -There are spaces like vertical shafts with glass louvers on both sides of the atrium. -There are corridors at two sides that connect the atrium with the outdoor.
FEP			Top: -The top is made of transparent roofing material which is clear polycarbonate

			skylight. The skylight is supported by high tensile rolled steel structure. Side: -There are three sides that face the building blocks. While the other one side faces a small courtyard. - There are corridors at two sides that connect the atrium with the outdoor.

2.3 *Field Measurement*

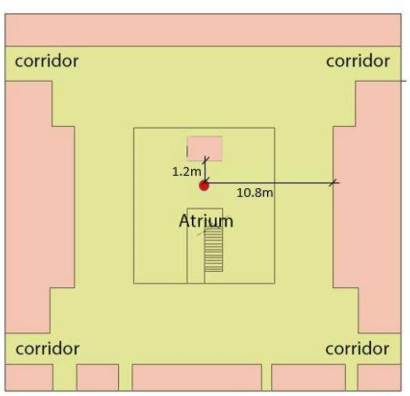
The field measurements for the selected atriums were executed at different times. The measurement for the FKAB's and FEP's atriums were conducted for five days in March 2018 and four days in April 2019, respectively. Both measurements started from 9 am to 5.59 pm. The duration for the field measurement was considered acceptable as it was also similar to the study executed by Huang et al. (2019). Though there was almost a year gap between each field measurement, the outdoor environmental data indicated no major difference, except for the wind velocity as shown in Table 4. This is due to the climatic condition of Malaysia which has constant air temperature and relative humidity all year round. The outdoor environmental data for both field measurements were derived from the weather station that was located at the roof top of the FKAB's building. The indoor environmental data for the field measurements were recorded at the interval of 5 minutes. The data were then averaged to develop the average hourly data from 9 am to 5 pm.

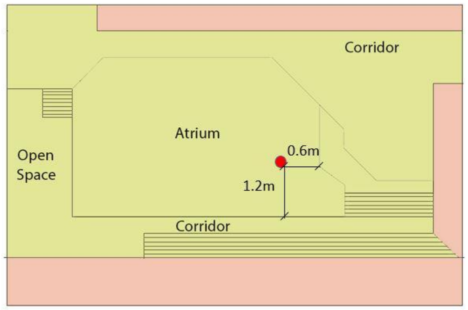
The indoor measurement tool that was utilized for the field measurement was Delta Log10. It is able to measure the environmental parameters such as relative humidity, air velocity, mean radiant temperature and air temperature. It has the measurement accuracy of ± 0.1 °C for the air temperature, ± 0.1 °C for the mean radiant temperature, ± 0.05 m/s for the air velocity and ± 2.5 % for the relative humidity. The calibration of measurement tool was executed prior to each field measurement. The calibration was executed by placing the instrument in parallel with the other measuring instrument when conducting the measurement. The measured data of both measurement tools were compared and the percentages of deviation were calculated.

The calibration of the tool for the measurement at the FKAB's atrium indicated that the percentage of deviation for the air temperature was 0.2 %, for the mean radiant temperature was 0.2 %, for the air velocity was 6 % and for the relative humidity was 6 % also. Meanwhile, for the measurement at the FEP's atrium, the calibration resulted in 0.2 % deviation percentage for air temperature, 0.2 % for mean radiant temperature, 10 % for air velocity and 5 % for relative humidity. During the field measurement, the tool was placed at the height of 1.1 m from the floor level, which is considered acceptable for the sitting and standing positions (ASHRAE, 2017). The location of the measurement tool at each atrium is depicted in Table 3. These locations were selected based on the safety factor of the tool due to the active usage of the atriums.

Table 3 Location of Measurement Tool

<table>
<tr><th>Atrium</th><th>Location of Measurement Tool</th><th>Photo</th></tr>
<tr><td>FKAB

FEP</td><td>
</td><td></td></tr>
</table>



2.4 Questionnaire Survey

The questionnaire surveys for both atriums were executed concurrently with the field measurements. The survey form had two sections. The first section was regarding the respondent's background such as gender, age, height, weight and attire, while the second section examined the respondent's thermal sensation and satisfaction of the atrium's indoor environment. The ASHRAE thermal sensation scale (1: cold, 2: cool, 3: slightly cool, 4: neutral, 5: slightly warm, 6: warm, 7: hot) was utilized in the thermal sensation evaluation (ASHRAE, 2017). Meanwhile, for the respondent's satisfaction, the 7-likert scale (1: very dissatisfied, 2: dissatisfied, 3: slightly dissatisfied, 4: neutral, 5: slightly satisfied, 6: satisfied, 7: very satisfied) was employed. The determination of acceptability by the users towards the indoor thermal environment can be categorized into two, namely the range between the 'neutral' to the 'very satisfied' thermal sensations, or a slightly wider range, which is in between the 'slightly dissatisfied' to 'very satisfied' thermal sensations (ASHRAE, 2017). Nevertheless, in this study, the acceptability percentages of the users were derived within the range of 'neutral' to the 'very satisfied' thermal sensations. The total numbers of respondents were 164 and 102 for FKAB's and FEP's atriums, respectively.

The respondents' data for the FKAB's and FEP's atriums were almost similar as majority of the users were the students and staff. Only small percentages of the users were visitors. For the weight and height categories of both atriums, majority of the respondents were found to be within 40 to 80 kg, and 150 to 170 cm high, respectively. The frequency of usage for both atriums was also similar where most respondents were the frequent users of the atriums. The questionnaire also required the respondent to select the clothing type that he or she was wearing during the survey. The results indicate that the respondents' attires of the FKAB's and FEP's atriums were quite formal to suit the regulation set by the university. Nevertheless, none of the respondents were found to wear thick clothes due to the climatic condition of Malaysia which is constantly hot and humid. Hence, the range of clothing values for the respondents of both atriums were between 0.57 to 1 clo (ASHRAE, 2017). The activities executed by the respondents at both atriums were either walking slowly, sitting or standing, and none of them were found running. Hence, the metabolic rates of the respondents were within the range of 1.0 to 2.0 MET (ASHRAE, 2017).

3. Results

The results are presented on the outdoor and indoor environmental data of the selected atriums, the predicted indoor comfort temperature, as well as the thermal sensation and satisfaction of the users.

3.1 Outdoor and Indoor Environmental Data of Selected Atriums

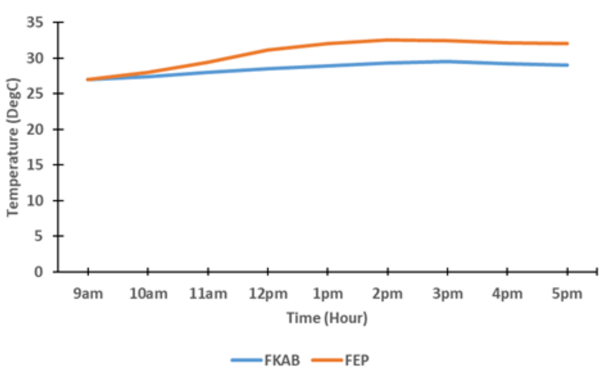
The average outdoor environmental data of the selected atriums are tabulated in Table 4. From the table, it shows that there is no significant difference between the outdoor environmental data of the atriums, except for the average wind velocity. Malaysia is tropical climate country that has almost constant air temperature and relative humidity all year round. The average outdoor air temperature (T_o) was recorded to be within the range of 27 °C to 34 °C, while the average outdoor relative humidity was within the range of 58 % to 94 %. Meanwhile, the outdoor wind velocity for FKAB's and FEP's atriums indicated almost similar values where they were around 0.4 m/s to 2.2 m/s.

Table 4 Average Outdoor Environmental Data of Selected Atriums

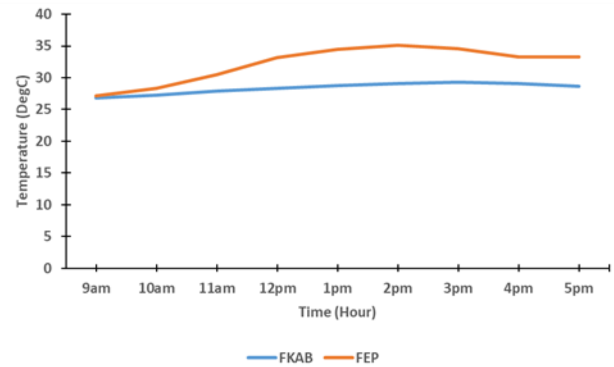
Time	Average Outdoor Air Temperature, T_o (deg C)		Average Outdoor Wind Velocity, V_o (m/s)		Average Outdoor Relative Humidity, RH (%)	
	FKAB	FEP	FKAB	FEP	FKAB	FEP
9am	27.7	27.8	0.42	0.46	86	94
10am	29.7	30.0	0.86	0.67	78	85
11am	30.9	32.0	1.44	1.04	70	77
12pm	30.9	33.0	1.62	1.20	68	70
1pm	32.5	33.5	1.98	1.29	62	69
2pm	33.3	34.0	1.96	1.53	58	66
3pm	33.5	33.2	2.20	1.74	58	68
4pm	32.0	32.3	2.27	1.52	61	69
5pm	30.1	31.4	1.99	1.34	68	72

The results of the indoor environmental data are depicted in Figure 3. The results in Figure 3(a) show a similar trend of both atriums, where the indoor air temperature increased from morning to afternoon, became peak in the afternoon, and decreased from the afternoon to evening. Nevertheless, the average indoor air temperature of FKAB's atrium was found to be less than 30 °C at all times compared to the FEP's atrium. The lowest average indoor air temperature was recorded at 9 am, which was 27 °C for both atriums. Meanwhile, the highest average indoor air temperature was recorded at 3 pm for the FKAB's atrium, with the reading of 29.5 °C. On the other hand, the FEP's atrium had recorded the highest indoor air temperature at 2 pm, with the reading of 32.6 °C. Figure 3(b) demonstrates the average indoor mean radiant temperature of the selected atriums. The results indicate that the FKAB's atrium had lower average indoor mean radiant temperature compared to the FEP's atrium. Similar to average indoor air temperature, the recorded average indoor mean radiant temperature of FKAB's atrium had also not exceeded 30 °C for the entire times.

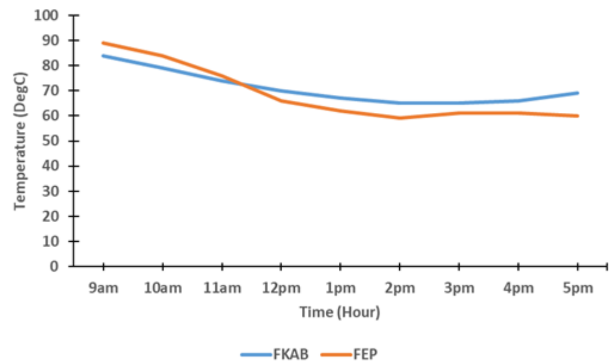
The average indoor relative humidity of the selected atriums is depicted in Figure 3(c). The results show that the average indoor relative humidity indicated similar pattern for all atriums where the highest relative humidity was found to be at 9 am, and it continued to decrease until late afternoon. Meanwhile, from 3 pm onwards, the average indoor relative humidity started to increase. The average indoor relative humidity was found to be higher in FKAB's atrium at most of the times compared to the FEP's atrium. The average indoor air velocity for all atriums is demonstrated in Figure 3(d). The results show that the average indoor air velocity at FEP's and FKAB's atriums were less than 0.3 m/s at all times. At most of the times, lower average indoor air velocity was recorded at the FKAB's atrium compared to the FEP's atrium.



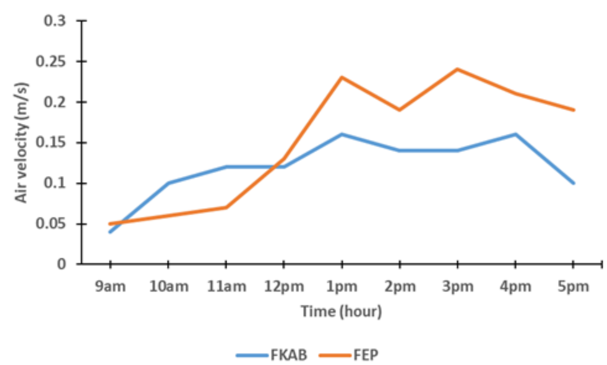
(a)



(b)



(c)



(d)

Figure 3 (a) Average indoor air temperature, (b) Average indoor mean radiant temperature, (c) Average indoor relative humidity, and (d) Average indoor air velocity, of the selected atriums

The measured indoor environmental data are important in calculating the indoor operative temperature. The operative temperature is the temperature that is sensed by the people, where it includes the air temperature, mean radiant temperature and air velocity. The operative temperature of the atrium is utilized in comparison to the thermal sensation and satisfaction felt by the users of the atrium, as well as the predicted indoor comfort temperature. The formula suggested in ANSI/ASHRAE Standard 55 (ASHRAE, 2017) was utilized in calculating the indoor operative temperature (T_{op}), which is as below:

$$T_{op} = A\,T_a + (1 - A)\,T_{mrt} \qquad (1)$$

where T_{op} is the indoor operative temperature, A is the value as a function of the average air speed, T_a is the indoor air temperature, and T_{mrt} is the mean radiant temperature. The value of A was referred to the suggested value by ANSI/ASHRAE Standard 55 (ASHRAE, 2017). Hence, the derived indoor operative temperature (T_{op}) of the selected atriums is shown in Table 5.

Table 5 Average Indoor Operative Temperature (T_{op}) of the Selected Atriums

Time (Hour)	T_{op} (deg C) of FKAB's Atrium	T_{op} (deg C) of FEP's Atrium
9 am	26.9	27.0
10 am	27.3	28.2
11 am	27.9	29.9
12 pm	28.4	32.1
1 pm	28.8	33.0
2 pm	29.2	33.9
3 pm	29.4	33.3
4 pm	29.1	32.6
5 pm	28.8	32.7

Besides calculating the indoor operative temperature (T_{op}), the measured environmental data of the atriums were also used to calculate the predicted indoor comfort temperature of the atriums (T_c). The adaptive thermal comfort (ATC) equation had been used to determine the predicted indoor comfort temperature. The reason for using this thermal comfort model is due to the condition of the atrium which is naturally ventilated. The ATC model is more appropriate for a naturally ventilated building compared to the PMV model due to the constantly changing environment (He et al., 2017). The ATC index embraces the principle that human has the ability to adapt himself or herself in achieving thermal comfort condition. The adaptability can be in the aspect of behavioral adjustment, psychological adaptation and physiological acclimatization (Brager and Dear, 1998). In contrary to the other thermal comfort indexes, the ATC equation is simpler and user-friendly where the main influencing parameter to the indoor comfort temperature is the outdoor air temperature.

The ATC index equation for naturally ventilated building in tropical climate based on the ASHRAE RP-884 database had been specifically developed by Toe and Kubota (2013). Humphreys et al. (2013) had also developed an ATC equation for naturally ventilated building, which was also based on the ASHRAE RP-884 database. However, the equation by Humphreys et al. (2013) was based on the database of various climates, while Toe and Kubota (2013) focused only the tropical climate. The developed equations by both studies are similar in the y-intercept value, but slightly different in the value of the slope of the function. Hence, for this study, the equation developed by Toe and Kubota (2013) had been used, which is as below:

$$T_c = 13.8 + 0.57\,T_o \qquad (2)$$

where T_c is the predicted indoor comfort temperature, and T_o is the mean outdoor air temperature. The results of the predicted indoor comfort temperature (T_c) for all atriums are depicted in Figure 4. These results are discussed in section 4, in conjunction with the field measurement and questionnaire survey results.

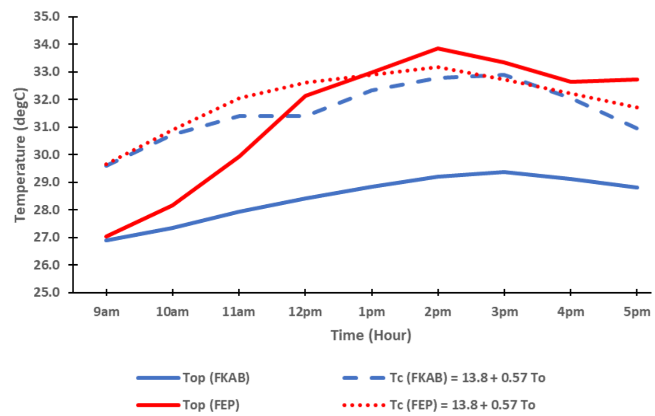


Figure 4 Comparison of indoor operative temperature (T_{op}) and predicted indoor comfort temperature (T_c) of the atriums

3.2 *Thermal Sensation and Satisfaction of Selected Atriums*

In this section, results are presented for the respondents' thermal sensation and satisfaction that were derived from the questionnaire surveys at the atriums of FKAB and FEP. Figure 5 depicts the percentages of thermal sensation of the users for the indoor operative temperature at the FKAB's atrium. The results show that at most of the time, majority of the users felt neutral except at 3 pm and 4 pm. Other than feeling neutral, many users also felt slightly warm being in the atrium area. Nevertheless, there were also some users that felt slightly cool and cool, in which this can be found at all times except at 12 pm. Meanwhile, there were also users who felt hot being in the atrium which were at 2 pm and 3 pm.

The thermal sensations of the users of FEP's atrium are depicted in Figure 6. The results indicate that in average, the thermal sensation that was felt mostly by the users throughout the measurement was either neutral or slightly warm. Most users felt neutral at 9 am, 10 pm, 1 pm, 2 pm and 4 pm. At the other times, the dominated thermal sensation was slightly warm. However, there were also users who felt hot, which was at 3 pm. In general, the morning hours at the atrium provided better indoor thermal environment compared to the afternoon hours.

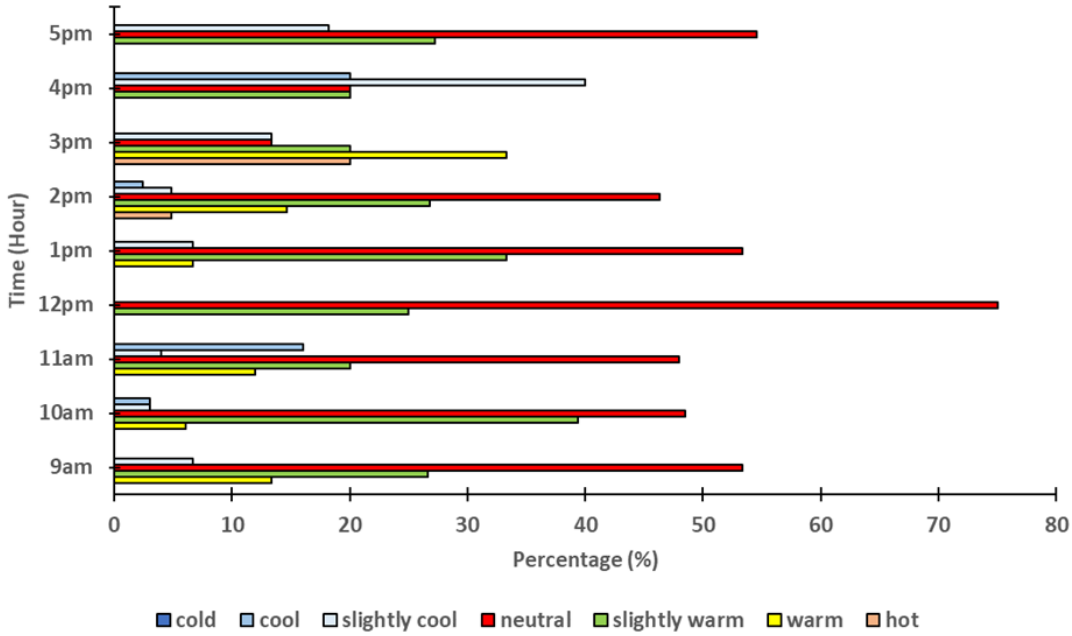


Figure 5 Thermal sensation of the users of FKAB's atrium

Figure 7 demonstrates the percentages of users' satisfaction of the indoor temperature at the FKAB's atrium. It is found that at most of the time, the users felt either neutral or slightly satisfied with the indoor temperature at the atrium area. In addition, the users who felt neutral, as well as satisfied and above are found to be more than those who felt dissatisfied and below at all times, except at 3 pm. Hence, it is found that the indoor operative temperature of FKAB's atrium is acceptable by the users at most of the times, as shown in Table 6. These results are in accordance with the results in Figure 5, where majority of the users felt neutral thermal sensation.

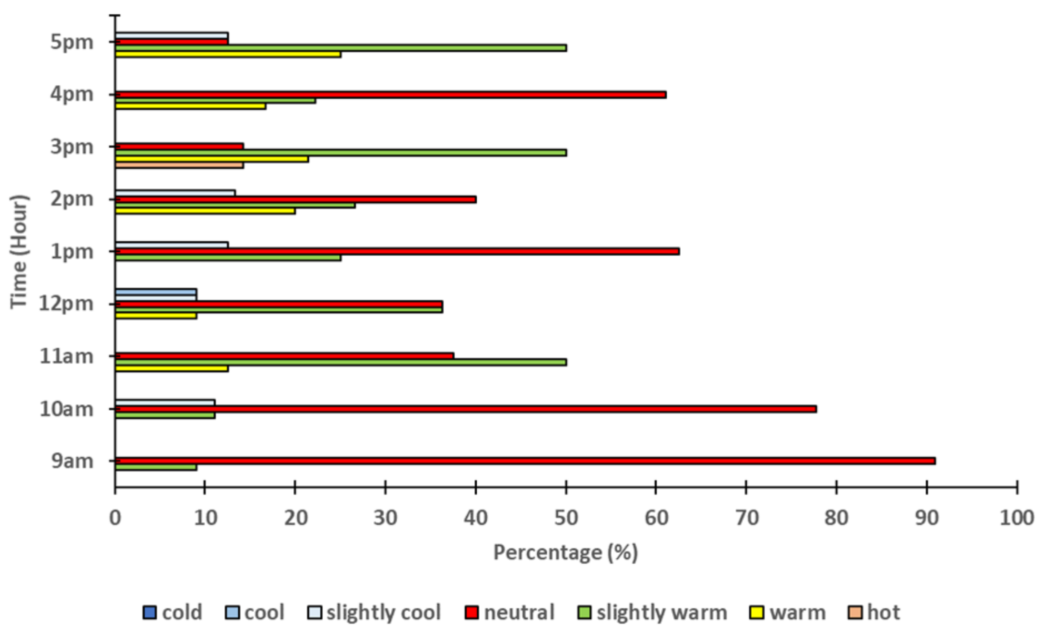


Figure 6 Thermal sensation of the users of FEP's atrium

The results of users' satisfaction of the indoor temperature at the FEP's atrium are presented in Figure 8. The results show that during the morning hours till noon, most users felt neutral, as well as satisfied and above with the indoor air temperature, except at 10 am and 12 pm, where some of them felt slightly dissatisfied. On the other hand, from 1 pm till 5 pm, the number of users who felt slightly dissatisfied and below increased. This is in line with the results in Table 6, where during this time, the acceptability level is below 80 %. The worst condition was found to be at 3 pm, where most users felt slightly dissatisfied, and even some of them did feel very dissatisfied. When comparison is made to the results in Figure 6, it is found that most users felt slightly warm thermal sensation.

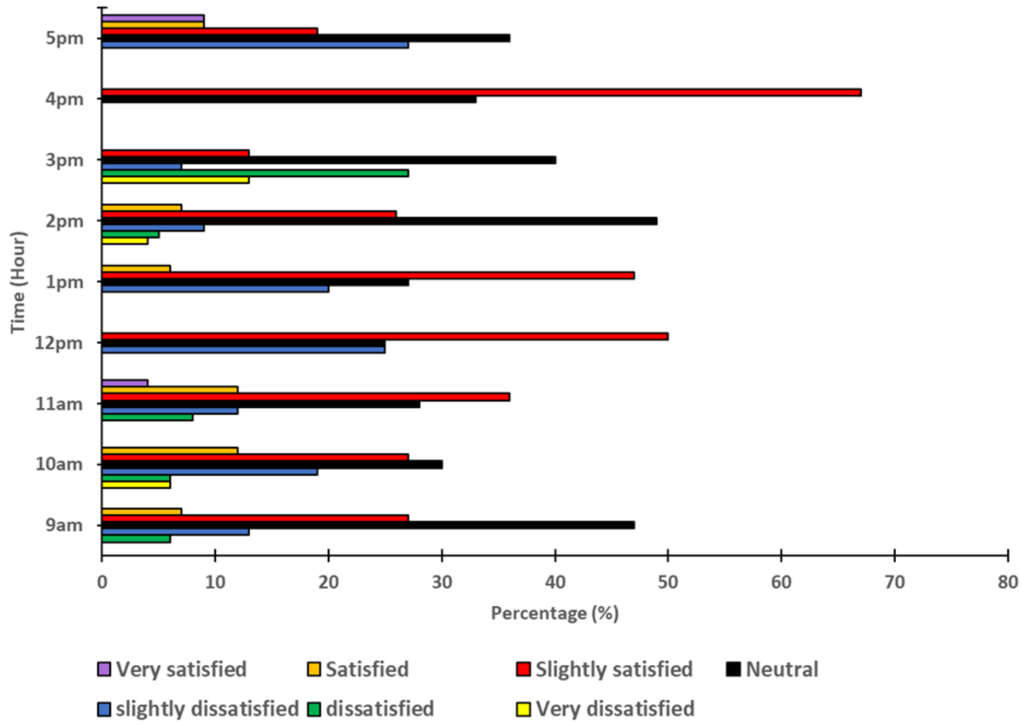


Figure 7 Users' satisfaction of the indoor operative temperature of FKAB's atrium

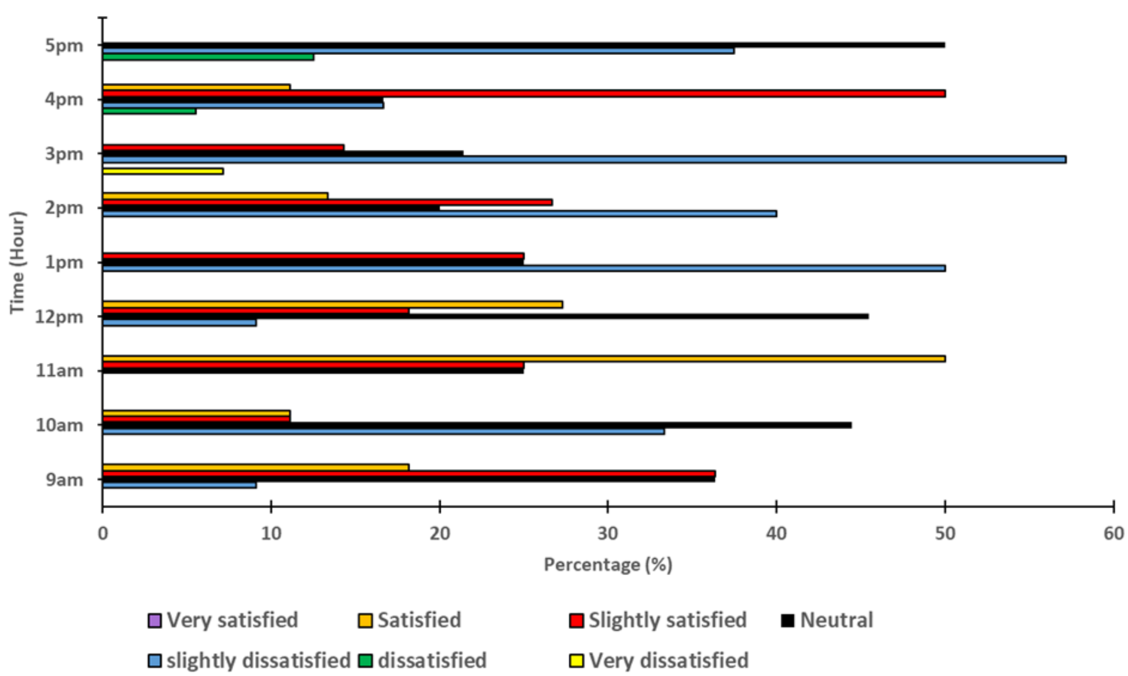


Figure 8 Users' satisfaction of the indoor operative temperature of FEP's atrium

Table 6 presents the acceptability percentages of the users of FKAB's and FEP's atriums of the indoor operative temperature. As mentioned earlier, the acceptability percentages of the users were calculated within the range of 'neutral' to the 'very satisfied' feelings. It is recommended by ASHRAE (ASHRAE, 2017) that the indoor thermal condition is within the comfort zone if the acceptability level achieved is 80 % or more. From the tabulated results, it is found that out of nine hours measurements in both atriums, the FKAB's atrium achieved more hours with the acceptability percentage compared to the FEP's atrium. Nevertheless, the worst condition was found to be at 3 pm for both atriums.

Table 6 Acceptability Percentages of the Users of FKAB's and FEP's Atriums of the Indoor Operative Temperature

Time (Hour)	Percentage of Acceptability (%)	
	FKAB's Atrium	FEP's Atrium
9 am	81	91
10 am	69	67
11 am	80	100
12 pm	75	91
1 pm	80	50
2 pm	82	60
3 pm	53	36
4 pm	100	78
5 pm	73	50

4. Discussion

The results of the indoor environmental data of the selected atriums show similar pattern where the average indoor air temperature increased from morning to noon, and decreased during the evening. Though the average outdoor air temperature recorded the reading of more than 30 °C started from 11 am for both atriums, it was found that the average indoor air temperature of FKAB's atrium remained below 30 °C throughout the day. In contrary, the average indoor air temperature of FEP's atrium started to be more than 30 °C from noon hours and remained high throughout the day. This pattern was also similar to the average indoor operative temperature of FKAB's atrium where it remained below 30 °C through the day. The comparative analyses of the users' thermal sensation also indicated that FKAB's atrium had more hours with majority of the users felt neutral compared to FEP's atrium. Even, there was one time, which was at 4 pm, where majority of the FKAB users felt slightly cool. The FKAB's atrium indicated seven hours with dominated neutral thermal sensation, while FEP's atrium indicated five hours only. For the FEP's atrium, majority of the users felt slightly warm at the other hours. Meanwhile, for the users' satisfaction, it is found that the FKAB's atrium had more hours where the users felt satisfied with the indoor operative temperature compared to the FEP's atrium.

Many previous studies had been executed on the indoor thermal comfort for naturally ventilated buildings in the tropical climate using various methods. The studies had suggested on various ranges of comfort temperature such as 27.4 °C to 28.8 °C (Hwang et al., 2006), 26.9 ± 1.3 °C (López-Pérez et al., 2019), 30.2 ± 0.2 °C (Djamila et al., 2013), and 26 °C to 28.9 °C (Daghigh, 2015). Hence, it can be summarized that the indoor thermal comfort temperature for the naturally ventilated building in tropical climate is within the range of 26 °C to 30.4 °C. In comparison to the average indoor operative temperature of the atriums, it was found that the FKAB's atrium was within the suggested thermal comfort temperature at all measurement times. Meanwhile, for the FEP's atrium, the indoor thermal environments were found to be outside the suggested thermal comfort range started from 12 pm. Nevertheless, there were users who still felt neutral or slightly cool at the times outside of this suggested thermal comfort range. This is due to the findings from the previous studies which stated that some people in naturally ventilated building can accept higher and wider range of comfortable indoor operative temperature (Lau et al., 2019; Hwang et al., 2006; Mishra and Ramgopal, 2014).

The results from the ATC equation by Toe and Kubota (2013) show higher predicted indoor comfort temperature (T_c) compared to the thermal comfort range of 26 °C to 30.4 °C suggested by the previous studies. Nevertheless, the average indoor operative temperature at the FEP's atrium was still above the predicted indoor comfort temperature at most of the times. In contrary, the average indoor operative temperature of the FKAB's atrium was found to be below the predicted indoor comfort temperature at the entire times.

The field measurement and questionnaire survey results show that the top and side configurations of the atrium play significant role in determining the indoor thermal environment. The top of the FKAB's atrium is made of opaque material compared to the FEP's atrium. This opaque material reduces the solar heat penetration into the atrium. On the other hand, the presence of skylight at the top of the FEP's atrium has allowed more solar irradiation into the indoor area. Hence, the side-lit strategy applied at the FKAB's atrium is found to provide better indoor thermal environment compared to the top-lit strategy as at FEP's atrium. This finding is also in accordance with the study by Abdullah and Wang (2012) which stated that the side-lit atrium with clerestory windows provided better thermal comfort than the fully transparent top-lit atrium for tropical climate.

The top configuration determines the penetration of solar heat into the building, while the side configuration influences the ventilation of the building (Huang et al., 2019). Though both atriums are semi-enclosed, but the side configurations have different approaches. The similarity of these atriums is their locations which are at the centre of the building, and surrounded by rooms or spaces. Hence, the corridors that connect the atriums with the outdoor function as the air flow paths. Nevertheless, though FEP's atrium is also located in the middle, it has an adjoining small courtyard at one side.

The results of indoor air velocity measurements have demonstrated that the FEP's atrium had recorded higher average indoor air velocity compared to the FKAB's atrium. Though the outdoor wind speed was recorded to be higher for FKAB's atrium, the side configuration of the atrium also plays important role in determining the air that flows in and out of the atrium. The locations of the corridors are significant in determining the cross ventilation that occurs inside the atrium, as they function as the air flow paths. Based on the layout plans of the atriums, the corridors of FKAB's and FEP's atriums are located at two sides only. However, the FEP's atrium has more advantages in term of natural ventilation as it has the adjoining small courtyard which helps to enhance the natural ventilation. Nevertheless, the FKAB's atrium has openings at the top of the walls which enable the stack ventilation to occur when the cross ventilation is ineffective. In overall, the summarization of the comparative analyses between the two atriums are presented in Table 7.

Table 7 Summary of comparative analyses between FKAB's and FEP's atriums

Criteria	FKAB's Atrium	FKAB's Atrium
Average indoor operative temperature	Remained below 30 °C throughout the measurement time	Started from 12 pm and above, the T_{op} was more than 30 °C
Users' thermal sensation	Out of 9 hours, there were 7 hours that neutral thermal sensation dominated	Out of 9 hours, there were 5 hours that neutral thermal sensation dominated
Users' satisfaction	Out of 9 hours, there were 4 hours that most users felt slightly satisfied and 5 hours that they felt neutral	Out of 9 hours, there were 2 hours that most users felt slightly satisfied, 3 hours that they felt neutral, 3 hours for slightly dissatisfied, and 1 hour for very dissatisfied
Thermal comfort range for hot humid climate suggested by literature	Within the suggested thermal comfort range at all the measurement times	Outside the suggested thermal comfort range started from 12 pm
Adaptive thermal comfort equation	The average indoor operative temperature was below the predicted indoor comfort temperature at the all times	The average indoor operative temperature was above the predicted indoor comfort temperature at most of the times

5. Conclusion

This study examines the indoor thermal environment of two different approaches of top and side configurations of semi-enclosed atriums. The top of FKAB's atrium is fully covered with opaque material, while the top of FEP's atrium is fully finished with transparent material. Meanwhile, both atriums are located in the middle of the building, and they are surrounded by rooms or spaces. The corridors of the FEP's and FKAB's atriums are found to be only at two sides. Nevertheless, the FEP's atrium has the advantage of having adjacent courtyard which helps to enhance the natural ventilation. From the investigation, the indoor thermal environment of FKAB' atrium was found to be at neutral thermal comfort condition felt by the users at most of the times compared to the FEP's atrium. The average indoor air and operative temperatures of FKAB's atrium were also found to be less than 30 °C at all times, though the average outdoor air temperatures were more than 30 °C. Hence, the findings of the study indicate that both top and side configurations of an atrium have significant roles in determining the indoor thermal environment. The findings also show that the top configuration has an effect to the solar heat penetration which influences the indoor air temperature. Meanwhile, the side configuration affects the natural ventilation inside the atrium, which influences the indoor air velocity. In addition, the findings also indicate that the top configuration of the atrium has more influence to the indoor thermal environment than the side configuration. Hence, for the tropical climate, it is important to reduce the solar heat penetration as much as possible into the atrium area, but at the same time does not compromise on the daylighting aspect. In addition, it is also important to enhance the cross ventilation inside the atrium area for the thermal comfort in tropical climate.

Acknowledgements

The author would like to thank the National University of Malaysia (UKM) and the Ministry of Education Malaysia (MOE) for funding the research through research grants GUP-2019-017 and FRGS/1/2019/TK10/UKM/02/4, respectively. The author would also like to thank Liow Shii Ni and Chia Yi Kuan, who assisted the execution of field measurements and questionnaire surveys.

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IJBES

International Journal of Built Environment and Sustainability
Published by Penerbit UTM Press, Universiti Teknologi Malaysia
IJBES 8(2)/2021, 49-61

Different Façade Types and Building Integration in Energy Efficient Building Design Strategies

Muammer Yaman
Department of Architecture, Faculty of Architecture, Gazi University, Turkey

ABSTRACT

Building façades play a major role in improving the effects of outdoor environment conditions on indoor comfort conditions. Façades, which are designed as energy efficiency, are created according to different performance parameters and can offer solutions appropriate for the climatic condition. This paper aims to describe and highlight the role of design and application determinants in building façade types according to energy efficiency in different climatic classes. For this purpose, 12 building façade types in different climate types were investigated and analyzed by a purposive or judgmental sampling technique. Façade analyses have been carried out by considering double skin, adaptive, photovoltaic panel, vertical green, media and structural membrane façades created as a result of developing technological opportunities. Balance of heat loss and gain, preventing overheating, providing daylight and natural ventilation, active and mechanical solutions for climate-sensitive, noise control, recycling and evaluating the initial investment cost are presented. With examinations, it has been determined that different façade systems are innovative construction systems in creating energy efficiency. It has been concluded that the effect of improving indoor comfort conditions of the building by controlling the outdoor environment conditions with the construction of different facade systems is very important in the architectural process. With the development of technology and smart systems, the impact of the façades on the climate analysis and energy efficient design strategies will be much more important in the future.

Article History

Received: *11 December 2020*
Received in revised form: *10 March 2021*
Accepted: *18 March 2021*
Published Online: *30 April 2021*

Keywords:

Façade systems, Façade materials, Building envelope, Energy efficiency, Indoor comfort conditions

Corresponding Author Contact:

muammeryaman@gazi.edu.tr

DOI: 10.11113/ijbes.v8.n2.732

1. Introduction

In the process from past to present, there has been a great increase in the amount of energy used on a global scale. The increase in energy use causes the deterioration of the natural systems globally. Depletion of the existing energy resources makes it necessary to turn to alternative energy sources. The sustainability of human and nature harmony in order to meet the basic needs of the users is created by analyzing the energy production-consumption at the optimum level. Especially when the energy uses of the century we live in is considered, the need for clean, inexhaustible and renewable energy resources is increasing day by day. Solar energy (passive, active, thermal and daylight), wind energy, biofuel energy, hydroelectric energy, ocean energy, geothermal energy and hydrogen energy are used as renewable energy sources (Lechner, 2015).

The most of the energy is consumed by buildings. Buildings aimed at providing the comfort conditions of the user are in an important position in terms of consuming energy. Considering the building life cycle, energy is an indispensable element for the building. There are differences in the increase in energy use in buildings and its global distribution. By following the traces of the past in sustainability and energy use, future evaluations and inferences are made. Recently, buildings that are self-sufficient within the framework of the building life cycle and independent buildings for energy have been designed and constructed (Oh et al., 2017).

Building envelope is of great importance in evaluating energy use in the building. In balance of heat loss and gain, particular attention should be paid to façade (exterior wall, door and window and façade openings), roof / ceiling and floor elements in proportion to heat losses (Shoubi et al., 2018). Approximately 60% of the heat losses occurring throughout the building in the residential where the most intensive vital activities are carried out are due to façades, 25% due to roofs / ceilings and 15% due to floors (Figure 1). In this case, building façades, one of the components of the building envelope elements, are of great importance in creating and improving indoor comfort conditions and in sustainable design.

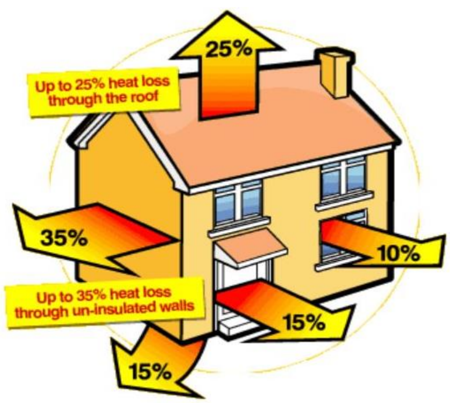


Figure 1. Distribution rate of heat losses in the building envelope (Haringey Council, 2017)

The evaluation of energy uses at the building and its systematic regulation in the building life cycle reveal the energy efficient building design process. In energy efficient building design, climatic data, context, building location, building form and façade components of the building can be taken as performance values. They are the building envelope that separate the outdoor environment and the indoor environment in the determination of performance properties, control the outdoor environment and enable the indoor comfort conditions to be design in the most appropriate solution. From this perspective, façade elements should be investigated in the design process and equipped with high performances in order to create the most appropriate values desired in the indoor environment (Manioglu and Koçlar Oral, 2010). In the design of the façade; the location of the façade, the location of the façade relative to other building façades, the orientation (direction) and form of the façade, the properties of the building façades, natural ventilation systems applied to the façade, and solar control systems applied to the façade are important parameters. In buildings, it is necessary to create a façade design that can adapt to the climatic conditions of the location, reduce energy and resource consumption and control outdoor environmental effects. The availability of different façade materials and advanced technical facilities play an important role in the development and advancement of façade construction systems.

In the historical process, depending on the technological possibilities and the development of building materials, the building façade systems have changed and transformed. When we systematically examine building façades according to the number of layers; we see it as single skin and double skin façades (Yesilli, 2016). However, in today's conditions, façade diversity has increased depending on different façade system solutions and performance requirements. Different façade configurations have been created as developed double skin, adaptive, photovoltaic panel, vertical green, media, structural membrane façades. Different performance requirements are revealed in the energy efficient use of façades with different design processes according to different climate types. In the scope of the literature, the efficiency obtained from the façades in energy efficient façade designs; climate data are shaped according to indoor comfort conditions and façade formation. Recently, buildings are created with Virtual Reality (VR) and Virtual Design and Construction (VDC) concepts are obtained. Simulations are used by means of Building Information Modelling (BIM) systems that develop with the stratification of performance evaluations and building integrated systems and future usage scenarios are estimated. Along with Virtual Reality (VR), optimization models for different parameters are also used for façade performance data (Loonen et al., 2014; Si et al., 2016; Huang and Niu, 2016; Giuda et al., 2019).

In this paper, the design and application of different facade types in different climatic zones are emphasized. Study has been conducted through the responses of the facade types created according to different climate scenarios to indoor comfort conditions. Within the scope of the study, the contribution of the use of new generation materials and technologies on a global scale and the construction of energy efficient facade systems to the building has been analyzed and evaluated. As a result of the study, suggestions for energy efficient facade design strategies are presented.

2. Literature Review

Building envelope has a great effect on the creation of energy efficient building design. Precautions to be taken in the building envelope contribute to the creation of indoor comfort conditions. Precautions should be taken according to energy efficient building design strategies in the façade design, which are one of the most important components of the building envelope. There are some basic criteria for designing high performance and smart façades in terms of energy efficient buildings:

- The position of the building and the shape of the form according to the influence of the sun,
- Design of shading elements to control cooling and heating loads,
- Use of natural ventilation to increase air quality and reduce cooling loads,
- Minimizing the energy used for mechanical heating and cooling systems and artificial lighting by optimizing exterior wall insulation and natural lighting (Aksamija, 2015).

The most important factor in the creation of high performance façades is the correct determination of the climatic conditions and their transfer to the process in façade system designs. Climatic properties; it affects the energy control mechanisms in façade design, material and system selection and façade setup according to the interior performance requirements (Kumar and Raheja, 2016) In general, there are performance characteristics expected from the façade according to heating and cooling-dominated climate, mixed climate types depending on climatic parameters (Table 1).

Table 1 Façade performance characteristics according to climate types (Aksamija, 2015)

Climate Type	Design Strategies in Sustainable Façades
Heating-dominated Climates	• Solar collection and passive heating: collection of solar heat through the building envelope. • Heat storage: storage of heat in the mass of the walls. • Heat conservation: preservation of heat within the building through improved insulation. • Daylight: use of natural light sources and increased glazed areas of the façade, use of high-performance glass, and use of light shelves to redirect light into interior spaces.
Cooling-dominated Climates	• Solar control: protection of the façade from direct solar radiation through self-shading methods (building form) or shading devices. • Reduction of external heat gains: protection from solar heat gain by infiltration (by using well-insulated opaque façade elements) or conduction (by using shading devices). • Cooling: use of natural ventilation where environmental characteristics and building function permit. • Daylight: use of natural light sources while minimizing solar heat gain through use of shading devices and light shelves.
Mixed Climates	• Solar control: protection of façade from direct solar radiation (shading) during warm seasons. • Solar collection and passive heating: solar collection during cold seasons. • Daylight: use of natural light sources and increased glazed areas of the façade with shading devices.

When the performance parameters of energy efficient building design strategies are considered through the façade systems, system designs of different qualities can be created. Passive systems, active systems and mixed systems (hybrid systems) are examples of system configurations.

Passive systems; are self-operating systems for the conservation and use of energy during the building life cycle. In passive systems, there is no need for energy in the design principles for the use of existing energy in natural resources (Altan et al., 2016). Design decisions are made to reduce heat losses for thermal comfort conditions and to prevent overheating in the interior within the framework of the precautions to be taken in passive systems in the façade installation. Designing shading elements according to the direction of the façades to provide natural light in the interior for optimum light control is frequently preferred in passive systems scale. The design of the parameters for removing the indoor exhaust air and ensuring the indoor air quality (IAQ) using pressure differences and wind are put forward on the basis of passive design strategies. At the same time, the provision of recyclable materials, initial investment cost and noise control mechanisms for the use of energy should be addressed in this regard. The development of material and system alternatives and widely used passive systems should be considered during the building design process and should be operated in integration with the building. As a result of the application of passive systems, different façade system proposals for heating, cooling and thermal energy storage emerge within the context of the building (Figure 2).

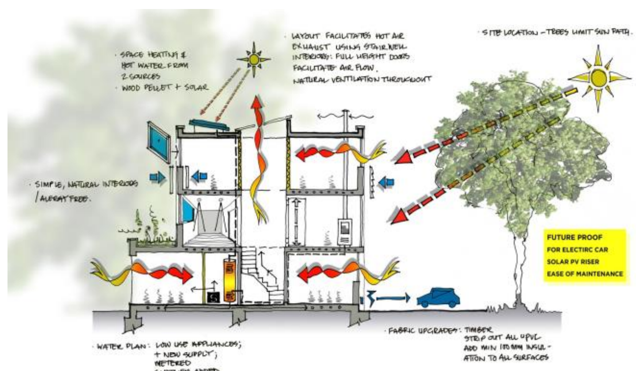


Figure 2 Designing passive system design strategies from the façade (Arch Monarch, 2020)

Active systems; include systems that contribute to energy efficient building design by taking part in the construction and operation of passive systems. These are the subsystems that make the control mechanism of the façade elements mobile when the climatic conditions are variable and the day-night / yearly climatic data are not stable. Active systems are known as adaptable, adaptive and kinetic façade systems in building façade systems. Self-extinguishing of lights, opening and closing of ventilation systems at different parts of the day, deflection of sunshade and photovoltaic elements on the façade and similar examples are used within the context of active systems (Kang et al., 2016). Having active systems creates a great performance value in energy efficient building design. The high initial investment cost is a design parameter that should be evaluated in today's buildings. In the evaluation of design and cost analysis, active systems should be considered as a future investment and cost-benefit analysis should be done in the long run.

The increase in zero-energy building designs in the future cannot be built only with passive or active systems. The location of the design, the resources it uses, the cost of formation and emission regulations should be designed and operated in the most appropriate way (Torcellini, 2006). This situation directs the designer to use active and passive systems together, designing the building in an energy efficient way according to the desired performance values at the building scale. Hybrid (mixed) systems emerge with the use of active and passive systems integrated with each other. Active sun shading elements, steam cooling systems, elements for indoor use of wind for ventilation purposes are within the scope of hybrid systems.

3. Different Façade Systems in Energy Efficient Building Design Strategies

Different performance properties affect the design and application of building façades. Providing performance properties for energy efficient building design has an important role in terms of user comfort conditions. For this reason, stability, utility, beauty (firmitatis, utilitatis and venustatis) should be established as the basic properties expected from the building façade. When we look at the time period we live in, it is observed that different detail solutions are produced with different materials. The use of different materials has provided the advantages and disadvantages of facade construction systems. In this context, the project design team is expected to apply energy-efficient building design strategies and create the most appropriate solution suggestions in the process of designing building façades in the light of stability, utility and beauty principles.

3.1 Double Skin Façades

Double skin façades are passive façade systems formed by adding a second façade to the first façade of the building. In the system, which is divided into two as inner layer and outer layer, the cross section gap layer varies between 20 cm and 200 cm. A continuous air circulation is provided from the gap. Air circulation can take place either naturally or mechanically. In the system, the outer layer is generally formed with a single transparent glass, while the inner layer is formed with low-e glasses or solar controlled glasses in order to provide heat control (Inan and Basaran, 2014). Double skin façade designs have advantages and disadvantages. Their main advantages are providing energy conservation, controlling daylight, reducing interior heating demands, providing ventilation, and providing appropriate acoustic comfort. On the other hand, the most important disadvantages of double skin façade designs are overheating of the gaps, high initial investment costs, and the need for maintenance and repair (Ahmed et al., 2016). One of the most important disadvantages of double skin facade designs is the risk of flame and smoke being carried to the top points quickly with the chimney effect during fire (stack effect).

Double skin façades have shown a lot of development space regardless of the building class. It provides the formation of high performance façades with the solution suggestions it brings to building materials and building performance. Double skin façades are classified according to the partitioning of the façade, type of ventilation and type of air flow (Figure 3). The expected double skin façade design should be made according to the requirements of the climate characteristics and indoor comfort conditions (Motevalian, 2014).

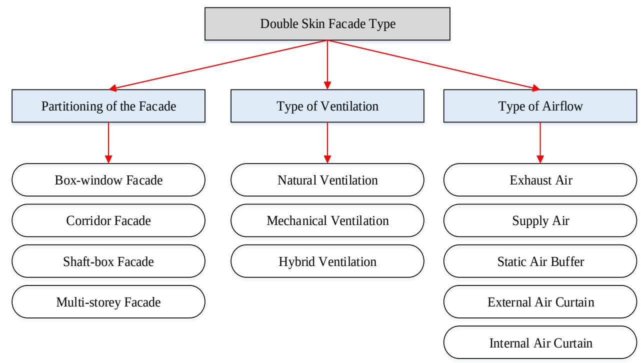


Figure 3. Double skin façade types (Motevalian, 2014)

3.2 Adaptive Skin Façades

These are active façade designs that are made to give a dynamic structure to the façade systems that separate the indoor and outdoor environment from each other and to give them the ability to move. In the design of movement systems, it is aimed to use the outdoor environment effects to create indoor comfort conditions in the most appropriate solution. In the regulation of performance parameters, there are heat, ventilation, vapour flow, precipitation control, use of sunlight, noise control, fire resistance, high stability and aesthetic (visual effect) purposes (Loonen et al., 2015) (Figure 4). Increasing the energy performance inside the building, ensuring daylight requirements and providing the highest level of thermal comfort are among the most basic requirements for façade design.

Movement ability on adaptive façades can be created with a manual system or can be designed with automatic-digital systems. However, the use of digital systems is a more appropriate solution for obtaining high efficiency and its continuity. At the same time, façade design solutions should be provided according to appropriate climatic conditions in building integration (Attia et al., 2018; Attia et al., (2020). According to the climate analysis at the initial stage of the project by the architect and the designer, active façades should be made by means of simulation programs in advance, and cost-benefit analyses should be determined in the future (Sharaidin and Salim, 2012).

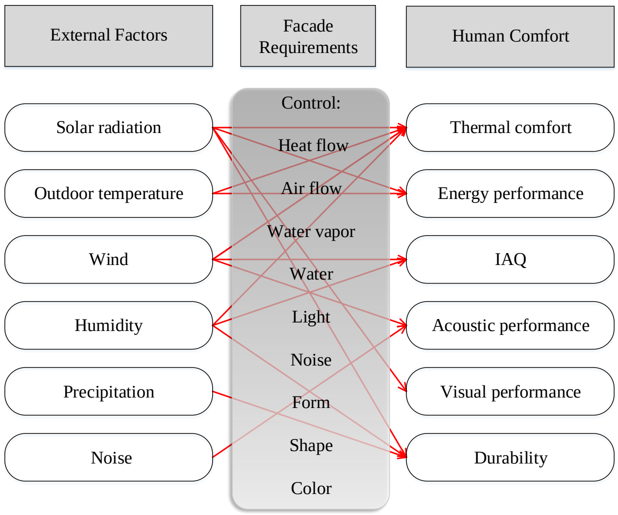


Figure 4 The relationship between the outdoor environment and indoor comfort conditions of adaptive façades (Aelenei et al., 2016)

3.3 Photovoltaic Panel Façades

When the use of photovoltaic panels in buildings is examined, it is generally seen on building roofs. Too much interaction with the sun has been an acceptable indicator of the use of the upper envelopes for this purpose. Today, when we look at the upper envelopes of the buildings, the use of panels on the façades has become widespread due to the change in the form of the roof types, the lack of sufficient space on the roof and the opening of the roof to occupant use. In façade use, the relationship with the sun should be properly designed, and elements that give various shade to the façade should be avoided. The relationship between climatic data and latitude should be considered as the most important parameters affecting the efficiency of photovoltaic panels used in façades. In the efficiency assessment of the use of photovoltaic panels, the annual sunshine duration of the region should be taken into account, and the cost-benefit analysis should be made within the framework of energy production (Grana and Haroldson, 2017).

In the use of photovoltaic panels, there are two different system proposals that can be adapted to the building (BAPV-Building Applied / Adopted / Added Photovoltaics) and building integrated systems (BIPV-Building Integrated Photovoltaics). However, higher efficiencies are obtained from photovoltaic panels that have been involved in the design process throughout the building system design and building life cycle, evaluated and transferred to the project (Snow and Prasad, 2011). Three different system proposals are developed for the use of building integrated systems on façades:

- Photovoltaic panels as façade exterior wall system,
- Photovoltaic panels as façade cladding material,
- Photovoltaic panels as additional elements in the façade.

Photovoltaic panel façades are great importance in finding energy generation in energy efficient building design strategies. Photovoltaic panels transform solar energy, which is an endless and renewable energy source, into electrical energy. As a response to the increasing energy demands in the world, photovoltaic panel types have increased, and a wide range of uses are offered to designers. It is possible to use photovoltaic panels in standard sizes as well as in special production types. (Pagliaro et al., 2010).

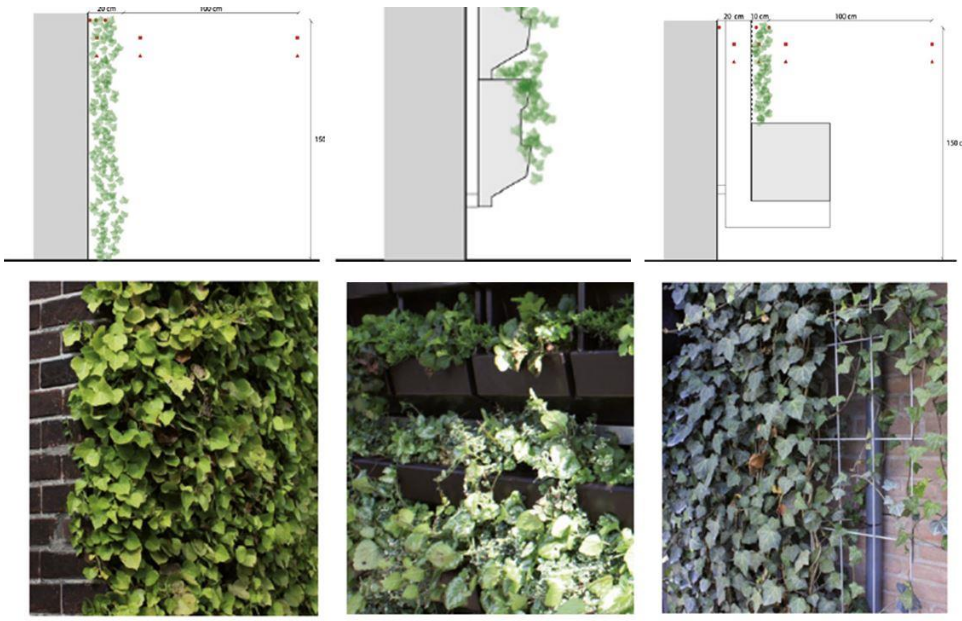
3.4 Vertical Green Façades

Vertical green façades are created with green façade systems with plants in the exterior wall system. Plants on the façade are used to control indoor comfort conditions together with environmental climatic conditions (Elgizawy, 2016). In the creation of the façade design, there are plants, habitat, carrier, filter layer, heat insulation layer, waterproofing layer, vapour barrier layer and exterior wall elements. Layers can be increased or decreased to appropriate design and application requirements.

The design of vertical green façades is especially preferred for the use of soil and plant roots for thermal insulation. The advantages of vertical green systems include reducing the urban heat island effect, increasing the outdoor air quality, providing an ecological balance and providing a habitat for various living organisms, assuming a protective role against rainwater and sun rays, and offering an architectural aesthetic value. It is seen as a disadvantage that vertical green systems require constant maintenance and seasonal changes for design and operation (Aygencel, 2011). Moreover, the initial investment costs should be optimized with the efficiency to be obtained in the process and planting should be made in accordance with the climate in which the building is located.

Different construction techniques are used in the design of vertical green façades:

- Green façades; They are the type of façade formed by wrapping the plant planted in the soil or in a pot on the exterior wall surface (Figure 5a).
- Planted walls; They are the type of façade where the exterior wall surface is used as a plant growing medium and the façade elements are directly active (Figure 5b).
- Living wall systems; They are the types of façade that are suitable for plant cultivation with different secondary elements in the exterior wall system (Figure 5c) (Perini, 2011).



(a) (b) (c)

Figure 5 Design types and application examples of vertical green façades (Perini, 2011)

3.5 Media Façades

Media façades have been used as a communication tool in an architectural design from past to present. It has a great cultural potential, social and technological values along with its commercial, artistic and entertainment uses. While providing an interactive façade for building and city users, media façade components must be properly designed. On the other hand, media façade design components are important in terms of the carrier of the façade, the media façade content, the environment of the façade and the time factor (Moere and Wouters, 2012) (Figure 6).

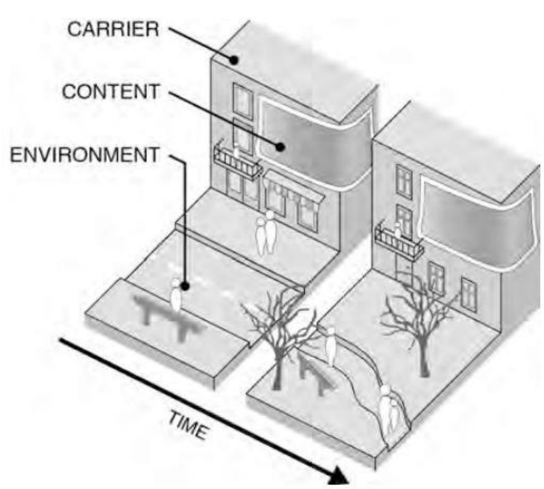


Figure 6 Design of media façades (Moere and Wouters, 2012)

When the purpose of use for media facade design are examined, energy efficient building design strategies should be evaluated. The design of media façades for lighting and visual comfort should be evaluated. Façade design should be planned to provide that visual effect and content resolution provide information transfer appropriately (Lee and Sul, 2017). The overheating risks of the lighting elements (point, strip, panel, etc.) used on the façade should be evaluated and investigated within the context of climate effects. Using kinetic elements, preferring double skin elements, and forming with shading elements, high efficiency is obtained from media façades within the scope of energy efficiency. In the design of media façades, the presence of photovoltaic panels used together with the media façades creates very useful products in terms of energy production. Designing with recyclable materials and using products compatible with technology increases the efficiency of the media façade system.

3.6 Structural Membrane Façades

In the light of developing technologies, a rapid development is seen in structural membrane designs on building façades. Structural membrane façades can be preferred for the design of the precautions that can be taken on the façades to create indoor comfort conditions (Figure 7). When we examine the structural membrane façades, we observe the façades constructed with two different materials:

- Textile façades, façades produced from a composite material consisting of woven elements coated on both sides,
- Foil façades, façades made of thin extruded materials less than 0.4 mm thick (Paech, 2016).

In structural membrane facades used for different purposes in buildings, fire resistance, UV transition resistance, life of the material, light transmittance are important parameters. Polyester (PES), polyvinylchloride (PVC), polytetrafluoroethylene (PTFE), are examples of textile façades as samples of structural membranes used in the façade. Ethylene tetrafluoroethylene (ETFE), ethylene chlorotrifluoroethylene (ECTFE) are samples of foil façades (Paech, 2016).

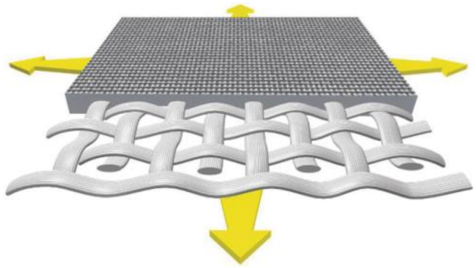


Figure 7 Components of structural membrane façades (Tensaform, 2020)

Structural membrane façades should be evaluated for building energy performance. Recently, it has been used as a single layer in the exterior wall system (especially in stadium structures) as well as a second layer. It has a great effect on reducing energy consumption, daylight control and natural lighting parameters. Playing a role in the improvement of indoor comfort conditions according to climatic conditions and the construction of elements that can be controlled in various designs are the primary parameters that should be evaluated in structural membrane façades (Chiu and Lin, 2015).

4. Methodology

Within the scope of the study, examinations were made on the types of façades that could respond to different outdoor environment conditions. Extensive literature research was carried out by considering double skin façades, adaptive façades, photovoltaic panel façades, vertical green façades, media façades, structural membrane façades as façade system design. The problem of this study is to determine whether there is a homogeneous distribution in the designs of façade types in the world. Using a purposive or judgmental sampling technique (Taherdoost, 2016; Ghauri et al., 2020), a sample group was created for the application of different façade systems, regardless of the building class. The design and energy efficient building design strategies of 12 façades (two samples for each façade type / in different climate types) were evaluated.

As a result of the study, it has been revealed that different façade variations can be used in energy efficient building design and the effect of differences that may occur in terms of performance. Evaluations and inferences have been presented on the energy efficiency and user comfort for the use of façade variations.

5. Data Analysis and Discussion

Recently, as a result of the development of technological possibilities, alternative façade construction systems have increased according to environmental conditions and different climate types. In the field of façade design and application, different façade types have emerged to provide added value data to the building, to plan the cost-benefit analysis appropriately, to apply energy efficient building design for the designers. Two building examples from different climate types for different façade uses were taken and detailed investigations were made (Figure 8). In the light of the data available in the literature and obtained from reliable Internet sources, the analysis of the building façades was made. In the framework of the analysis, the name of the building, its designer, the year of construction, the number of floors, location, usage class, the climate class of the region and the explanations and evaluations regarding the energy efficient use of the facade systems were emphasized (Table 2). In the selected sample group, façade design decisions for different climate types were evaluated and general inferences were made.

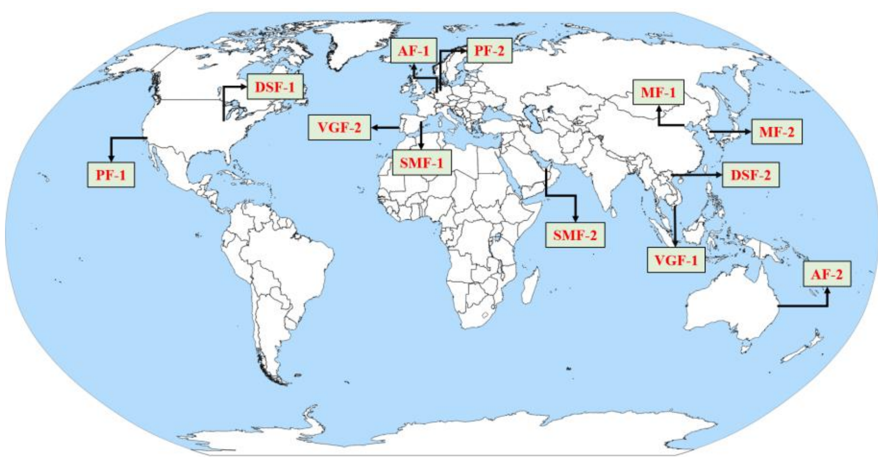


Figure 8 World distribution of the case study samples (Author, 2020)

In the light of the façade samples examined, the result is that different façade system solutions are used at a common point for energy efficient design strategies. The properties of different façade constructions, independent of height, construction year and building class, were examined in detail in the buildings investigated within the scope of energy efficient building design strategies. In the investigations made on different climate classes, transformations and integrated systems were determined to reach the common goal. In the GreenPix-Zero Energy Media Wall sample, a double skin façade, a photovoltaic panel façade and a media façade were designed and applied together. In the advanced stage of the study, the façade samples examined were analyzed according to their façade performances in energy efficient building design (Table 3). The following findings were obtained within the scope of the examined façade samples group:

Table 2 Analysis of different façade systems in energy efficient building design strategies (Author, 2020)

Façade Type / Building Sample		Designer / Architect	Year / Floors	Location	Building Class	Climate Types	Explanations
Double Skin Façade 1 **(DSF-1)**	 The Richard J. Klarchek Information Commons	Solomon Cordwell Buenz	2007 / 2 Floors	Illinois / USA	Office Building	Humid Continental Climate (Dfa) - Köppen	The double skin façade is used for solar control through automation, as well as increasing the indoor air quality. Horizontal blinds hung on the façade reduce the radiant effect and prevent overheating, while at the same time providing a homogeneous natural lighting in the interior. The façade system design provides an energy saving of 52% for building (McLauchlan and Lavan, 2010).
Double Skin Façade 2 **(DSF-2)**	 Brick Passive Designed University	Architects TAISEI DESIGN Planners Architects & Engineers	2017 / 2 Floors	Hung Yen Province / Vietnam	Education Building	Humid Subtropical Climate (Cwa) - Köppen	The building façade designed as a shaft-type façade from double skin façades provides passive ventilation. The use of cleaner and climatically attenuated air in the interior improves the indoor comfort conditions. Energy consumption was aimed to be minimized with passive air conditioning. Improving indoor air quality has been a priority for the humid subtropical climate (Archdaily, 2020a).
Adaptive Façade 1 **(AF-1)**	 Q1, ThyssenKrupp Quarter	JSWD Architekten, Chaix & Morel et Associés	2010 / 13 Floors	Essen / Germany	Office Building	Marine West Coast Climate (Cfb) - Köppen	The sunshade elements used in the façade prevent overheating and glare of the sun's rays in the interior. It rotates at an angle of 90 degrees horizontally and is positioned to be sensitive to external sunlight. At the same time, thermochromic glasses used as facades offer various precautions for light transmittance (Solla, 2010; Güncü and Kurnuç Seyhan, 2013).
Adaptive Façade 2 **(AF-2)**	 Brisbane Airport Domestic Terminal	Urban Art Projects (UAP) and Ned Kahn	2012 / 8 Floors	Brisbane / Australia	Carpark	Humid Subtropical Climate (Cfa) - Köppen	The façade is a 5,000 square meter kinetic design formed by the combination of small elements. 118,000 aluminium panels on the façade move with the effect of the wind. This effect of the façade filters the light transmitted to the interior, while at the same time providing a natural ventilation. The façade system built increases the indoor comfort quality (Designboom, 2020).
Photovoltaic Panel Façade 1 **(PF-1)**	 Green Dot Animo Leadership High School	Architects Brooks + Scarpa Architects	2013 / 2 Floors	Inglewood / USA	Education Building	Mediterranean Climate (Csa) - Köppen	Photovoltaic panels placed on the southern façade as a second layer generate electricity from solar energy. Except for certain transparencies, completely photovoltaic panels are used as façade finishing material. There is no urban facility near the façade that would prevent sunlight. 650 photovoltaic panels were used (Archdaily, 2020b).
Photovoltaic Panel Façade 2 **(PF-2)**	 Monte-Cenis Academy	Jourda & Perraudin	1999 / 2 Floors	Herne / Germany	Mixed Use Building	Marine West Coast Climate (Cfb) - Köppen	Photovoltaic panels placed in a single façade layer were used in the roof and façade integrated into the building. With the transportation of the building with light structural elements, the entire building envelope was formed with transparent elements. By using photovoltaic panels in certain parts of transparent elements, energy production-based efficiency in indoor energy use has been increased (Pasquay and Müller, 2000; Pagliaro et al., 2010).

Table 2 Analysis of different façade systems in energy efficient building design strategies (cont.) (Author, 2020)

Façade Type / Building Sample	Designer / Architect	Year / Floors	Location	Building Class	Climate Types	Explanations
Vertical Green Façade 1 **(VGF-1)**  Stacking Green	Vo Trong Nghia, Daisuke Sanuki, Shunri Nishizawa	2011 / 3 Floors	Ho Chi Minh / Vietnam	Residential	Humid Continental Climate (Dwb) - Köppen	In the project, there is a green façade design constructed in a narrow area of 20 m depth and 4 m width. Plants, which allow for controlled temperate ventilation, are transported through prefabricated panels. At the same time, plants that take sunlight into the building in a controlled manner provide insulation on the façade in terms of noise control (Archdaily, 2020c).
Vertical Green Façade 2 **(VGF-2)**  Patrocinio House	Architects Luís Rebelo de Andrade, Manuel Cachão Tojal, Tiago Rebelo de Andrade	2012 / 2 Floors	Lisbon / Portugal	Residential	Mediterranean Climate (Csa) - Köppen	A green relationship was established with the city by covering most of the façades with plants. A suitable ecological habitat has been created in which 25 different plant species belonging to the Iberian and Mediterranean regions are used in close to 4000. Plants that offer different living spaces for small living organisms provide different scents and clean air quality to the building user (Williamson, 2013).
Media Façade 1 **(MF-1)**  GreenPix - Zero Energy Media Wall	Simona Giostra & Partners Architects and ARUP	2008 / 10 Floors	Beijing / China	Entertainm. Complex	Humid Continental Climate (Dwa) - Köppen	The photovoltaic panels in the system, which works as a double skin façade designed as a media façade, are used to energy production. Obtaining the energy, it needs through panels reduced the cost of the façade and revealed the sustainability values of the building. The building has a façade layout in accordance with its purpose (Howard, 2008).
Media Façade 2 **(MF-2)**  Galleria Centercity	UN Studio	2010 / 8 Floors	Cheonan / South Korea	Shopping and Commercial	Humid Continental Climate (Dfa) - Köppen	The façade is designed as a double skin. The outer layer is created in flat and angled combinations. It provides an optical illusion on the façade. While the DSF provides proper ventilation and solar control, a media façade has been created with lighting fixtures placed on the outer layer. Media façade and luminaires with higher resolutions create a dynamic facade design (Mandaglio, 2019; UN Studio, 2020).
Structural Membrane Façade 1 **(SMF-1)**  Media-ICT	Enric Ruiz-Geli - Cloud 9	2007 / 9 Floors	Barcelona / Spain	Mixed Use Building	Tropical and Subtropical Steppe Climate (Bsk) - Köppen	The façade is created with ETFE panels that have swelling and deflation movement. The system working with nitrogen fog and sensitive to sunlight creates a sun filter. While ETFE panels act as a sunshade with their swelling, they provide thermal insulation with the air buffers formed in the balloon. Different dynamic façade design has been achieved (Eberl, 2016; Shahin, 2019).
Structural Membrane Façade 2 **(SMF-2)**  Hazza Bin Zayed Stadium	Pattern Design	2014 / 5 Floors	Abu Dhabi / UAE	Stadium	Tropical and Subtropical Desert Climate (Bwh) - Köppen	PTFE elements have been added to the façade as a second layer. Elements with an active structure can move around the axis at certain periods. The shading elements provide solar control in the desert climate and at the same time allow cooling with the ventilated façade. These data help the cultivation of lawns by creating a special microclimate area indoors. In the evening, the façade elements can be illuminated with LED systems (Paech, 2016).

- In order to create thermal control, precautions are taken against overheating of the interior environment in all façade types. Shading elements, moving (dynamic) systems and façades designed as secondary layers have been important design elements in preventing overheating. Providing internal air circulation and associating the circulation with the interior are among the façade design decisions generally. However, not all façade types can be used effectively in preventing heat losses. Climatic data affect façade control parameters in this context. Because of the desert climate in the Hazza Bin Zayed Stadium building, preventing heat losses is insignificant.
- In general, various precautions are taken on all façade types to provide lighting control. The healthy use of daylight is considered as an important parameter, especially in the framework of the buildings examined, its homogeneous distribution within the space. In lighting control, some shading element solutions have been offered within the scope of various suggestions on all façades in order to avoid the negative effects of direct sunlight and to protect against harmful ultraviolet rays. In addition, the balanced control of the lighting requirement and the overheating parameters has been resolved in the façade system design before the indoor space. The location, orientation and form of the building constitute the basic parameters that should be examined with the façade components in providing lighting control.
- In order to create the ventilation, solutions were presented to improve the indoor air quality (IAQ) in façade types. Especially on the façades that can be designed as the second layer, ventilation systems are considered and ventilation criteria are provided by creating buffer zones. Passive solution proposals were developed for different façade types for the extraction of indoor exhaust air and for the use of fresh air indoors. The façade elements play the most important role in creating a healthy interior environment. Monte-Cenis Academy, Green Dot Animo Leadership HS, GreenPix buildings have not created high-performance relationships between facade and ventilation criteria.
- Creation of climate sensitive active solutions varies according to façade types. The preference rates are low in terms of managing and supervising the system control mechanism by an expert and creating problems for business continuity. Façade movement and dynamism are not considered in the R. J. Klarchek Information Commons, Stacking Green, Patrocinio House buildings.
- The changing situations in façade types for the creation of noise control, especially the sound of kinetic elements and the use of sound systems in media façades, have different characteristics. In the façade systems recommended in noisy spaces, it is necessary to create high efficiency façades for exterior wall sound insulation. It is important to consider plants as sound absorbers on vertical green façades in terms of noise control.
- The possibility of recycle is one of the main parameters that can be observed in all façade types examined. Choosing building materials that are based on building material life and that offer the possibility of reuse and recycle is a common idea adopted in different façade types.
- It is revealed that façade types are generally not suitable within the framework of initial investment cost eligibility. It is seen to high costs arise especially when compared with traditional façade design methods. However, within the framework of the building life cycle, cost-benefit analysis should be arranged according to energy use analysis. It was deemed appropriate to consider the initial investment costs as a whole within the framework of future costs and to make efficiency analysis.

Table 3. Analysis of different façade systems selected as sample group (Author, 2020)

Samples of Different Façade Systems	Passive Systems				Active Systems	Noise Control	Recycle Opportunity	Initial Investment Cost Eligibility
	Thermal Control		Lighting Control	Indoor Air Quality Control (IAQ)				
	Reduce of Heat Loss	Reduce of Overheating						
(DSF-1)	+	+	+	+	-	+	+	-
(DSF-2)	-	-	-	+	+	-	+	+
(AF-1)	+	+	+	+	+	Variable	+	-
(AF-2)	-	+	+	+	+	Variable	+	-
(PF-1)	+	+	+	-	+	-	+	-
(PF-2)	+	+	+	-	+	+	+	-
(VGF-1)	+	+	+	+	-	+	+	+
(VGF-2)	+	+	+	+	-	+	+	+
(MF-1)	+	Variable	+	-	+	Variable	+	-
(MF-2)	+	Variable	+	+	-	Variable	+	-
(SMF-1)	+	+	+	+	+	-	+	-
(SMF-2)	-	+	+	+	+	-	+	-

Within the scope of the study, two different facade designs from each facade alternative in different climatic zones were considered and evaluated. However, the increase in sample numbers for future studies, changing climate scenarios and creating unique uses in different projects may differ in the use of façade alternatives in energy efficient building design strategies. In the light of climatic data, the basic requirement is that the façade design, which will be used in the creation of indoor comfort conditions, is designed and applied with high performance and smart façade systems.

6. Conclusion

Today, the need for clean and renewable energy is increasing day by day in order to increase the use of energy in buildings and to improve user comfort conditions. In this context, it has important tasks in providing indoor comfort requirement to the building envelope. It is expected that the building envelope will be designed to respond to outdoor environmental conditions (climatic data). Façade systems, especially as a building envelope, must be able to provide appropriate performance conditions at different times of the year. In energy efficient building designs, façade systems should be able to balance changing climatic conditions and user requirements and minimize energy consumption.

Different façade systems are being built with the recently developed technology and building materials. Double skin façades, adaptive façades, photovoltaic panel façades, vertical green façades, media façades and structural membrane façades are the main types of façade construction systems. Façades that offer different design and application possibilities are considered within the framework of suggestions that create energy efficient building design. The use of different façade construction systems provides the design to be created according to climatic data. Within the framework of energy efficiency; balancing heat losses and gains, preventing overheating, provide daylight control, increasing indoor air quality, developing active and mechanical solutions sensitive to climate are qualities that can be applied within the context of different façade systems. Moreover, providing noise control from different façade construction systems and the possibility of using recyclable materials increases the use of façade systems. It is known that the initial investment costs of different façade systems are generally high. However, in the building life cycle, it is necessary to make cost-benefit analyses of energy efficiency and to develop solutions according to the results. Energy efficient design, which is directly related to the building material and building system, can be created with active-passive solutions in different façade systems. The use of integrated systems for different façade systems to create climate sensitivity and indoor comfort conditions is important for active and passive systems to apply together to achieve a high performance façade. It is necessary to design façades that can respond to appropriate climatic conditions with the guidance of experts and façade consultants in the process of building and application the façade design system.

Energy efficient building design strategies, which are developing rapidly in the field of architecture in our country and in the world, are created by selecting materials that provide energy efficiency, high performance, recyclable materials and which are less harmful to the environment for designers. The construction of façade systems, which should be considered within the framework of sustainable architecture, helps the transfer of the three most basic concepts of architecture (stability, utility, beauty) to future generations. It is expected to create energy efficiency by designing facade systems according to the requirements of different interior and exterior environment created according to changing climatic conditions. Increasing the samples selected from different climate zones, differentiation of regional climate scenarios, changing climate data on a global scale and creating different designs specific to the buildings can show different approaches in defining and interpreting energy efficient facade systems. For future studies, researches are proposed on the design and implementation of energy efficient facade systems according to the changing climate scenarios on a regional and global scale, and their ability to respond to different performance criteria based on building usage class. In the future, it is a necessity and an indispensable design concept to design original and different facade systems in accordance with energy efficient design strategies, to create a sustainable world life and to provide values suitable for user comfort conditions.

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IJBES

International Journal of Built Environment and Sustainability
Published by Penerbit UTM Press, Universiti Teknologi Malaysia
IJBES 8(2)/2021, 63-71

Planting Design Approach in Sustainable Urban Planning

Demet Ulku Gulpınar Sekban
Department of Landscape Architecture, Karadeniz Technical University, Trabzon, Turkey

Ertan Düzgüneş
Department of Landscape Architecture, Karadeniz Technical University, Trabzon, Turkey

ABSTRACT

The increased pressures associated with climate change and urbanization processes adversely affect the quality of life of the cities and damage the sustainability of the cities. Sustainability of a city depends on the social, economic and ecological flexible uses that these pressures can tolerate. The examination of these flexible uses within the city brings along the sustainability of the landscape. Landscape serving flexible uses for urban sustainability; All the unconscious elements that make up that landscape, especially the vegetation landscape element, should support the concept of sustainability. Within the scope of the study, it was aimed to determine sustainable design approaches in the fields of planting and to create an evaluation scale accordingly by examining the sustainable planting design approaches in urban scale. An answer was sought to the question of how sustainable the planting activities of Trabzon province are. In the study, 40 studies defined as sustainable landscape areas were examined and 27 sub-parameters were developed under 4 main titles within the framework of these studies. The parameters are examined in the regions represented by the city components that make up the city and it is tried to determine what is necessary for the sustainability of the city.

Article History

Received: *27 July 2020*
Received in revised form: *01 january 2021*
Accepted: *18 February 2021*
Published Online: *30 April 2021*

Keywords:

Sustainable planting design, sustainable planting, sustainable cities, urban planning, Trabzon

Corresponding Author Contact:

demetsekban@ktu.edu.tr

DOI: 10.11113/ijbes.v8.n2.674

1. Introduction

The pace of consumption and disruption of natural resources of humankind as the result of population increase, has now outdone the regeneration speed of the nature (Alberti, 2005). The fact that the nature could not recover the damages it suffered brought about many interrelated problems, and their impacts have become more visible in recent years. Rapid population growth and urbanization, technological developments, industrialization, non-environmentally friendly manufacturing and consumption patterns, as well as faulty policies adopted, are among the main factors causing these sorts of problems.

Disruption on a global or regional scale brought about by deteriorating natural environment as the result of human-oriented utilizations has played an important role in generation of the concept of "sustainability". Sustainability, which is defined as maintaining intactness and continuity of resource values by not exceeding carrying capacity, is a multidisciplinary term (Aklanoğ lu, 2009; Bozdoğ an, 2003; Collins, 1999; Çakılcıoğ lu, 2002). Foundations of the term sustainability were first laid with the Stockholm Declaration adopted by the UN Conference on the Human Environment held in Stockholm, Sweden in 1972. The Second Principle of the Declaration, signed by 113 countries including Turkey, stresses that the natural resources of the earth, including air, water, land, flora and fauna and especially representative samples of natural ecosystems, must be safeguarded for the benefit of present and future generations by means of careful planning (Stockholm Decleration, 1972). However, sustainability could not attain its current status until the

Brundtland Report issued by World Commission on Environment and Development in 1987. It was stated in the 7th chapter of the Report that sustainable development policies and programs should be adopted in order to ensure environmental sustainability and prevent the loss of biodiversity and environmental resources (WCED, 1987). Two separate protocols, namely for the 'developed' and 'developing' members, were prepared in the Kyoto Protocol signed in 1997, as the goals set in Rio Conference had not been attained, so that parties to the protocol could reduce their carbon emissions as low as the targeted limits, improve technologies to attain this goal and, in return, ensure sustainability of the resource values. In 2002, during the World Summit on Sustainable Development, which took place in Johannesburg (South Africa) in presence of the representatives of 191 countries, it was stressed that action schemes and strategies for sustainable development could be revised in the light of the goals determined. In the Rio+20 Summit held in Rio 2012, on the other hand, the concepts of 'sustainable development' and 'green economy' were discussed, and the consensus document called "The Future We Want" was signed by participating nations (SKD, 2016).

Urban settlements, which are the leading actors in disrupting natural ecosystems, hosted more than half of the total population of the world as of 2009 (Status of the World, 2016). Urban areas occupying only 2% of the surface area of the entire world are responsible for 80% of the carbon emission, 60% of water consumption and 80% of wood consumption (Grimm et al., 2008). In this respect, even if they have been the driving force of economic development, urbanized settlements of present day must be re-planned in the sense of sustainability to ensure the survival of natural cycles.

Sustainable cities are expected to consist of flexible systems and networks that have a balanced and harmonious ecosystem in social, economic and ecological terms (Alberti, 1996). Yet, it is not always easy to accomplish the multidimensional planning of such urban systems and networks (Braulio-Gonzalo, Bovea, & Ruá, 2015). That is because cities are rather complex and rigid systems that are in constant interaction with one another in biological and physical terms (Pickett, McGrath, Cadenasso, & Felson, 2014). Sustainable cities, therefore, should be the combination of flexible and living systems that focus on solving environmental problems, meeting ever-changing needs of society and that can resist internal and external threats. In this respect, extra attention should be paid to landscape design, and consequently, the effect of the landscape design on the balance of urban environment in the scope of sustainable urban areas (Coccolo, Kämpf, Mauree, & Scartezzini, 2018).

1.1 Relationship of Sustainable Urban Areas and Planting Design

When the concept of sustainability is combined with landscape, sustainable landscapes are supposed to be environmentally conscious combinations of spaces and systems that play an active role in social life and meet social needs (Gould & Lewis, 2017), because natural and artificial elements of a landscape area generate intra-urban and extra-urban comfort by providing environmental advantages through social interaction, thus increasing the quality of life (Xiao, Dong, Yan, Yang, & Xiong, 2018). Provided we design landscape areas to attain comfort based on the concept of sustainability, can we create living spaces that tolerate the negative impacts of urban areas on the environment in a multidimensional way.

While landscape incorporates habitats supporting urban biodiversity thanks to its green spaces on the one hand, it cleans the urban air by storing the carbon in the air on the other. Aside from these, green spaces increase the quality of lives of urban people as they lessen the effects of heat islands (Atwa, Ibrahim, Saleh, & Murata, 2019; Fitzgerald, 2010; Selman, 2008; Xiao et al., 2018).

In order to be able to benefit from the green spaces of the landscape and contribute to the sustainability of the urban areas, continuity of these spaces within the elements of the city should be taken into account. Designs whose continuity is maintained in the urban elements but their continuity is not ensured in the sense of sustainable designs may end up with spaces that requires excessive use of such resources as water, energy and maintenance. The more the need for resources, the heavier are the risks posed on the sustainability of a given green space. Unsustainable landscape designs turn out to be rather disadvantageous for the urban areas, and bring along environmental, social and economic problems.

So as to maintain sustainability of the landscape, designers must make sure that they use natural and economic resources efficiently and consider design in a multidimensional way (Nikologianni, Moore, & Larkham, 2019). Sustainability in landscape design is a combination of concepts composed of numerous constituents and many 'rights'. The concept of sustainable landscape focuses on three fundamental subjects on the urban scale. First of them is design and protection of natural assets and resources; the second is emphasizing, protecting and utilizing the dynamics constituting ecosystems and multifunctional relationships, and the third is the welfare of inhabitants of the urban areas (Acar, Gülpınar Sekban, & Acar, 2017; Gülpınar Sekban, Bekar, & Acar, 2018; Selman, 2008). Accordingly, it is not always possible to say that every successful sustainable landscape design is suitable or right for any given place, because every urban area is a living metabolism, which has its own characteristics, shaped by its special dynamics, and seeks to meet the needs of only its residents (Maclaren, 1996). Authentic and contemporary approaches should be developed on how the space and landscape will work for any landscape to be designed to ensure that landscape design serves to the understanding of sustainable urbanization, and on how it will interact with the dynamics that constitute the ecosystem, both on local and global scale (Maclaren, 1996; Nikologianni et al., 2019). Such an approach accompanies a set of comprehensive and genuine parameters. American Society of Landscape Architects (ASLA) specified the main components of parameters required for sustainable landscape design as choice of land and placement, vegetation, water consumption, soil, air and energy, waste management and choice of materials, and defined different landscapes accordingly (ASLA, 2018). Defined landscapes can only contribute to the sustainability of the urban areas when all the elements constituting the landscape – especially vegetation elements of landscape- do support the concept of sustainability (Nikologianni et al., 2019). In order to achieve this, planting design, where vegetation elements of landscape are used, must to be planned and implemented in accordance with sustainable design criteria. Plants, the main element of planting design, are ever-changing, developing biological assets that have dynamic characteristics. Therefore, plants occupy an important place in people's lives both functionally and aesthetically. Beyond their importance for human life, plants are such landscape design elements that have aesthetic, economic and ecological functions on the urban scale. Plants help balancing the interaction among users, urban area and nature by adding both visual and functional values to the city. In this way, they ensure the sustainability of the ongoing relationship between the environmental systems and users in the equilibrium of preservation-utilization, which can only be achieved through accomplishing the sustainability of intra-urban green spaces in structural and botanical terms.

In the current study, an answer was sought for the question: "What should planting design approaches be like in sustainable urban planning?" The main purpose of the study is to determine the sustainable planting parameters, for which a consensus has yet to appear in the literature, by assessing them as a whole and to create a rating scale accordingly. In the scope of the study, planting designs implemented within the elements of urban areas were scrutinized. Sustainability status of several already designed and implemented planting areas were discussed as per the generated rating scale. Defaults of parameters deemed necessary for the sustainability of urban planting were spotted. This study is expected to serve as a guide for designers to ensure the sustainability of urban planting schemes to be implemented in the future. In conclusion, deficiencies in sustainable planting designs implemented in the province of Trabzon were highlighted, and further steps were proposed to alleviate sustainability problems of the city.

2. Material and Method

The material of the current study is made up of urban areas located within the borders of downtown Trabzon and that represent specific elements determined according to the method (Figure 1). In the scope of the method, 40 individual studies conducted by American Society of Landscape Architects (ASLA) on The Sustainable Sites Initiative, SITES® were scanned to be able to determine the sustainable planting parameters. Accordingly, 4 main and 27 sub-parameters were identified (Atwa et al., 2019; Braulio-Gonzalo et al., 2015).

Taking the five elements that make up the urban area (paths, edges, districts, nodes and landmarks) (Lynch, 2010) as a reference, sample areas that represent downtown Trabzon were specified, which are;

Paths: Yavuz Selim Boulevard (Tanjat Road), Beş irli Coastal Road, Atatürk Boulevard, Maras Avenue

Edges: Besirli Coast, Atatürk Boulevard, Degirmendere Streambed, Ganita Beach, Trabzon Port, Maraş Avenue

Districts: Besirli, Kalkınma, Kanuni Campus of Karadeniz Technical University, Çamlık, Ortahisar

Nodes: Meydan Park, Ayasofya Junction, Degirmendere Junction, İ tfaiye Junction

Landmarks: Ayasofya Museum, Boztepe Sightseeing Site, Trabzon Airport, Akyazı Stadium, Forum Shopping Center, Ganita

144 experts were administered the "Delphi Survey" (Hess & King, 2002) to identify each and every element that best represents the area it is related to. Then, the same group of experts were asked to score the parameters specified for sustainable planting designs within certain groups of parameters in terms of importance, so as to determine the effect rate of each parameter.

To find the effect rates of the main parameters, initially, sustainability coefficients (SC) of each title were calculated. In order to do that, the sum of scores given by participants (SP) was divided by the number of participants (n).

$$SC_{\text{main group}} = \frac{\sum SP}{n}$$

To find the effect rates of sub-parameters, on the other hand, the sum of scores given by participants (SPP) was divided by the number of participants (n), and as each main title does not contain equal number of sub-parameters, the attained result was divided by the number of sub-parameters (n_p) within each set.

$$ERP=[\frac{\sum SPP}{n}]/n_p$$

In this way, sustainable planting design was evaluated on the scale of downtown Trabzon, and the level of sustainability of the existing planting schemes in the Province of Trabzon was revealed.

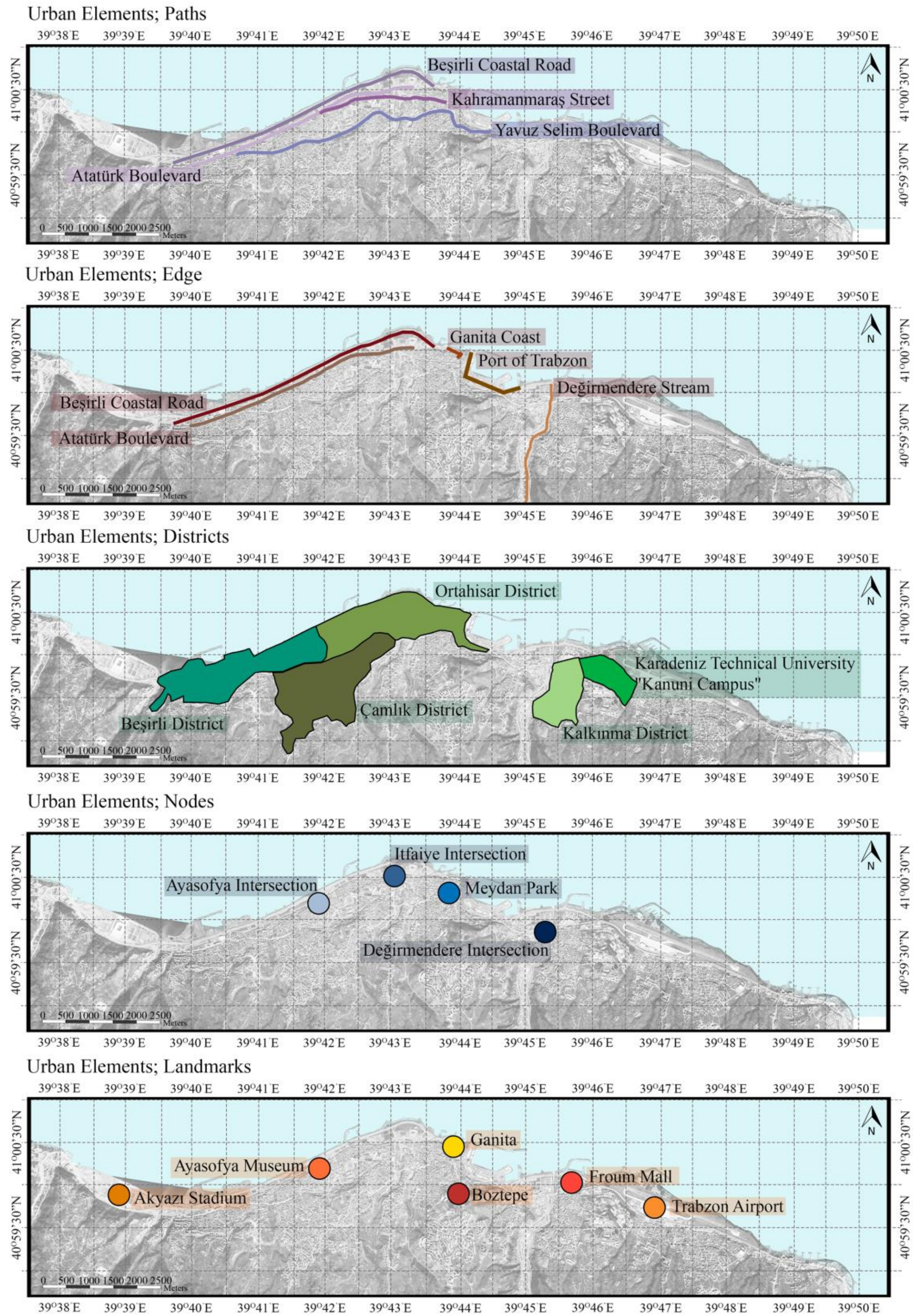


Figure 1 Locations of study areas according to urban elements

3. Findings

Main parameters and sub-parameters identified through literature review are presented in Table 1. The demographical structure of the participants and the distribution of percentages of preference of the specified areas as the result of the Delphi Survey administered to find the areas that best represent the five main urban elements are presented in Table 2.

According to Table 2, 38.21% of the participants specified Maraş Avenue as the *path* element, 29.89% regarded Beş irli Coast as the *edge* element, 36.13% spotted Kanuni Campus of Karadeniz Technical University as the *district* element, 61.12% saw Meydan Park as the *node* element, and 33.36% chose Ayasofya Museum as the *landmark* element.

Table 1 Sustainable planting parameters on the urban scale

Sustainable Planting Parameters	**Parameter Codes**
Material	
Use of natural elements in planting design and implementation	M_1
Use of recycled elements in planting design and implementation	M_2
Healthy specimens of plant species used in planting design and implementation	M_3
Use of natural/endemic species in the area	M_4
Ecology	
Variety of plant species used in the project area	E_1
Majority of species used in planting are natural	E_2
Adaptability of the species used in the design to the climatic conditions	E_3
Tolerance of the species used in the design to air pollution	E_4
The plants used in the area support the variety of animals, meet their needs of feeding, sheltering and safety.	E_5
Existence of a plan and a design for water management	E_6
Existence of an arrangement that will make use of rain water and excess water	E_7
Use of species that are resistant to diseases	E_8
Taking and implementing decisions that are suitable for the soil characteristics	E_9
Inclination of the species used in the design to balance the urban ecosystem and create a micro-climate effect	E_{10}
Management/Maintenance/Economy	
The seed resource value of the plants used	MME_1
Low maintenance need of the area	MME_2
Spatial function of the plants used in design	MME_3
Protection and maintenance plan for plant species with special status in the area	MME_4
Management and maintenance program for the control of invasive species	MME_5
Contribution of the area to the local economy	MME_6
Existence of a soil management plan	MME_7
Planning schemes supporting recycling (i.e. transforming the fallen leaves as compost)	MME_8
Planning/Design	
Contribution of the design to the consciousness of sustainability	PD_1
Suitability of species used in the area for all seasons	PD_2
Compatibility of the design with the topography of the area; support of topography utilization	PD_3
Use of species that have an important place in the culture and/or history of the area.	PD_4
Taking into consideration the criteria of accessibility and guidance in selection of spots for plant species in the design	PD_5

Table 2 Demographical structure of the participants and preference of urban elements

Demographical Structure of Participants			
Gender			
Female	85 Participants	Male	59 Participants
Job			
Landscape architect	46 Participants	Forest engineer	30 Participants
Architect	33 Participants	Others	35 Participants
Urban Elements			
Path Element	**Preference Per.(%)**	**Path Element**	**Preference Per.(%)**
Yavuz Selim Boulevard (Tanjat Road)	16.66%	Atatürk Boulevard	18.05%
Beş irli Coastal Road	27.08%	Maras Avenue	38.21%
Edge Element	**Preference Per.(%)**	**Edge Element**	**Preference Per.(%)**
Besirli Coast	29.89%	Degirmendere Streambed	21.52%
Atatürk Boulevard	14.58%	Maraş Avenue	7.63%
Ganita Beach	13.19%	Trabzon Port	13.19%
District Element	**Preference Per.(%)**	**District Element**	**Preference Per.(%)**
Beş irli	%22,22	Kanuni Campus of Karadeniz Technical University	36.13%
Kalkınma	8.33%	Çamlık	2.08%
Ortahisar	31.24%		

Node Element	**Preference Per.(%)**	**Node Element**	**Preference Per.(%)**
Meydan Park	61.12%	Ayasofya Junction	27.08%
İtfaiye Junction	3.47%	Degirmendere Junction	8.33%
Landmark Element	**Preference Per.(%)**	**Landmark Element**	**Preference Per.(%)**
Ayasofya Museum	33.36%	Boztepe Sightseeing Site	26.38%
Akyazı Stadium	6.25%	Trabzon Airport	9.02%
Forum Shopping Center	14.58%	Ganita	10.41%

According to Table 2, 38.21% of the participants specified Maraş Avenue as the path element, 29.89% regarded Beşirli Coast as the edge element, 36.13% spotted Kanuni Campus of Karadeniz Technical University as the district element, 61.12% saw Meydan Park as the node element, and 33.36% chose Ayasofya Museum as the landmark element.

Then, the coefficients of 4 main parameters and the effect rates of sustainable planting parameters were calculated within their sets. Accordingly, it was revealed that the main parameter "Ecology" had an effect on sustainability by 3.16, "Management/Maintenance/Economy" by 2.55, "Planning and Design" by 2.27 and "Material" by 2 (Table 3).

Table 3 Sustainability coefficients and effect rates of sustainable planting parameters

		Sustainability Coefficients (SC)
Parameter Codes	**Material**	*2*
		Effectiveness Rates of Sustainable Planting Parameters (ERP)
M_1	Use of natural elements in planting design and implementation	0,916667
M_2	Use of recycled elements in planting design and implementation	0,652778
M_3	Healthy specimens of plant species used in planting design and implementation	0,333333
M_4	Use of natural/endemic species in the area	0,597222
		Sustainability Coefficients (SC)
	Ecology	*3,16*
		Effectiveness Rates of Sustainable Planting Parameters (ERP)
E_1	Variety of plant species used in the project area	0,427778
E_2	Majority of species used in planting are natural	0,766667
E_3	Adaptability of the species used in the design to the climatic conditions	0,672222
E_4	Tolerance of the species used in the design to air pollution	0,538889
E_5	The plants used in the area support the variety of animals, meet their needs of feeding, sheltering and safety	0,527777
E_6	Existence of a plan and a design for water management	0,594444
E_7	Existence of an arrangement that will make use of rain water and excess water	0,605556
E_8	Use of species that are resistant to diseases	0,311111
E_9	Taking and implementing decisions that are suitable for the soil characteristics	0,483333
E_{10}	Inclination of the species used in the design to balance the urban ecosystem and create a micro-climate effect	0,655556
		Sustainability Coefficients (SC)
	Management/Maintenance/Economy	*2,55*
		Effectiveness Rates of Sustainable Planting Parameters (ERP)
MME_1	The seed resource value of the plants used	0,680556
MME_2	Low maintenance need of the area	0,805556
MME_3	Spatial function of the plants used in design	0,479167
MME_4	Protection and maintenance plan for plant species with special status in the area	0,493056
MME_5	Management and maintenance program for the control of invasive species	0,486111
MME_6	Contribution of the area to the local economy	0,416667
MME_7	Existence of a soil management plan	0,5
MME_8	Planning schemes supporting recycling (i.e. transforming the fallen leaves as compost)	0,722222
		Sustainability Coefficients (SC)
	Planning/Design	*2,27*
		Effectiveness Rates of Sustainable Planting Parameters (ERP)
PD_1	Contribution of the design to the consciousness of sustainability	0,733333
PD_2	Suitability of species used in the area for all seasons	0,622222
PD_3	Compatibility of the design with the topography of the area; support of topography utilization	0,644444

PD_4	Use of species that have an important place in the culture and/or history of the area.	0,488889
PD_5	Taking into consideration the criteria of accessibility and guidance in selection of spots for plant species in the design	0,511111

Close examination of sub-parameters listed under 4 main parameters according to Table 3 revealed that the “Use of natural elements in planting design and implementation” sub parameter of the “material” parameter had the highest effect rate with a score of 0.916667, while “Healthy specimens of plant species used in planting design and implementation” sub-parameter had the lowest effect rate with a score of 0.333333.

10 sub-parameters were scrutinized under “ecology” main parameter. Findings revealed that “Majority of species used in planting are natural” sub-parameter had the highest effect rate with a score of 0.766667, while “Use of species that are resistant to diseases” sub-parameter had the lowest effect rate with a score of 0.311111.

Among the sub-parameters of “Management/Maintenance/Economy” main parameter, “Low maintenance need of the area” sub-parameter had the highest effect rate with a score of 0.805556, while “Contribution of the area to the local economy” sub-parameter had the lowest effect rate with a score of 0.416667.

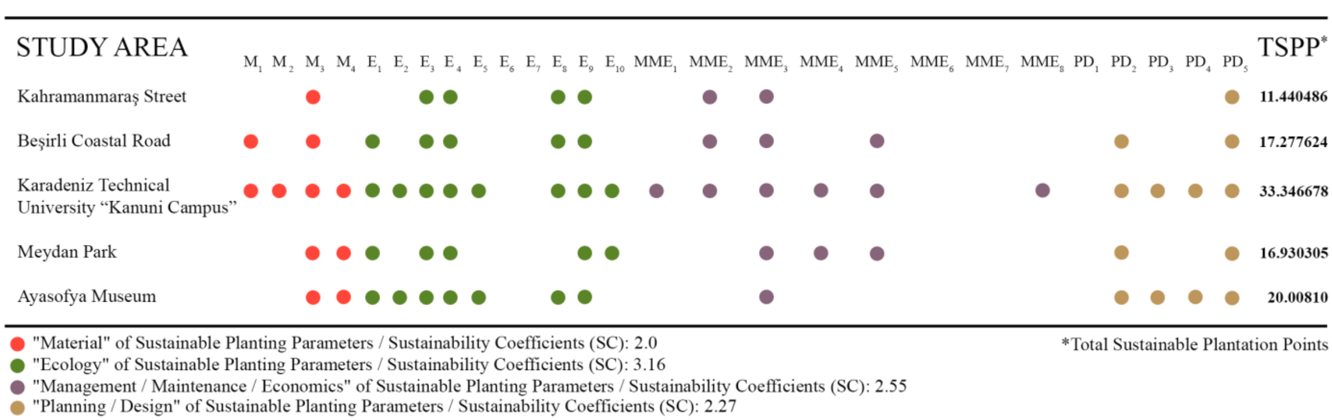
5 sub-parameters were listed under “Planning/Design” main parameter. In this set, “Contribution of the design to the consciousness of sustainability” sub-parameter had the highest effect rate with a score of 0.733333, while “Use of species that have an important place in the culture and/or history of the area” sub-parameter had the lowest effect rate with a score of 0.488889.

When all 27 sub-parameters listed under 4 main parameters in the scope of sustainable planting design were considered, it was seen that the sub-parameter of “Majority of species used in planting are natural” had the highest effect rate among 27 sub-parameters when its mere score of 0.766667 was multiplied by the sustainability coefficient of the main parameter it is related to. Even if the “Healthy specimens of plant species used in planting design and implementation” sub-parameter had an effect rate of 0.333333 in its own set, it had the lowest effect rate among all the sub-parameters with a score of 0.666667 when it was multiplied by the relevant sustainability coefficient.

3.1 Evaluation of Downtown Trabzon in Accordance with Sustainable Planting Parameters

The areas Maraş Avenue, Beş irli Coastal Road, Kanuni Campus of Karadeniz Technical University, Meydan Park and Ayasofya Museum, which constitute the elements of the urban area and which were chosen as the representatives of the elements, were assessed through quantal comparison in respect to their characteristics and parameters (Figure 2).

Figure 2 Evaluation of urban elements according to sustainable planting parameters



At the end of the assessments, it was seen that Maras Avenue scored highest in the “Ecology” main parameter among the 4 main parameters. Examination revealed that the avenue was rather insufficient in terms of sustainable planting parameters. Numerous problems (both botanic and structural) were spotted in Maras Avenue in terms of materials used. Sub-parameter of “Healthy specimens of plant species used in planting design and implementation” scored 0.666667 in the “Material” parameter. We detected that there was no endeavor relating water management of the plant species used and green spaces designed. It was also seen that most of the species used in the area were not domestic ones, rather they were species imported suitably for the climate. With the use of uniform species suitable for climate and soil characteristics, the area scored 6.337554 in the “Ecology” main parameter. In respect to “Management/Maintenance/Economy” main parameter, the area was considered only for spatial existence, no effort could be detected relating the management issues, which is indispensable for the sustainability of a given area. The area scored 3.276044 in “Management/Maintenance/Economy” main parameter and 1.160222 in “Planning/Design” main parameter. Based on these values, Total Sustainable Plantation Points (TSPP) of Maras Avenue is 11.440486.

Besirli Coastal Road scored highest in the “Ecology” main parameter among the 4 main parameters (7.689332). Examinations indicated that recycled materials and endemic species were not preferred in the area. While the area scored 2.5 in the “Material” main parameter, it scored 4.515626 in “Management/Maintenance/Economy” and 2.572666 in “Planning/Design” main parameter. It was observed in the study area that no planning was made to support water harvest and recycling. Based on above-mentioned scores, TSPP of Beş irli Coastal Road is 17.277624.

Kanuni Campus of Karadeniz Technical University scored highest in the “Ecology” main parameter among the 4 main parameters. The investigations indicated that the campus is fairly sufficient in terms of sustainability parameters, yet endeavors on water management were far from being sufficient. On the other hand, it was observed that important steps were taken in using more and a wide variety of endemic species, as well as recycled materials. The area hosts all the sub-parameters listed under “Material” main parameter. While the area scored 5 in the “Material” main parameter, it scored 13.851332 in “Ecology” main parameter, 9.350014 in “Management/Maintenance/Economy” and 5.145332 in “Planning/Design” main parameter. Based on above-mentioned scores, TSPP of Kanuni Campus of Karadeniz Technical University is 33.346678.

Meydan Park scored highest in the “Ecology” main parameter. Observations performed in the area revealed that the park came to a considerable extend in terms of sustainability parameters, but there were numerous deficiencies. Further deficiencies were spotted in the use of materials and in some other sub-parameters listed under “Management/Maintenance/Economy” main parameter. Besides, even if the arrangement of the area aimed at finding spatial solutions, ecological benefits of the materials used were not taken into consideration. While the area scored 1.86111 in the “Material” main parameter, it scored 8.777778 in “Ecology” main parameter, 3.7187517 in “Management/Maintenance/Economy” and 2.572665 in “Planning/Design” main parameter. Based on above-mentioned scores, TSPP of Meydan Park is 16.930305.

Lastly, Ayasofya Museum and its surroundings scored highest in the “Ecology” main parameter among the 4 main parameters. Examination revealed that the area was quite insufficient in terms of sustainable planting parameters. Especially, most of the insufficiencies derived from the “Management/Maintenance/Economy” main parameter. Further planning is needed for the area, which is used as a public space with its unique historical values, in terms of this parameter. While the area scored 1.86111 in the “Material” main parameter, it scored 11.779775 in “Ecology” main parameter, 1.221875 in “Management/Maintenance/Economy” and 5.145332 in “Planning/Design” main parameter. Based on above-mentioned scores, TSPP of Ayasofya Museum and its surroundings is 20.00810.

4. Conclusion And Recommendations

As the result of the conducted study, it was revealed that the concept of sustainability cannot be limited to a single point of view, rather it has to be considered from multiple points of view in areas and designs where decision makers seek a decent level of sustainability. Planting design and implementations are among the primary tasks in open green spaces, which are included in the area of expertise of landscape architects. Therefore, the subject of ‘planting’ is especially important in considering open green spaces in terms of the concept of sustainability. Planting is not only about the species used in the given area. The notion also embraces the materials used in the planted sections of open green spaces, as well as the ecological qualities of the functions used and the contributions made to the nature and urban ecology. On the other hand, economy – which is always stressed in any work on sustainability- poses particular importance in sustainable planting schemes as well, because sustainability of projects which cost considerable amount of funds, requiring huge amounts of efforts and funds for maintenance due to lack of an intact management plan, usually come to a complete breakdown sooner or later. As it is known, design and planning are of utmost prominence in planting, as it is in any other project. The fact that all the decisions taken support the concept of sustainability and are shaped in accordance with this concept is particularly essential in planting efforts, where the subject matter is living beings.

In the scope of the current study, sustainable planting projects were scrutinized through urban elements, and an answer was sought for the question to what extend the existing planting projects in Trabzon are sustainable. To do that, certain parameters were specified with the help of literature, and urban elements were examined according to these parameters. Compared to others, Kanuni Campus of Karadeniz Technical University was found to have far higher Total Sustainable Plantation Points. Apart from ecological concepts, it is very important that the campus is administered in the scope of economic/management and preservation plans. However, the lack of an effort for water management is the main drawback of the campus area.

Maras Avenue, which is located in the heart of Trabzon, attained the lowest scores in terms of sustainable planting parameters. Examining the street works indicated that implementers did a negligent work with planting, and finished the work with only a few plant species scattered around the avenue. Despite the fact that the avenue hosts a dense traffic and it is surrounded by buildings, which is the main problem of the area, further efforts can be made to improve the ecological and environmental characteristics through better planting designs.

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IJBES

International Journal of Built Environment and Sustainability
Published by Penerbit UTM Press, Universiti Teknologi Malaysia
IJBES 8(2)/2021, 73-87

Resilience of Pontian Farmers in the Face of the Impact Changes of Rapid Development in Iskandar Malaysia

Joharudin Samion
Greenovation Research Group, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Malaysia.

Ismail Said , and Tun M Irfan
Greenovation Research Group, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Malaysia

Lee Yoke Lai
Department of Landscape Architecture, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Malaysia.

ABSTRACT

The issues of community resilience arise from the need to develop an understanding of how people would respond to internal and external disturbances. In-depth discussion towards the impact of a city to a neighbouring district has little been discussed. The District of Pontian is located west of Iskandar Malaysia. It has received an unprecedented level of infrastructural development to boost the economy of Iskandar Malaysia. This study examines the land use pattern change of Pontian District impacted by Iskandar Malaysia. Additionally, the study aims to assess the social, economic and environmental capital and the factors that contribute to the adaptabilities and resilience of farmer communities in Pontian. Build-up area for each period using Google earth satellite imagery from the year 2005 to 2015, was classified to analyze the change of build-up area. Markov Chains technique is applied to predict changes of land use. Next, survey questionnaires were utilized to measure the levels of community resilience. Subsequently, an interview was employed to identify the factors that contribute to the stresses. The results indicate that rapid development of Iskandar Malaysia gave an impact to agricultural land and changed the land use pattern of Pontian. The findings revealed the perspective of individuals, community, and system resilience capacity to survive. It was found that farmers were able to adapt to various stresses. The result indicates that individuals and communities can be adaptive, absorptive, and transformative. The findings can assist in formulation of strategies for communities to be better prepared for the current and future impact of the triple threat of urbanization, globalization and climate change.

Article History

Received : *30 July 2020*
Received in revised form: *01 January 2021*
Accepted: *18 February 2021*
Published Online: *30 April 2021*

Keywords:

Community resilience, Iskandar Malaysia, Farmer community

Corresponding Author Contact:

b-ismail@utm.my

DOI: 10.11113/ ijbes.v8.n2.676

1. Introduction

After thirteen years of its existence, Iskandar Malaysia has grown into a region now recognized as a global brand. It started under the 9th Malaysian Plan when southern Johor was identified as one of the national development corridor. Khazanah was given the mandate in 2005 to proposed and came out with a plan to develop a new economic zone in the state of Johor, which was then known as South Johor Economic Region (SJER). The new region will be developed to become a sustainable metropolis with a vision to be known at international level. Since 2006, when Iskandar Malaysia was adopted as one of the economic corridors in Malaysia, Iskandar Malaysia has brought in more focused in the area of economic and infrastructure investments to the optimum level. The established of these new urban conurbation which strategically located at the southernmost tip of Peninsular Malaysia has progressed rapidly and managed to draw in a large number of domestic and international investment. Five local authorities fall under the jurisdiction of the three districts, namely Johor Bahru, Kulai and Pontian are included in Iskandar Malaysia. The five local authorities are Johor Bahru City Council, Iskandar Puteri City Council, Pasir Gudang Municipal Council, Kulai Municipal Council and Pontian District Council. Since Iskandar Malaysia was recognised as the Iskandar Development Region in 2006, it has contributed significantly to the economy of the state of Johor. At the state level, it contributes nearly three-quarters of the state gross domestic product and about 47 per cent of the employment of Johor (Authority, Comprehensive Development Plan ii, 2014).

Seemingly without surprising, urbanization impact on land-use change has now manifested in Pontian district. Moreover, the issue of land use alterations in Pontian for the last thirteen years threatened the communities. Pontian district was chosen because of the acceleration of economic development and infrastructure expansion commencing from Iskandar Malaysia development (refer to Table 1). Certainly, the prominent economic sectors are industry and trade based activities concentrated in Pontian region (Authority, Comprehensive Development Plan i, 2006) where most land banks in this area are agriculture land and mangrove forest. As such, the large tract of its land is purchased by developers and turned into industrial, residential and commercial uses. In short, most of the developments in this district fail to confront Pontian Local Plan (2002-2015) (refer to Figure 1 and Figure 2), and the trend of no confirmation is accelerating to this date. Besides, urbanization threats had to change the social, economic and environmental structure of Pontian communities where most of the communities in the nearby area are farmers and fishermen. Thus, the understanding of the resilience issues and community adaptation is vital. Accordingly, the purpose of this research is to evaluate land use pattern change in Pontian district and its relationship to social, economic and environmental capital applied to community resilience. This research will become a guide for sustainable land use planning and predict the future development direction of Pontian district, which is to reduce the chronic stress imposed on the community.

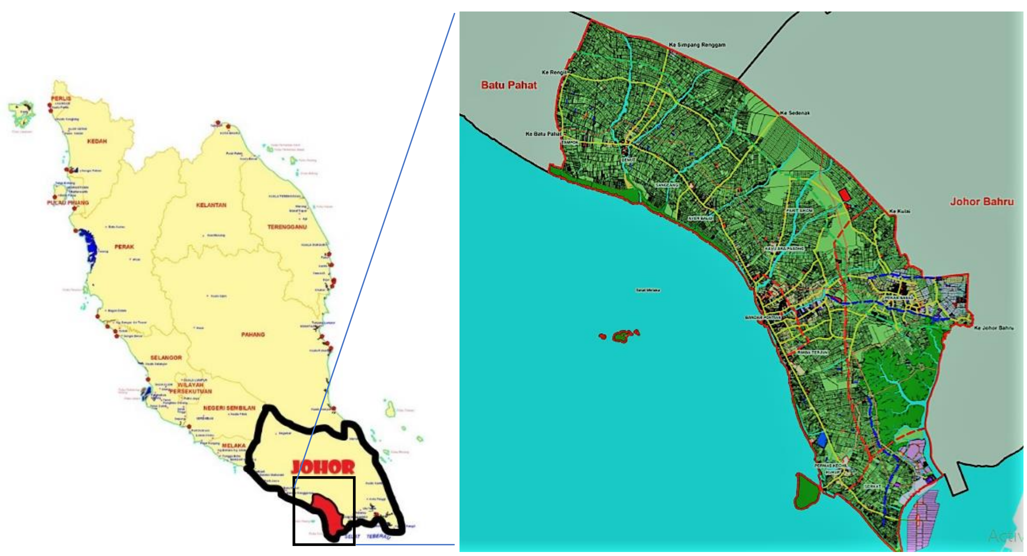


Figure 1 Map of Pontian Source: Pontian District Council Local Plan 2030

Table 1 Land Use 2010 and 2015

LAND USE	2010 (HEK)	%	COMMITED DEVELOPMENT (HEK)	2015 (HEK)	%
Landuse (housing, business, industrial, institution & public infrastructure)	2,552.60	2.99	6,252.82	8,805.42	9.60
Infrastructure & Utility	3,958.55	4.34	18.93	3,977.48	4.63
Forest & RAMSAR	12,182.71	14.26	-	12,182.71	13.29
Agriculture	72,993.04	78.11	-	66,721.28	72.77
TOTAL	**91,686.90**	**100.00**	**6,271.75**	**91,686.90**	**100.00**

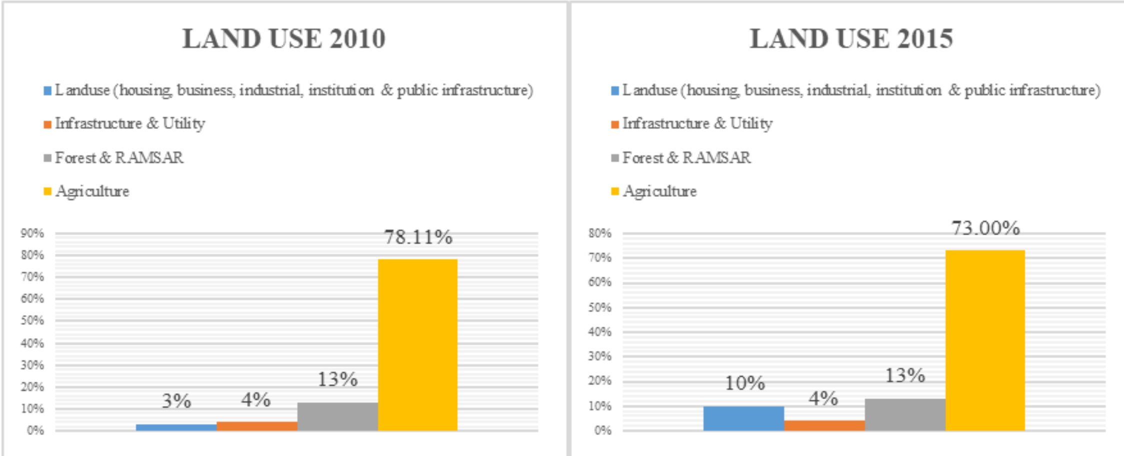


Figure 2 Comparison of Land Use 2010 and 2015
Source: Pontian District Council Local Plan 2002-2015 (revised 2010)

2. Theoretical Background

In general, research on community resilience is still new. The issues of community resilience arise from the need to develop an understanding of how people would respond to internal and external disturbances. Although much study has been done on environmental and social resilience, the study on community resilience has received little attention, and little work exists on the possible interlinkages (Folke, 2006). However, lately, community resilience begins to emerge definitions that are more measured and more practical and realistic. Resilience has been a popular term parallel with sustainability, particularly in the field of urban planning. Indeed, a conception of resilience in urban planning and urban design perspective borrowed from how ecological system studies can cope with the uncertainties triggered by the external factors and stresses (David & Welsh, 2004).

Most resilience studies focus on how each city can withstand or adapt from any potential threat to society, economy, and environment. There are few factors either it internal or external forces found in various literatures can influence the community resilience, such as threats, shocks, perturbation, disasters, hazards, disruption, and disturbances ((Folke, 2006); (Forbes, et al., 2009); (Magis, 2010)). The elucidation of resilience, mainly on communities, responds and reacts towards acute shocks. Acute shocks are referring to an unexpected natural catastrophe (e.g., hurricane, earthquake or volcanic eruption) and very few studies discussed in-depth on rapid development impact against the neighboring district of a city which potentially imposed chronic stresses. Chronic stresses are referring to stresses that imposed to the community due to the physical development. The massive development may create homelessness and unaffordable housing, poverty and inequity, crime and safety, education, healthcare, high unemployment, economic diversity and vibrancy, land use and availability, transportation network, ageing infrastructure, rising sea level and coastal erosion, pollution and environmental degradation (Gordon, 2014). Hence it is essential to investigate how communities, especially farmers in Pontian to adapt and prolonged living to the economy, social and physical development alterations. As development escalates with demand, the more plantation lands are traded with infrastructure, and housing to accommodate the excessive growth in the human population and industrial development. In this study, the community resilience will be measured base on the understanding of the same value interlink concept brought by (Wilson G., 2012) and the adaptation from the chronic stress factors by (Gordon, 2014). Interrelation among three significant components of community development, according to (Wilson G., 2010) has the potential to create different classification of resilience or vulnerability (refer to Figure 3).

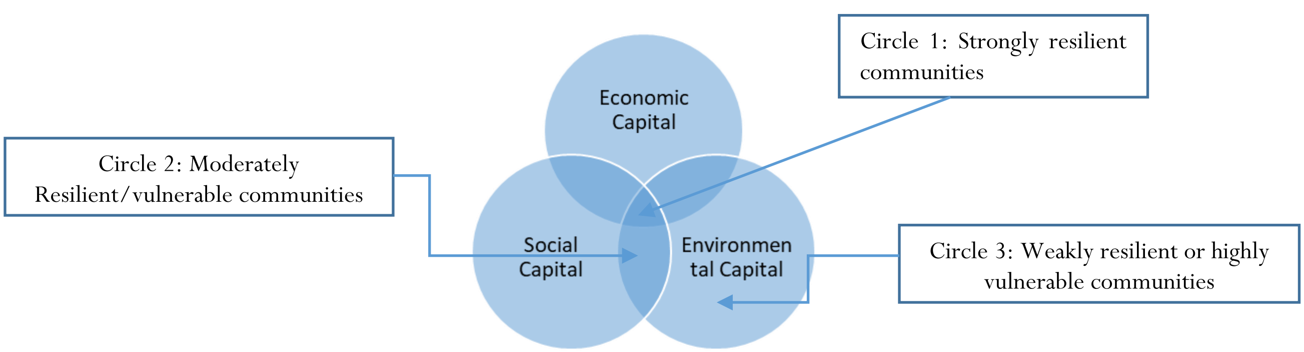


Figure 3 Community resilient and vulnerability measure using economic social and environmental capitals.
Source: (Wilson G. , 2010)

(Wilson G., 2010) designates the centre core (or core area), where there is balanced interception of economy, social, and environmental capitals of the communities. As for communities with any two capitals which are well developed are considered as moderately resilient or vulnerable communities, while for communities with only one developed capital (or none) categorized as weakly resilient or highly vulnerable communities. In short, community resilience would be achieved through efforts to create and maintain the balance needs in economic, social, and environmental capitals. The economic capital of a community generally stresses the importance of maintaining the community's financial stability through a provision of jobs with a more stable income, and diversification of economic activities. In contrast, social capitals highlight the need for self-development among the members of the communities through training and education, for example, by acquiring appropriate skills and knowledge for the current situation and needs. The community social capital of a community also encourages the maintenance of the relationship among the members of the community through participation in decision-making processes, leadership, and organizational structures as well as empowerment of minority (or female) group. Finally, environmental capital gives more emphasis on issues of pollutions and poor management of natural resources. These factors, in turn, are expected to improve the economic wellbeing of the people within the community. The understanding of these indicators will become a guide to formulate the questionnaire to suit with the farmer community that will be measured.

3. Method

There are two steps of analysis. The first step of this research is to investigate the land use pattern change of Pontian from the year 2005 to 2015 and the second step is to evaluate how the land uses pattern impact farmer communities, economically, socially and environmentally.

3.1 Step 1: Analyzing Land Use Pattern Change And Projection

Geographical information system (GIS) and remote sensing were used to investigate the land use pattern change in Pontian district. By assessing the land-use change's pattern in Pontian district, it provided the opportunity to evaluate the fast-growing urbanization process impacted by Iskandar Malaysia. The integration of GIS and remote sensing considered as powerful tool for land use and land cover (LULC) mapping of Iskandar Malaysia and Pontian (Jaiswal, Kumar, & Mukherjee, 1999); (Yagoub & Giridhar, 2006); (Misra, Ankita, R, & Vethamony, 2015); (Mengistu, Daniel, & Salami, 2008). Combined with IDRISI software, it can be used to expand the opportunities and predict the future land use of Pontian district. Data on land-use change in Pontian district measured in five phases, namely, data acquisition, image pre-processing, image classification, change detection, and projection of land use (Figure 4).

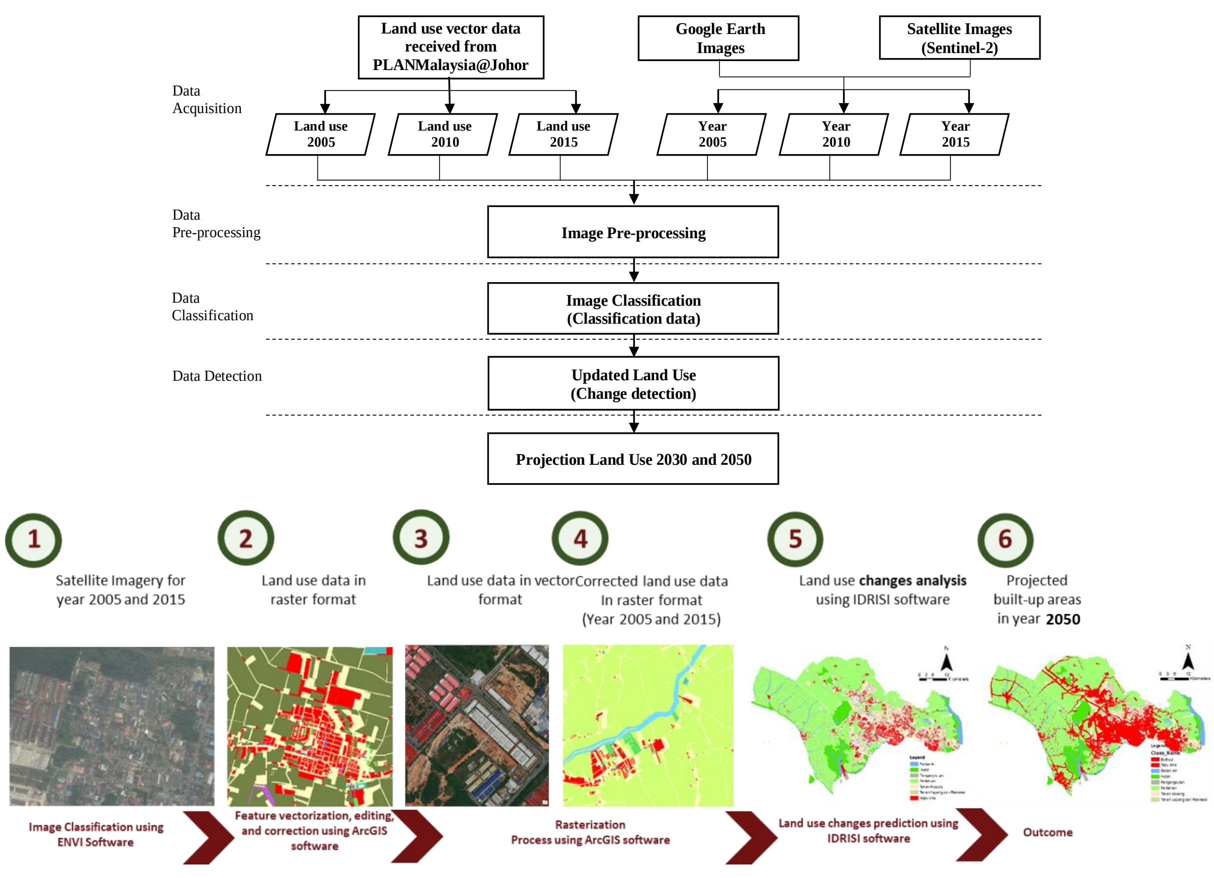


Figure 4 Flow chart of land use data processing and analysis in Pontian district

As shown in Figure 4, the data sourced was from (1) vector data received from PLANMalaysia@Johor, (2) satellite images from Google Earth Images, and (3) sentinel-2 satellite images as raster data. The three different datasets were gathered from periods of 2005, 2010 and 2015 for both vector and raster images. Table 2 displayed datasets.

Table 2 Description of land use datasets of Pontian district

Data	Description	Sources
Vector data: i. Land use data ii. The boundary of Johor district and IRDA	Data received in shapefile format with RSO Projected Coordinate System.	PLANMalaysia@Johor.
Raster data: i. Satellite images	Three (3) different satellite images for the years 2005, 2010, and 2015. The original data of google earth was in WGS84 projection. Then the data were converted to RSO Projection Coordinate System.	Google Earth Images and Sentinel-2 satellite images.

Generally, one of the main objectives of satellite remote sensing is to interpret the object and classify features based on reflectance pixel. Different types of objects on the earth covering Iskandar Malaysia and Pontian district have different spectral reflectance and remittance properties. The purpose of using both of the data format, vector, and raster, is to ensure the updates and completeness of the data (Rizk, Ibrahim, Mosbeh, & Rashed, 2015). It is essential to scrutinize the quality of the data provided by PLANMalaysia@Johor. By given raw remotely sensed imageries, a set of different land cover can be categorized by applying Sentinal-2A images being classified by using ENVI software. This image was chosen due to its excellent characteristics. For instance, consists of 13-bands in the visible, near-infrared, and short-wave infrared, and also provides 10/20 meter of spatial resolution. The output from this process is classified data based on different land-use types in raster format. This result was then used with Google Earth imageries to validate and update the land use data of Iskandar Malaysia, including Pontian district that received from PLANMalaysia@Johor. Change detection from different land-use types and years that is 2005, 2010, and 2015. This process was done by using IDRISI software, specifically Land Change Modeller (LCM) application. LCM is an innovative land planning and decision support system that is fully integrated into the TerrSet software. The complexities of change analysis can be simplified by applying an automated and easy workflow of LCM system. LCM provides efficient analysis of land cover change, empirically model relationships to explanatory variables and can simulate projected land change in Iskandar Malaysia and Pontian district. The process of land use projection can be carried out by applying Markov Chains technique. In general, Markov Chains is a stochastic technique that widely used in identifying the change from one state to another by giving a transition probability matrix (Glenn-Lewin et al., 1992; Hu and Lo, 2007; Cabral and Zamyatin, 2009). The changes in land use patterns between different years would produce a probability transition matrix and further used to predict land use at specified dates.

The mathematical equation of the transition probability, as stated below:

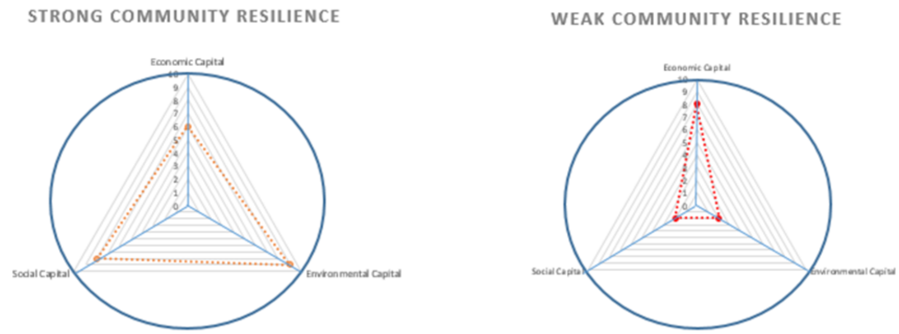
$$\sum_{i=1}^{m} P_{ij} = 1 \quad i = 1,2 \ldots\ldots\ldots.. m \qquad (8)$$

$$P = \left(P_{ij}\right) = \begin{matrix} P11 & P12 \ldots & P1m \\ P21 & P12 & P2m \\ Pm1 & Pn2 & Pmm \end{matrix} \qquad (9)$$

where: Pij = the probability of transition from one land use to another, m = the type of land use of the area studied, Pij values are within the range 0–1.

3.2 Step 2: To evaluate the impact of land-use change on Farmers in Pontian

There are two methods used: questionnaires and interview. Questionnaires will be used to measure farmer's resilience level, whereas interview will be used to identify the factors that might cause the chronic stresses to the farmer community. A total of 30 questions will be used to measure resiliency of farmers in Pontian, addressing economic, social and environmental capitals as an indicator. The question will focus on indicator that helps to identify the critical resilience issues in the context of Pontian farmers. The data analysis section, involving the quantification of resilience for farmer community based on a ranking score from 0 which will be shown as the indication of high vulnerability, to 10, which will indicate strong resilience. The same approach has also been used by (Gahin, Veleva, & Hart, 2003), (Western, Stimson, Baum, & Van Gellecum, 2005), (Thomalla & Klocker Larsen, 2010), and (Nurul Islam, Yew, Abdullah, & Viswanathan, 2011). The specific average scores which then be calculated for each of the three capitals in farmer community to establish an overall average for the economic, social and environmental capital (Refer Figure 5).



Community A
Resilience/Vulnerability score = 7.7

Community B
Resilience/Vulnerability score = 4.0

Figure 5 Hypothetical example of two case study communities with high and low resilience scores based on the quantification of social, economic and environmental capital. Source: (LEDDRA, 2011)

Primary data were based on the standardized questionnaire collected from 5 sub-districts in Pontian within Iskandar Malaysia. Primary data were gathered using quantitative (via questionnaire guided survey), and SPSS 24 software will be used to analyze the result. The survey questionnaire was formulated based on the list of indicators proposed in Table 3 and divided into three capitals. There are 30 questions in total; economic capital with nine indicators, social capital with 13 indicators and environmental capital with eight indicators.

Table 3 List of specific resilient community indicator

Community's Resilient Issues	Proposed Specific Questionnaire
1.Economic Capital	a. Do your income has increased compared to the last 10 years.
	b. Do you have a more stable income now as farmers?
	c. Do you and your family depend on money from relatives living and working outside the community?
	d. There is no need for you and your family household to develop multiple sources of income.
	e. The locally produced goods product only sold locally.
	f. The government give enough financial aids, funds, subsidize and welfare of the community.
	g. You have been involved in making decisions within the community on matters of economic activities.
	h. There are opportunities for new business and potential economic development in your communities.
	i. Do you and the local community can get additional income due to the development of Iskandar Malaysia.
2.Social Capital	a. Do you feel happy with the current situation compared to the last 10 years?
	b. Do you feel proud to be part of the community?
	c. Do you intend to live and continue to stay with the community?
	d. Do you know/trust your neighbor?
	e. Do you got involved in new developing opportunities/projects in the community?
	f. Do you always agreed and obey the decision made by the local leaders and committee members in the community?
	g. Do young people get involved in the decision-making process?
	h. Several agencies and relevant authorities effectively performing their tasks.
	i. Various types of new skill training and knowledge available in the community.
	j. The local knowledge and skills passed on from the older to the younger generation.
	k. New knowledge and skills shared from younger to older generations.
	l. Can you adapt to the changes and the development of Iskandar Malaysia?
	m. Social problem reduced due to the new development of Iskandar Malaysia.
3.Environmental Capital	a. Natural resources still in good condition.
	b. Natural resources were improved and manage well by relevant government agencies.
	c. The necessary infrastructure such as electricity, access to clean water, the road was improved.
	d. A natural disaster such as flood was reduced in your community.
	e. The cultural issue such as "pollution" is not an issue in the community.
	f. Everyone involved in planning and the use of natural resources in the community.
	g. New policy and laws well implemented by relevant government authorities really help the local community.

	h. The government, through relevant agencies, helps solve the issue raised by the local community concerning environmental issues.

An adaptation from: [(Kamarudin, Ngah, Razak, Ibrahim, & Harun, 2014); ((Ekins, Simon, Deutsch, Folke, & De Groot, 2003); (Lebel, et al., 2006); (Smit & Wandel, 2006); (Parnwell, 2007); (Chaskin, 2008); (Cutter, et al., 2008); (Ostrom, 2009); (Magis, 2010); (Oudenhoven, Mijatovic, & Eyzaguirre, 2010) in (Wilson G. , 2012, pp. 22-29)]

The interview was formulated based on the three questions to identify what are the factors that worry them economically, socially and environmentally. Interview will be used to identify the factors that might cause the chronic stresses to the farmer community. Chronic stresses are referring to stresses that imposed to the community due to the development. That may create homelessness and unaffordable housing, poverty and inequity, crime and safety, education, healthcare, high unemployment, economic diversity and vibrancy, land use and availability, transportation network, ageing infrastructure, rising sea level and coastal erosion, pollution and environmental degradation. (Gordon, 2014). The data were gathered using qualitative, and NVivo 12 will be used to analyze the result.

4. Result and Findings

4.1 Land-use Change Detection Analysis and Projection

The outcome of the transformation pattern land use in Pontian for the last 15 years and the investigation of land-use change pattern in Pontian district. Google Earth satellite imagery for the years 2005, 2010 and 2015 was used to generate graphs and maps of the land-use change, including gains and losses, net change, persistence and specific transitions (refer Figure 6.). Each period was classified by using ENVI and ArcGIS software. The result then combined with IDRISI software. MARKOV chain technique is then used to predict the land use built-up area by 2030 and 2050 (refer to Figure 7).

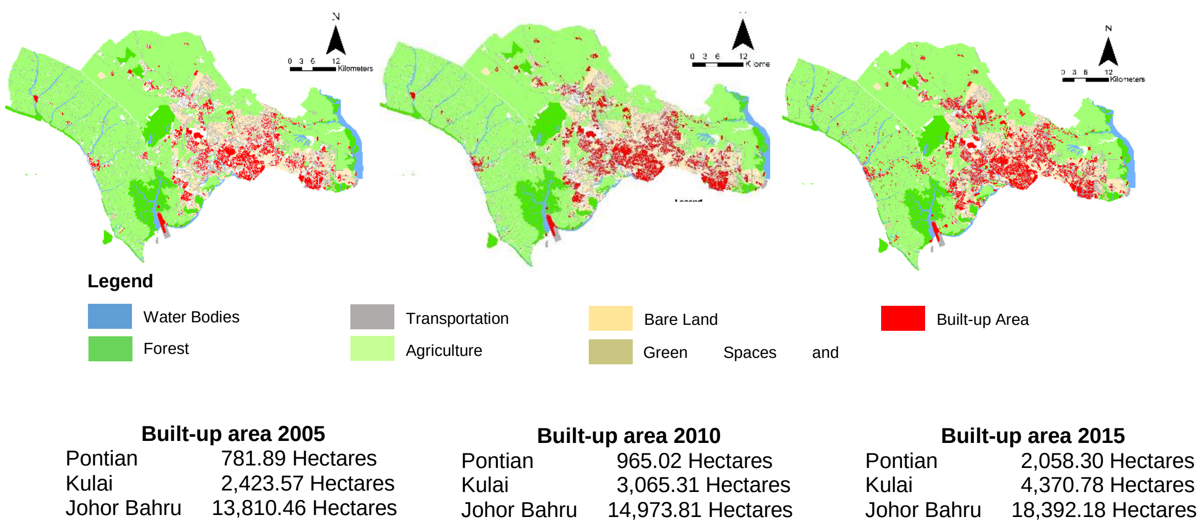


Figure 6 Land use/ land covers 2005, 2010, 2015 generated by using ArcGIS software

The result shows that from three districts within Iskandar Malaysia, namely Johor Bahru, Kulai and Pontian, the district of Pontian mostly affected of percentage of build-up areas. The result shows that there is an increase of 263.2% of the build-up area from the year 2005 to 2015 for the district of Pontian, 180.3% increased for the district of Kulai, and 133.2% increased for the district of Johor Bahru.

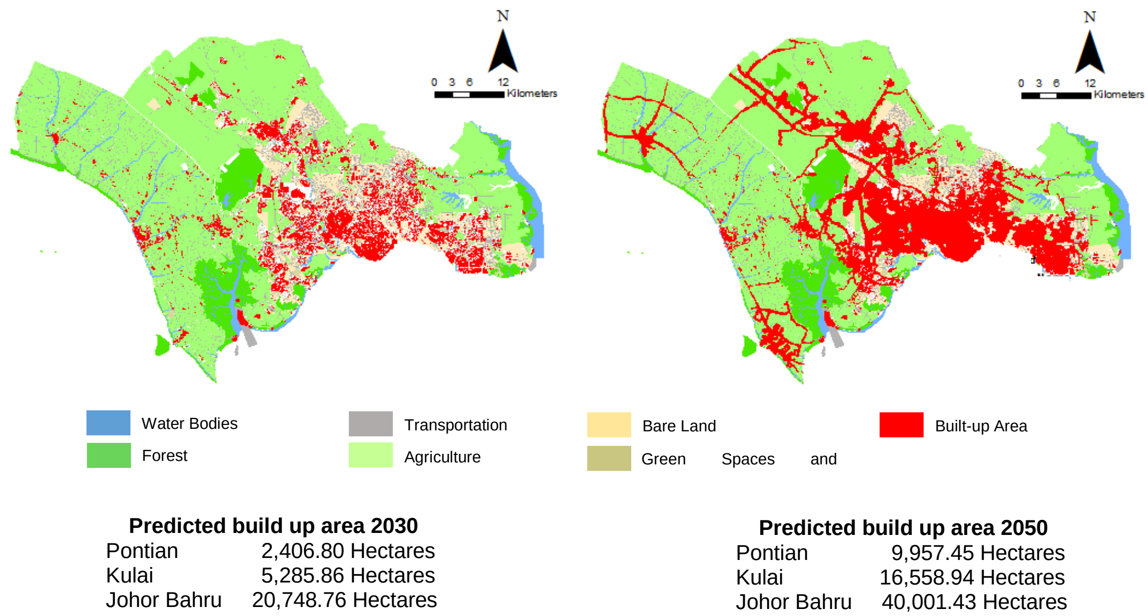


Figure 7 Projection of Land use or land covers by the year 2030 and 2050 generated by using IDRISI software and MARKOV chain technique

Table 4 Detail Pontian district built-up area by Mukim for 2005, 2010, 2015 and projection of 2030 and 2050

Mukim	Area (Hectare)				
	2005	2010	2015	2030	2050
Api Api	28.20	35.20	134.01	219.15	368.78
Ayer Baloi	20.12	23.28	57.45	85.20	198.46
Ayer Masin	15.82	20.26	55.28	88.64	295.13
Benut	55.28	68.12	125.12	154.32	341.03
Jeram Batu	165.63	250.82	492.77	520.97	3070.87
Pengkalan Raja	11.16	11.16	21.15	37.16	238.51
Pontian	258.63	310.00	620.17	630.52	2747.06
Rimba Terjun	135.82	149.97	321.46	330.25	1032.71
Serkat	42.10	45.90	116.77	214.77	1,420.23
Sungai Karang	18.54	18.54	26.54	33.95	81.68
Sungai Pinggan	30.59	30.59	86.59	91.87	132.00
TOTAL	**781.89**	**965.02**	**2,058.30**	**2,406.80**	**9,957.45**

Pontian District is prrojected to increase to 2,406.80 Hectares of build-up area by the year 2030 and 9,957.45 Hectares by 2050. The prediction is inconsistency with the data collected from Pontian Land Office which shows the application for land conversion has increased from 307 applications for the year 2006 to 2010 to 731 applications for the year 2011 to 2015, An increase of 138% for the interval period of five years. (Refer to Figure 8)

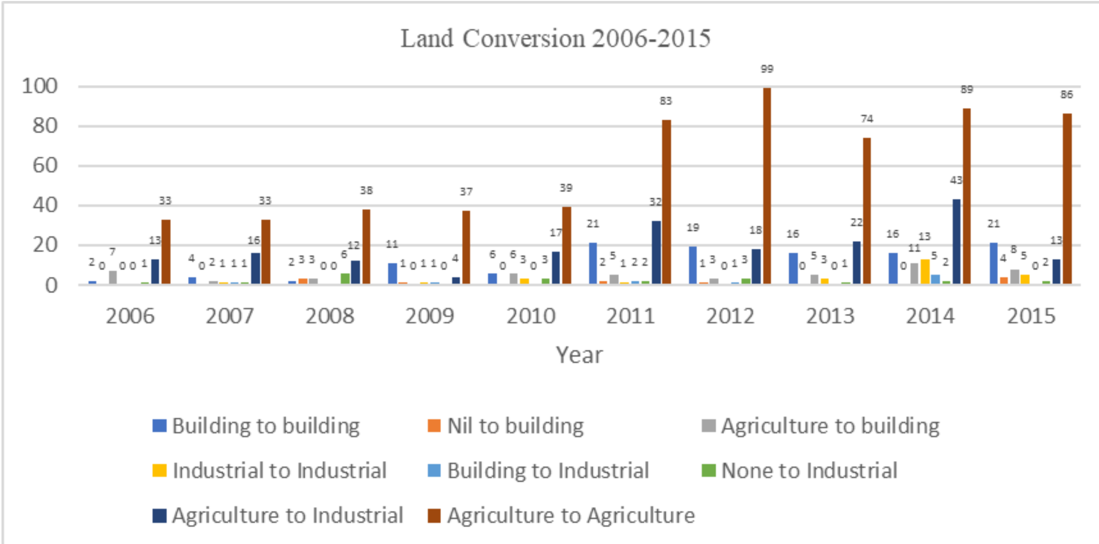


Figure 8 Land conversion 2006-2015.
(Source: Pontian land office)

Data obtained from Pontian District Council shows that there was a drastic increased in the numbers of applications of the planning permission after the announcement of the development of Iskandar Malaysia. For the year of 2001 to 2005, there are only 51 applications for Planning Permission were submitted, 144 applications between the year of 2006 to 2010, an increase of 282% and 319 applications for the year 2011 to 2015, an increase of 625% for the interval period of five years. The statistics suggest that the rapid and massive development of Iskandar Malaysia could give the early indication an impact on the pattern of land use and have altered the social, economic and environmental capital of community in Pontian. Due to the rapid economic growth and urban development of Pekan Nanas, its population is expected to increase rapidly by the year 2025 (MDP, 2016). Refer Figure 9.

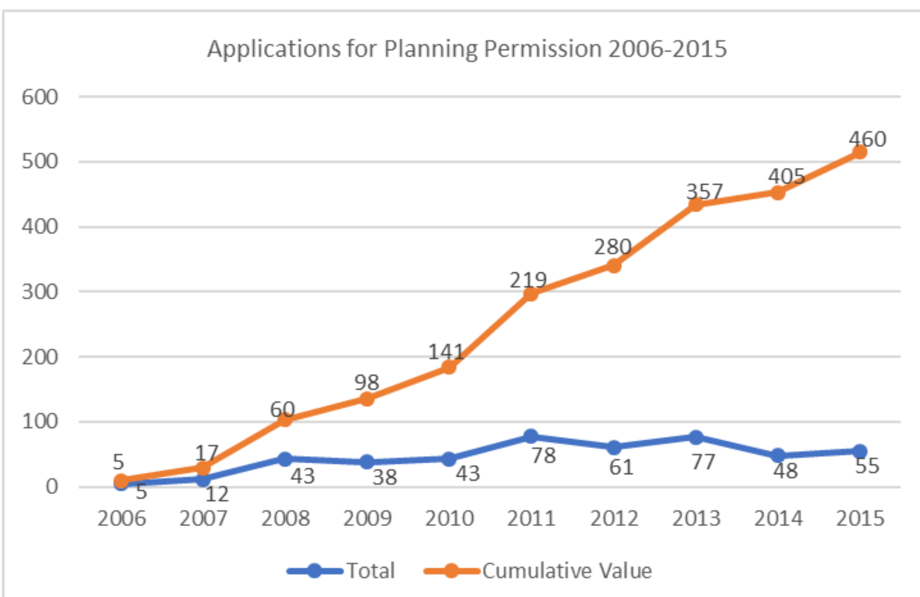


Figure 9 Applications for Planning Permission 2006-2015.
(Source: Pontian District Council)

4.2 Measuring resilience level of farmers in Pontian

The survey questionnaire was formulated based on the list of indicators proposed in Table 5 and divided into three capitals. Economic capital with nine indicators, followed by social capital with 13 indicators and environmental capital with eight indicators which make up 30 questions in total. The question-guided survey which was conducted at four Kompleks Penghulu multipurpose hall. During the questionnaire guided survey, each respondent was asked to give a score of 1 to 10. 1 for not agree, and 10 if they agree with the statement ask. The response from 72 farmers as shown in Table 5.

Table 5 Economic, Social and Environmental resilience mean score

	ECONOMIC (N=72)			SOCIAL (N=72)			ENVIRONMENT (N=72)		
		Mean	Std. Deviation		Mean	Std. Deviation		Mean	Std. Deviation
	Q1	8.31	1.851	Q10	8.31	2.107	Q23	6.29	2.619
	Q2	7.61	2.205	Q11	8.21	1.711	Q24	6.11	2.587
	Q3	4.15	3.116	Q12	8.82	1.202	Q25	7.58	2.174
	Q4	5.13	3.184	Q13	8.65	1.235	Q26	7.51	2.883
	Q5	8.79	1.363	Q14	6.64	1.916	Q27	5.50	3.009
	Q6	6.79	2.264	Q15	7.25	1.829	Q28	6.10	2.913
	Q7	6.21	2.420	Q16	6.69	2.243	Q29	5.36	2.692
	Q8	6.92	1.813	Q17	6.85	1.836	Q30	7.31	1.881
	Q9	6.96	1.772	Q18	6.88	1.776			
				Q19	6.69	2.430			
				Q20	6.06	2.572			
				Q21	7.24	1.842			
				Q22	4.15	2.532			
	Economic capital, Social capital and Environmental capital resilience score								
Mean	6.7623			7.1100			6.4705		
Std. Deviation	1.05497			1.00518			.82396		

4.2.1 Economic capital

Nine questions are representing nine indicators tested in this category, and the results from the data analysis presented in Table 5. The result illustrated in Table 5 indicate that majority of farmers agreed that their income had increased and stable compared to the last ten years with a mean score of 8.31 and 7.61 respectively. However, they also still need for the household to develop other sources of income and monetary help from other family member. They believe that the development in Iskandar Malaysia increased the demand for their agricultural production, and they satisfied with the help from government agencies in giving financial aids, funds and subsidies to farmer communities. They were also positive about the prospects in new forms of economic activities (agro tourism-related initiatives) initiated by local leaders and government agencies with the involvement of local communities.

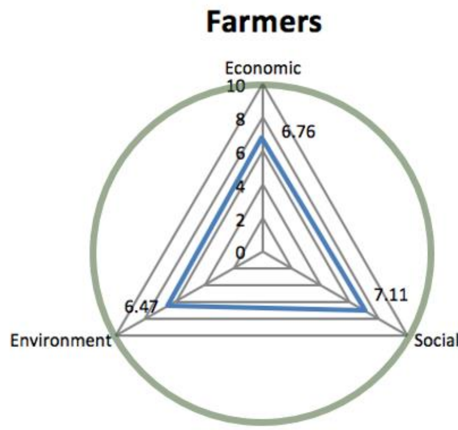
4.2.2 Social capital

Thirteen questions representing thirteen indicators in this category. The result shows that almost all indicators presented here indicated a high level of the social capital score, hence indicated a strong community social capital except for Q22. Majority of them believed that the development of Iskandar Malaysia does increase the related social problem to the local community. The social bonding among the farmer community is at the highest score (refer Q10-Q13) where a majority of them feel happy, have trust in each other and proud to be part of the community and intend to live and continue to stay with the community. The majority of the respondents have received training in relevant skills provided by government agencies such as the bee farming course, food packaging, tourist guiding and sewing (especially for female villagers). The lack of follow-up or monitoring overshadows the positive attitude towards such training after the training by related government agencies. The follow-up process by related agencies is required to assess which skills and new knowledge is given to the farmers has empowered and improved their socioeconomic standings. They also positive together with the young people not only pass down their knowledge but also get to know new knowledge and to be able to get involved in developing new opportunities and project in the community.

4.2.3 Environmental capital

Eight questions are representing eight indicators in this category. Based on the data analysis, the communities' environmental capital can be classified as weak compared with the other two capitals (economic and social). However, the mean score indicates that it is still satisfactory. The farmers acknowledged the efforts made by the government in providing necessary infrastructures such as roads, electricity, access to clean water and other related necessity (refer to Q25,26 and Q30). With continuous commitment from the government, the farmer communities were able to withstand the possibility of occurring natural disasters such as floods, landslide, soil erosion and casualties.

The finding from data analysis presented at Table 5 are then compared to the concept of community resilience as presented in Figure 5, and the resilience level of farmer communities in Pontian. As shown in Figure 10, all have well balance developed capitals which were indicated with the resilience score for economic capital at 6.76, followed by social capital at 7.11 and environmental capital at 6.47.



Economic Capital = 6.76
Social Capital = 7.11
Environmental Capital = 6.47

Figure 10 Community resilience level presented by economic, social and Environmental capital.

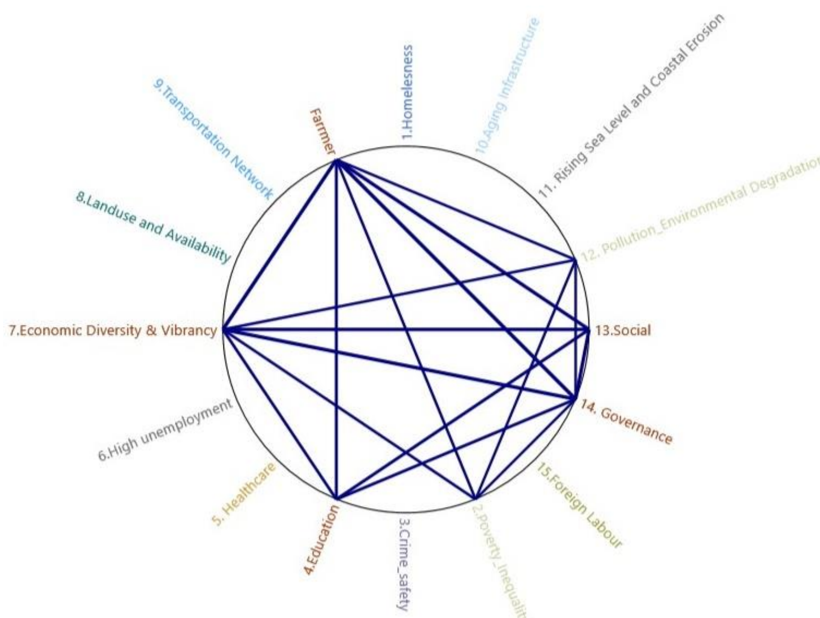


Figure 11 Nodes clustered by words similarity.

Figure 12 Hierarchy chart, Nodes compared by the number of coding references

The interview was formulated based on the three questions proposed in Table 5 to identify what are the factors that worry them economically, socially and environmentally. The respond from 25 farmers as shown in Figure 11 and Figure 12. The result shows that; six main factors can contribute to the ability of the farmers to adapt to the development of Iskandar Malaysia. There are economic diversity and vibrancy, governance, social, education, pollution & environmental degradation and poverty and inequality. Governance and social factor are the additional two factor that had been discovered during the interview. The first factor is economic diversity and vibrancy. We might think that the Farmers may find themselves difficult to adapt to the economic development of Iskandar Malaysia due to their profession as a farmer without broad diversity and vibrancy as farmer is labour intense job. The development of Iskandar Malaysia undeniably creates a massive demand for product from farming activities, and the farmers took the initiative to change the farming as shown in Figure 10. The decisive score as shown in result questionnaires, question no 19 and 20 (refer Table 4) shows that the transfer of knowledge and skill from the older to the younger generation and new knowledge from younger generation shared to older generation.

The second most significant factor is governance. The government involvement in agricultural activities through their agricultural-related department in the form of government aid such as subsidies is vital as government may not put the priority on agricultural industry as the main economic activities in the development of Iskandar Malaysia. The third factor is social. Farmers may need stronger community bonding with the residents and the local leader. The social problem involving the communities, especially the younger generation, will jeopardize the future of the agricultural industry. The fourth factor is education. Farmers may need education in getting update with new technology in improving the productivity of their crops. The fifth most significant factor for the farmer is pollution and environmental degradation. They also suffer much from the development as many of the natural resources need to restructure to adapt the economic activities such as lands are acquired to build infrastructure where the kampung lifestyle as a farmer may be destroyed. The sixth factor is about poverty and inequality. Due to the way how Iskandar Malaysia developed, farmers have in mind that farming activities may not be the main priority in developing Iskandar Malaysia.

From the quantitative analysis, there are exciting findings that relate to farmers, specifically in Pontian. The finding is slightly at variance with the research hypothesis which made them difference from other developed nations, whereas many critical rural kinds of literature has highlighted. (Marsden, Milbourne, Kitchen, & Bishop, 2003); (Robinson, 2008) Highlighted that many farming communities are relatively conservative in the way they address the need for change and innovation where farmers tend to stick to what they know best about how their parents and grandparents farmed and to how things have always done (Wilson G. A., 2007); (Burton, Kuczera, & Schwarz, 2008). These findings are related to respondents and farming communities' own experiences with their past. The ability to adapt to a different type of government farming program is the factor that enhance adaptability. The development of Iskandar Malaysia undeniably creates a massive demand for product from farming activities. The improvement level of education among the farmers and family members has improved. They can manage the farm by using new technology but also give an extra advantage and opportunity for them to find a job close to their community and helps improve economic capital at the community level by reducing dependency on farming activities. Malaysian has experienced tremendous economic growth since its independence in 1957. The current economic development in the country has transformed Malaysia from an agricultural nation to an industrial country and is moving well along the path of modern economic (Subramaniam, 2008). As a result, the agricultural sector share in a total gross domestic product (GDP) and the share of employment in the sector have declined steadily (refer to Figure 13).

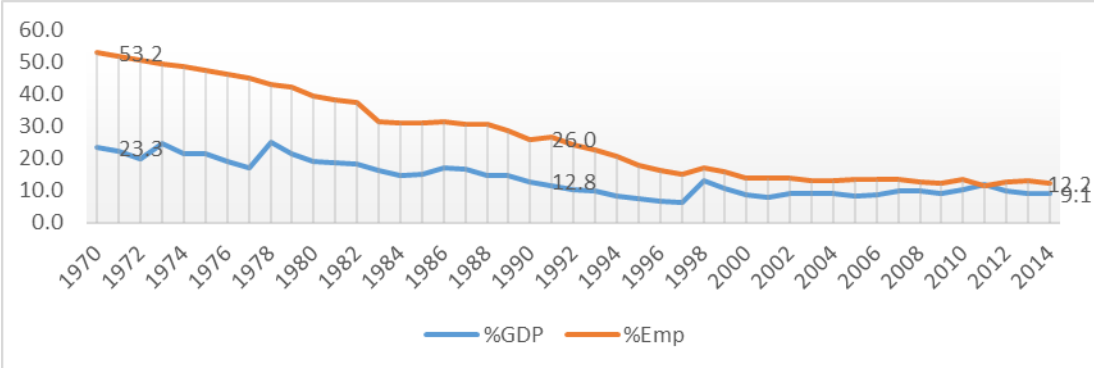


Figure 13 The contribution of agricultural (GDP) and share of employment
Source: Department of Statistic, Labour Force Survey 2014

At the national level the share of employment in agriculture has declined from 53.5% which contribute 23.5% of Gross Domestic Product (GDP) in 1970 to 12.2% share of employment which contributes 9.1% GDP in 2014 due to economic structural changes. The contribution of Agricultural to employment tends to decrease by 1.3 per cent every year while the contribution of agriculture to GDP tends to decrease 0.6 by per cent every year.

At the state level, 8.6% of Johor population involve in the agricultural sector in the year 2016. Rapid development and industrialization have taken more agricultural land spaces to a housing project or industrial site. The built-up area for the district of Pontian experiencing the most increased in terms of percentage compared with the other two districts within Wilayah Iskandar, district of Kulai and district of Johor Bahru. Based on the result, the farmer communities in Pontian tend to have the ability to adapt to the rapid development at Iskandar Malaysia. Data collected from the Johor Agricultural department under Ministry of agriculture, tend to agree that the farmer communities in Pontian can adapt and able to change to different types of farming activities to suit the land-use change and current market demand. It is because most of the farmer is the owner of their farmland and the majority of them own smallholders (2 hectares – 5 hectares) considerably, which make them easy to change to another economically sound crop. Historically, the primary agricultural product of Pontian in early 1960s was dominated by industrial crop, followed by rubber tree, pineapple, cocoa in 1970s, then the domination of palm oil in early 1980s until now. The data presented in Table 6 shows that from 2006 to 2016 there is a significant drop of fruit crop which was reduced to 52.36 per cent followed by industrial crop minus 44.5 per cent, rubber tree minus 48.99 per cent. The combination of the drop in market price and the need of intensive labor force with the minimum return might be the cause. The data also have shown that the herbs, cash crop and vegetable increased more than 100 per cent. Apart from the demand created by the new market in Iskandar Malaysia; this particular crop requires a small space of land to manage, quickly returned of investment and suite to the young farmers in the community.

Table 6 Pontian crop statistics (2006-2016). Source: Johor Agricultural Department (2006-2016)

Year	Industrial Crops	Spices	Herbs	Cash Crops	Vegetables	Fruit Crops	Rubber Tree	Palm Oil
2006	7135.06	37.27	28.00	530.57	91.14	10164.90	7151.00	43377.29
2008	6154.00	38.00	31.00	539.00	96.00	8787.00	5935.00	45474.00
2010	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2012	5313.80	8.20	1.00	891.00	107.83	6952.86	3648.00	42889.00
2014	4058.10	40.50	4.00	912.80	94.00	4979.10	N/A	N/A
2016	3960.10	33.00	86.40	1185.80	210.52	4842.50	N/A	N/A
Percentage (%)	-44.50	-11.46	208.57	123.50	130.99	-52.36	-48.99	-1.13

5. Conclusions

This study's primary contribution lies in the ability to illuminate how the farmer communities in Pontian district can withstand or adapt from a threat to social, economy and environment. Taking into account the massive development in Iskandar Malaysia for the past thirteen years, scholars and professionals from various disciplines have begun to address issues of community resilience. This study contributes to a deep and detailed understanding that the rapid and massive development of Iskandar Malaysia not only indicates an impact on the pattern of land use, it is also altered its social, economic and environmental capitals of farmers in Pontian district. Moreover, setting Pontian district in relation to Iskandar Malaysia as the object of this study also expand the theory of resilience thinking study as an addition to the concept of sustainable development in planning a new development in the future.

The findings revealed the perspective of individuals, community, and system resilience capacity to survive. It was found that farmers were able to adapt to various stresses. The result indicates that individuals and communities can be adaptive, absorptive, and transformative. With this knowledge, the triple threat of urbanization, globalization and climate change can be better prepared for its current and future impact. The notion of resilience thinking in its study illustrate a systematic perspective of those particular challenges and how it impacts the farmers. With knowledge, it will prepare them to think differently and comprehensively for possible solutions that are needed to face future challenges.

The most critical aspect for the community is to understand the importance of ethical values. The value proposition of resilience thinking its use for good economic, social and environmental practices as found in Pontian farmers impacted by Iskandar Malaysia. Participatory among members of the community is vital to ensure that there is good development practice while giving space for voices of stakeholders are to be heard. When we think about the additional value of what resilience brings, it helps us to educate stakeholders, particularly farmers, with proper knowledge for a better understanding. With that, we gain insight into the core of the problem. What may seem to be a problem initially might not be a problem. Redefining the problem at stake allows us to access not only a particular sector or issue but how it relates to other issues and challenges. From there, we can look across scale, across time, understanding and mapping of and various stakeholders through how they interact with one another and the connection with one another is a critical aspect of resilience thinking. The challengers to the parties involved in development are how we begin to apply this practice and implementing resilience in the development system. Most of the previous is more about learning and influencing insight but not about implementing what we have learned from building a community resilient.

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IJBES

International Journal of Built Environment and Sustainability
Published by Penerbit UTM Press, Universiti Teknologi Malaysia
IJBES 8(2)/2021, 89-102

Suitable Locations for Industrial Setup in Urban Context: Way Forward To Meet the SDGs for Khulna City, Bangladesh

Md. Nazmul Haque
Department of Urban and Regional Planning, Khulna University of Engineering & Technology (KUET), Bangladesh

Mizbah Ahmed Sresto and Sharmin Siddika
Department of Urban and Regional Planning, Khulna University of Engineering & Technology (KUET), Bangladesh

ABSTRACT

Industrial Site selection is one of the rudimentary decisions to expand or relocate any business start-up process. This paper aimed at finding suitable location for possible industrial site as per reaching the SDGs taking Khulna City as a case. For instance, the targeted SDGs Goal 9: Resilient Infrastructure, Sustainable Industrialization and Innovation. The research also focused on the existing locations of the industries in the Khulna city and filled the gap to propose the new locations. To achieve this, a three-stage method have been adopted. At first, the existing industries were categorized on the basis of basic/non-basic, small/large scale, input/output characteristics in geo-spatial environment. Location Quotient (LQ) technique was applied to detect basic, non-basic industries and industrial zone. Then, Analytic Hierarchy Process (AHP) was conducted to define weights of important criterion such as temperature, slope, water body, land use, city center, connectivity and structures. The calculation of Consistency Ratio (CR<0.1) showed rational consistency of the factors. Finally, Multi Criteria Decision Analysis (MCDA) was adopted in GIS platform to address the suitable locations. The analysis shows 10% of the total KCC area is suitable for constructing industrial zones. According to the results most of the suitable land was found in the eastern side and a few suitable lands was found in the upper western part of the map. Another findings state that, 5% change in vacant land can increase this percentage to 17% which eventually escalates sustainability, resilience and locational advantages. In addition, the study assesses the land use change in Khulna City Corporation for recent years which have potential for industrial establishment through land suitability analysis (LSA) to emphasize both land use and industries with sustainable development.

Article History

Received : 10 August 2020
Received in revised form: 03 January 2021
Accepted: 18 February 2021
Published Online: 30 April 2021

Keywords:

Analytic Hierarchy Process (AHP), Industrial zone, Multi Criteria Decision Analysis (MCDA), Site Suitability, Sustainable development.

Corresponding Author Contact:

nhaque13@urp.kuet.ac.bd

DOI: 10.11113/ ijbes.v8.n2.679

1. Introduction

Bangladesh is a country of rivers located in South Asia with a coastline of 580 km in the north coast of the Bay of Bengal (Islam, Hossain, Abbas, Silvy, & Hasan, 2020). Over the past four decades, Bangladesh has undergone significant structural changes in the economy. The contributions of industrial and service sectors have expanded (Salam, 2016). In developing countries like Bangladesh main focus is given on greater production (Islam, Banik, Sakib, & Begum, 2018). Bangladesh is one of the fastest growing economies of Asia with an amazing growth in the last 10 years (Islam, Bhattacherjaa, & Fatema, 2019). Industrialization

across major economies of the world has led to various economic, social, and environmental opportunities as well as challenges (Gupta & Racherla, 2016). Economic development is the process of structural transformation from traditional agriculture to modern agriculture, industries and services (Fernando, Pinnawala , & Edussuriya, November-2015). The greater the level of urbanization, the greater the contribution of cities are observed to the GDP and thus in economic growth (Rahman & Kabir, 2019). For achieving economic growth and better GDP sustainable development is important. The Sustainable Development Goals (SDGs) were adopted by the United Nations (UN) at the end of 2015 immediately after achievement of the MDGs. SDGs agenda was adopted after wide consultation with governments, civil society and development partners to agree on a new agenda which would be inspirational for global development. The SDGs connect people, planet, and prosperity, and provide a framework for all countries, developed and developing alike, to pursue a better way for development (Paul, 2019). The SDGs seek to achieve what MDGs were unable to achieve. On September 25, 2015, the UN General Assembly adopted the Agenda of 2030 for Sustainable Development to push humanity towards a sustainable path. UN is committed to achieve sustainable development in its three dimensions economic, social and environmental in a more balanced and integrated manner. Sustainable development envisage a world in which every country enjoys sustained, inclusive economic growth and decent work for all. A world in which consumption and production patterns and use of all natural resources from air to land, from rivers, lakes and aquifers to oceans and seas are sustainable (NATIONS, 2018).
SDG's 9^{th} goal states "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation." (Paul, 2019). In a developing country like Bangladesh it is important to develop inclusive and sustainable industrialization. Finding a suitable geographic focus for the industry is very important for the administrator of the company, investors and government (Moses, Iwara, Gbadebo, Olubukola, & Omin, 2018). Suitable site selection of industrial zone is critical point in the process of starting, expanding or changing the location of industrial system (Hadipour & Kishani, 2014). Several reports indicate industrial areas are the second most important factor which increased the problems of toxic pollution worldwide (Fernando, Pinnawala , & Edussuriya, November-2015). Most high-income countries have strict rules and codes for their industrial areas, but in some low and middle-income countries, little is done to protect the surrounding communities waste and by-products of these concentrated industries (Fernando, Pinnawala , & Edussuriya, November-2015). The choice of the industrial site is a strategic decision that involves several criteria for review of technical, economic, social, environmental and political issues (Rikalovic, Cosic, Labati, & Piuri, 2017). In a selection process of industrial site, analysts strives to determine the optimal location that meets the selection criteria (Hadipour & Kishani, 2014). Historically raw materials, transportation, and industrial energy are considered as important factors for industries (Rahman & Kabir, 2019).

A number of tools can be used to determine the appropriate site for industrial location. Mapping tools include Geographic Information System (GIS), the image processing system and remote sensing techniques. GIS and remote sensing provide a wide range of capabilities for the industrial zone mapping, monitoring and facilitating decision making process and GIS techniques for industrial site selection. (Fernando, Pinnawala , & Edussuriya, November-2015) addressed a GIS based model for site selection process. (Boutkhoum, Hanine, Agouti, & Tikniouine, 2014) developed Fuzzy AHP and OLAP based model for strategic industrial location selection.

The main motive of the research is to identify the existing condition of industries in KCC area and to find out suitable locations for developing new industries in future to attain SDGs goal 9. Suitable site selection for industries is one of the fundamental steps of sustainable industrialization (Nations, 2015). This research will push one step forward to achieve sustainable industrialization in context of Khulna city. In this research AHP (Areal Hierarchy Process) and GIS based weighted overlay analysis was done to fulfill the objective. Khulna is a city with numerous industries of various categories (Partha, Mohaimin, & Islam, 2018). Present conditions of the industries in Khulna city indicates that there is somewhat less management to achieve optimization of utilization and conservation (Johar, Jain , & Garg , 2013). Moreover, they are not resilient as stated in SDGs goal. Choosing the correct location can help an industry to bring out more profit. Even it can reduce the cost of transportation, cost of labor and cost of raw materials and create more employment opportunities. It is quite necessary for construction industries because it generates jobs which in turn increases the people's source of income that makes not only economically stable people, but also the economy of the state in general (M , Saran , & Ramana , 2018).

Researchers have developed different methodologies for identifying suitable locations for industries. For example (Fataei, erdi , Farhadi, & Mohammadian, 2015) established integrated index overlay and weighting method of AHP for environmental planning and location choice. Khulna is a port city on the banks of Rupsha and Bhairab River. As a result the southern region has become a hub of the Bangladeshi industry. It hosts many national companies. After the construction of Padma Multipurpose Bridge it will link south-west region of the country to the north-east region and industrial growth will be faster (Islam, Hossain, Abbas, Silvy, & Hasan, 2020). It is high time to take initiative for identifying the suitable locations for developing new industries in Khulna city.

2. Methodology

In this section various steps and tools assembling considering proposed methodology, starting from evaluation of the selected criteria, assessment of potential alternatives and finally, presentation of the final results were discussed.

2.1 Area of Study

Khulna is the third largest city of Bangladesh located within 22 51’8” north latitude and 89□ 32’35” east longitude. It has an area of 4389 square kilometers with a population of 2,318,527. The district is bounded by Joshore and Narail on the north, Bagerhat on the east, Satkhira on the west and Bay of Bengal on the south. It has an elevation of 9m from mean sea level and is considered to be a low lying city. The soil condition here is mostly black peat, dark grey clay and sulphate grey silty clay (Ahmmed, et al., 2013). Khulna City Corporation consists 64.76 square kilometer of land area with 31 wards (Figure 1). The total population of KCC is 0.7 million and approximately 16,268 people live in per square kilometer here. There are about 320 small and large water bodies located in the city. Different industries are playing an important role in the socio-economic structure of Khulna city (Haque, Mamun, Saroar , & Roy, 2019). The industries could be classified into diverse sector such as, timber and furniture, bakery and food processing, leather industries machineries, fisheries, manufacturing and Agro-processing. These industries are often found to be clustered along the major road of the city and on the open space along the river Bhoirab (Ahmmed, et al., 2013)

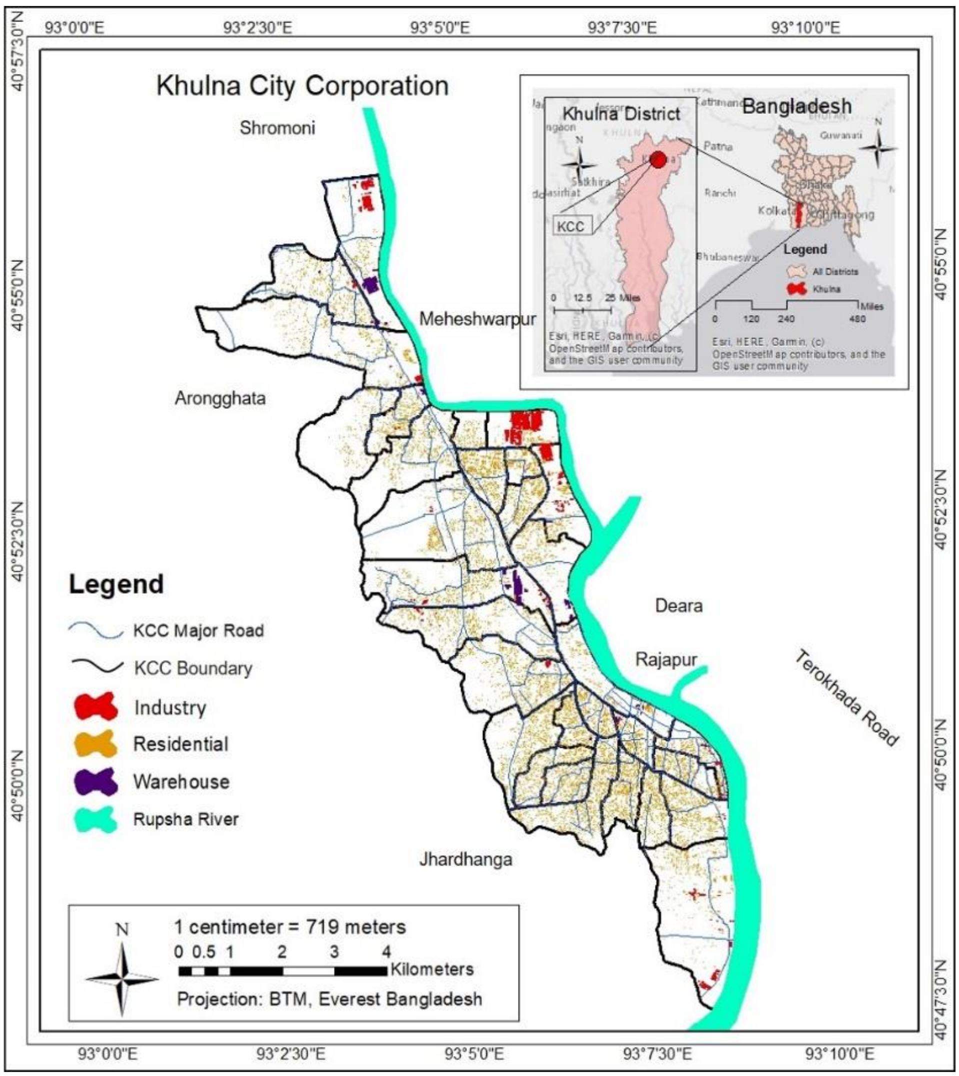

Figure 1 Study Area Map (Author, 2020)

2.2 Methods

A conceptual illustration that reflects the methodological approach for this research is given below in figure 2. Here the breakdown of each stages is shown so that, the whole process can easily be summarized.

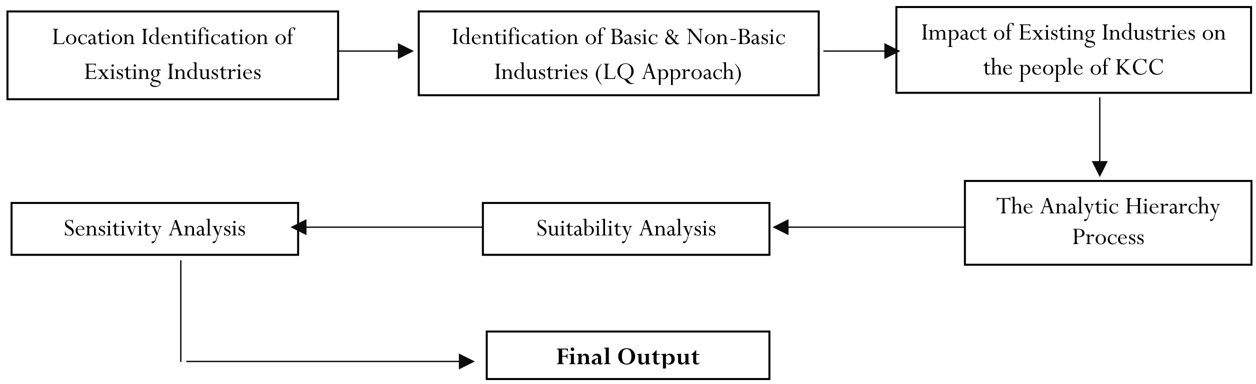

Figure 2 Methodological Framework (Author, 2020)

2.2.1 Identifying Basic and Non-Basic Industries - Location Quotients Approach

According to Florence, (S., 1937) location quotient is the number of the concentration of any certain industry in an area and comparing it will all the persons involved in that particular industry of the given area with consisting proportion for the country. It is an important tool that helps to determine and evaluate the size and strength of a particular industry in a region. (Goodwin, 2018). Location quotient is a technique to study economic condition of a region, to identify economic sectors of a region, to assess condition of each economic sector and to evaluate the impact of different development or investment (Wang & Hofe, 2007).

The Location Quotient equation can be represented by-

$$LQ_i = \frac{e_i\, E}{e\, Ei}$$

Where,

e_i= Local employment in industry i

e= Total local employment

E_i= National employment in industry i

E= Total national employment

If, LQ= 1 it indicates local industries are producing just enough output to satisfy local needs.

LQ>1 indicates local industries are producing an excess for export. (Basic industry).

LQ<1 indicates local industries are not producing enough to export and products need to be imported (Non-Basic).

2.2.2. Data Collection

Secondary data on suitable site selection for industrial location has been collected from online questionnaire survey. A total of 215 people participated in this survey. Other important sources comprises of Khulna Civil Surgeon Office, KCC Ward Office, KCC and KDA. Industrial zones were created in a clustered way following current agglomeration of various industries.

2.2.3. Multi-Criteria Decision Analysis (MCDA)

Multi-criteria decision analysis can classify multi-criteria decision-making problems based on major components of it such as multi-objective decision analysis (MODA) and multi-attribute decision making (MADA), group decision making problems to individual decision-making problems and decision under certainty and uncertainty (Rikalovic, Cosic and Lazarevic 2014). There are three phases a multi-criteria decision analysis can be performed (Rikalovic, Cosic, Labati, & Piuri, 2017). Firstly, definition of the criteria weights. Then estimation of the consistency ratio and finally evaluation and ranking of the location alternatives.

To determine the first phase Analytic Hierarchy Process is applied.

The Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) is introduced initially by Saaty (1980), is a powerful and flexible methodology in the solution of complex decision-making problems (Boutkhoum, et al. 2014). It is a pairwise comparison technique to identify the relative relevance of criteria (Rikalovic, Cosic, Labati, & Piuri, 2017). Analytic Hierarchy Process (AHP) has been used in multi-criteria decision making to release the restriction of hierarchical structure. It has been applied to environmental studies, project selection, product planning, strategic decision, supply chain management system analysis and other fields (Hadipour & Kishani, 2014). In this paper Spatial AHP is used to spot suitable sites for industries and to quantify the levels through categorization and usage of knowledge, facts based user preference and data contained in GIS map (M, Saran, & Ramana, 2018). The most difficult task in carrying out land suitability analysis approach for an exacting land use type is to assign the relative weights of the entity criteria that are to be considered. Thus, the study limited the criteria to the nine most important aspects.

Table 1 Saaty's Scale

Intensity of Importance on an Absolute Scale	Numeric Rating
• Equal importance	1
• Moderate importance of one over the other	3
• Essential or strong importance	5
• Very strong importance	7
• Extreme importance	9
• Intermediate values between two adjacent judgments	2, 4, 6, 8

Source: (M, Saran, & Ramana, 2018)

AHP is divided into 4 step- (Zahedi, 1986)
Step 1- The creation of the hierarchy decision to break the decision problem into a hierarchy of decision elements which are related.
Step 2- Collecting input data by pairwise comparison of decision elements.
Step 3- Using the method of eigenvalues to estimate the relative weights of the decision elements.
Step 4- Aggregating the relative weights of decision elements to arrive a set of ratings for the decision alternatives.
In the second phase the steadiness of the obtained criteria weights should be considered. Decision makers are rarely stable in estimating these weights in pairwise comparisons. Firstly evaluate the Consistency Vector, λ was done by multiplying the pairwise comparison matrix with the vector of the criteria weights (Rikalovic, Cosic, Labati, & Piuri, 2017). The Consistency Index CI, of the envisioned pairwise comparison matrix is defined as-

$$CI = \frac{\lambda \max - n}{n - 1}$$

Where, λ_{max} = Average value of the consistency vector, n = Number of criteria
The Random Index, RI, provides a reference for consistency when the comparison matrix is created without any agreement between decision makers on criteria weights. The Consistency Ratio, CR, measures the agreement among the decision makers, such as how much the pairwise comparison matrix ratings were randomly generated instead of being based on an objective, shared view of criteria among decision makers. The consistency ratio is defined as-

$$CR = \frac{CI}{RI}$$

A value of CR < 0.1 gives reasonable consistency. If there is any inconsistency considering the criteria weight the pair-wise comparison should be stimulated again.
The last phase of AHP is to aggregate the following equation of suitability index, S

$$S = \sum w_{i*} x_i$$

Where, w_i = Criteria weight, x_i = Criteria value

2.2.4. Sensitivity Analysis

Sensitivity analysis is a method used for evaluating how sensitive the spatial multi-criteria model output is to small changes in the input values. This approach aims at analyzing the effects of introduced perturbations in the input values on the output.
The two most important essentials to consider in sensitivity analysis are criterion weights and attribute values. Out of these, sensitivity to attribute weights is perhaps more important. If the ranking of alternatives proves to be sensitive to one or more weights, the accuracy in estimating weights should be inspected carefully (M, Saran, & Ramana, 2018).

3. Analysis & Findings

3.1 Land Use of Khulna City Corporation

From Figure 3 it is clear that almost 49.45% area of Khulna City Corporation is build up. The amount of vacant land is relatively less with respect to the amount of water bodies, vegetation and build up area. 25.25% land is covered with vegetation and only 16.65% area is covered with water bodies. Industrial zones have additional advantage if they are located near riverside or major road or railway. This is crucial for transporting goods and products easily and efficiently. River has been performing as a primary medium to carry heavy loads, manufacturing goods and materials for a very long time. Within KCC the area along Bhoirab River is already used for residential, commercial and small industrial purpose. As a result there are a few suitable places for establishing new industries. If the industries grow haphazardly then it might impact badly on people living in urban areas and industries might not gain profit. So the less amount of vacant land (8.35%) should be used wisely and the industries should be relocated carefully. Relocating alone cannot solve problems if the vacant land is not suitable enough or does not fulfill all criteria of site suitability. It should be not be interspersed with residential zone and have minimum proximity to it. No vegetation land should be demolished in order to build industrial zone. Figure 3.1also illustrates that ward-01, 03, 04 and 05 has relatively dense vegetation compared to remaining wards. These lands should not be occupied to form industrial zone. SDGs goal 9 also promotes inclusive and sustainable industrialization and no sustainable industrialization is possible without proper utilization of land. Categorizing buildup areas according to proper planning is crucial for industrial development.

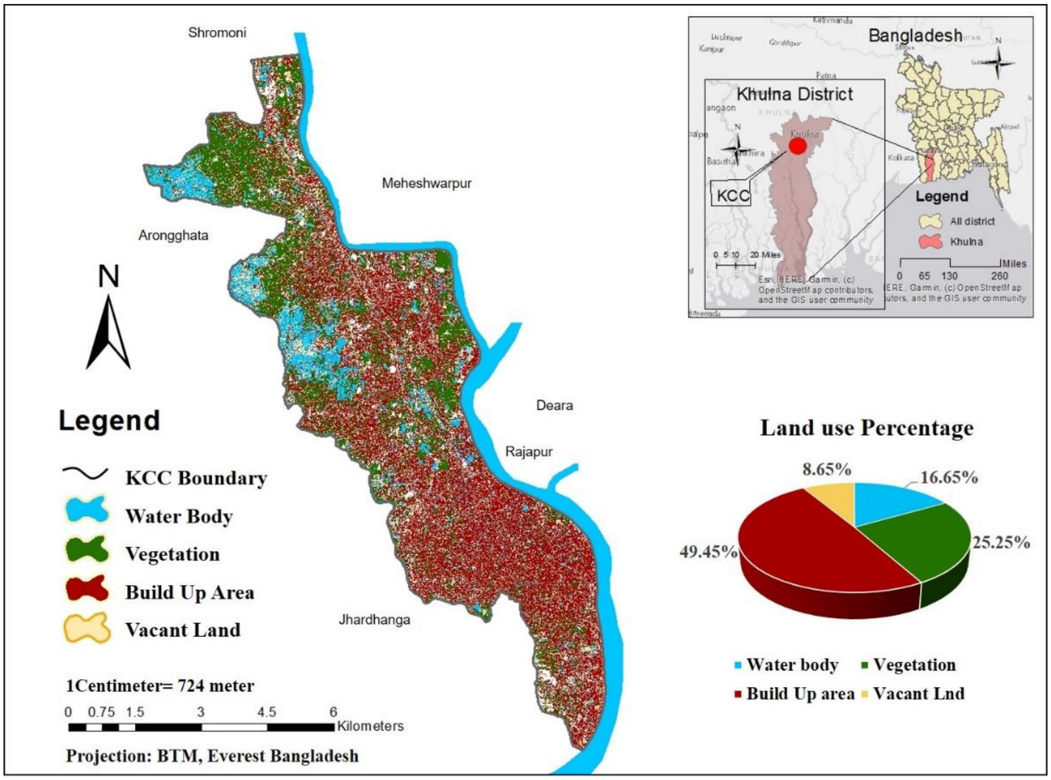

Figure 3 Land use map of KCC (Author, 2020)

3.2 Condition of Existing Industries

Figure 4 (a) shows not only the location of the current industries but also the variety of industries located in the study area. From suitability analysis for industrial location it is observed that most of the industrial location should follow a boundary line such as riverside area, alignment of the roads and railway. Khulna is an old, unplanned city. Most of the wards of KCC are not shaped in a planned way. As the population grew rapidly demand for goods and services increased. To fulfill the local demand several industries began to burgeon everywhere in the city. There are approximately 374 small and large industries currently functioning in Khulna City Corporation. They not only causes environmental pollution but also damages the surroundings of the area. But in few cases some of the industries such as wire and cable manufacturing industries in ward-02, jute mills in ward-08, hardboard and paper factories in ward-13, rice mills in ward-16 and ward-31 are built along river shore and along the major road. They are clustered in manner and have an internal cycle for input and output product. On the contrary, some of the industries are scattered in manner. They are constructed haphazardly and without any planning. Because of this, the overall production of industries are hampered. Products are not being transferred to the large industries from small industries. Most of the time these industries cause complications and spoils the balance of surrounding zones. These issues are causing hindrance in achieving SDGs goal 9. Garment factories, plastic recycling factories, agro based industry and machinery repair industry in ward-09, 14, 17, 25 are such industries. Wire and cable industry, wood and wood product factories, jute mills are industries that yields goods and products in a large scale. These are large scale industries and they transport goods in regional and national market. Whereas, rice mills, saw and hardboard industries, plastic and paper factories are small scale industries. They only occupies the local market. Indicator 9.a.1. In SDGs goal 9 emphasizes on governments effort in building well-structured and well-planned industries to support its objective of achieving accelerated growth and poverty reduction and this objective is only achievable by creating sustainable industrial zones and quality infrastructures (Bangladesh Planning Commission, 2018). Over the last two decades manufacturing sector in industries has been expanding steadily in Bangladesh. Dominant segments of the sector such as textiles, furniture, jute goods, and leather are labor intensive. Therefore, the employment in these industries have also been increased. Advanced growth of industrial output has resulted in higher proportion of employment in the sector (Bangladesh Planning Commission, 2018).

Table 2 Calculating Location Quotient for Basic, Non-Basic Industry

Types of Manufacturing Industries	National Employment (E_i)	Total National Employment (E)	Local Employment (e)	Total Local Employment (e_i)	$LQ_i = (\frac{e_i E}{e\, Ei})$
• Manufacture of food products(rice, oil, pulse)	280,257	5,015,936	1032	121,421	0.152
• Manufacture of textiles	805,508		106		0.005
• Manufacture of leather and related products	75,524		888		0.485
• Manufacture of wood and products of wood	8528		593		2.872
• Manufacture of paper and paper products	42,376		694		0.676
• Wire, cables and optical products	16,390		420		1.058
• Manufacture of chemicals and chemical products	52594		Null		Null
• Manufacture of rubber and plastics	41,139		30		0.030
• Manufacture of basic metals	120,965		356		0.122
• Manufacture of electrical equipment	44,556		300		0.278
• Manufacture of machinery and equipment	10,001		120		0.496
• Manufacture of furniture	33,143		556		0.693
• Jute mill	187,000		19,253		4.253
• Saw mill	95,422		1154		0.499

Source: (Statistics and Informatics Division (SID), 2013), (Economic Census 2013 District Report: Khulna, 2016), (Bangladesh Statistics , 2018), (Statistics and Informatics Division, 2013).

It is known that, when the location quotient value of an industry is less than 1, the industry is known to be non-basic which means the products that industry produces only able to fulfill the need of local demand. From table 1 it is observed that in Khulna City Corporation (KCC) most of the industries are non-basic type. Factories such as rice and pulse mills, oil mills produce goods in small scale. Similarly, the number of garment establishments are scarce in Khulna City Corporation, so it is considered as non-basic industry. Shoes, belts, bags and other leather products are produced in small quantity to meet the need of local market indicating a non-basic market in corresponding sector. Khalispur Newsprint Mill Ltd and Hardboard Mill Ltd. is the first newsprint mill in Bangladesh that once produced glut of pulp, mechanical pulp, board, paper and paper made products to hold both local and regional market. But its production capacity and quality reduced and in 2001 the authority was under the debt of almost 100 billion. As a result, once appraised industry unit of public sector is now on the brink of collapsing (Khulna newsprint mills (KNM), 2008). Thus, it is categorized as non- basic. Plastic and rubber products, basic metals, manufacture of electrical equipment, manufacture of furniture, saw mills are also non-basic. They have a balanced market but only in local territory. Most of the times these products are required to be imported from outside. Plastic recycling and rubber production has little to no manufacturing progress in KCC. Whereas, manufacturing furniture have far many possibilities. On the contrary, from Table 2 in KCC there are a few industries that could be categorized as basic industries such as manufacturing wood and wood products, wire, cable and optical products and Jute factories. Wood, especially Gewa, Goran of Shundarbans, Mehgoni are the primary raw materials in these factories. Due to the abundance of wood in this region wood factories are burgeoning. From field survey it is observed that ward-02 of KCC has a flourishing wire, cable and optical industrial zone. It transports their products in national and international market thus considered as basic industry. Jute is another basic industrial sector that exports raw materials and jute made products in foreign countries. In KCC there are approximately 19,253 workers working in government and non-governmental jute mills (Statisics and Information Division, 2013). It is a significant economic sector in the Khulna. If we focus on increasing efficiency of basic industries, create agglomerated industries so that one industries output can be other industries input it will help developing economy of KCC. One of the targets of SDGs goal 9 is to increase the access of small scale industries and other enterprises, in developing countries such as Bangladesh. For this, agglomeration of basic, non-basic industries, ensuring conducing policy environment and industrial diversification is necessary.

Figure 4 (b) Shows the industrial zone of basic and non-basic industries in Khulna City Corporation. It is perceived that Ward-02, 08, 13, 16, 22, 31 has been developed as industrial zone. Industries are agglomerated in manner. Zone-01 comprises of jute mills that is basic in nature. Zone -02 has agglomeration of wire and cable industries that is basic in manner. Zone-03 consists of non-basic industries such as agro-based industry and paper mills. Zone-04 is considered as non-basic industry as it includes small scale mills such as rice mill, pulse mill, oil mill and food processing. Zone-05 and zone-07 also represents non-basic industries such as saw and hardboard industries, rice mills, agro based industry. Finally zone-06 has several wood and wood product manufacturing industries which are basic.

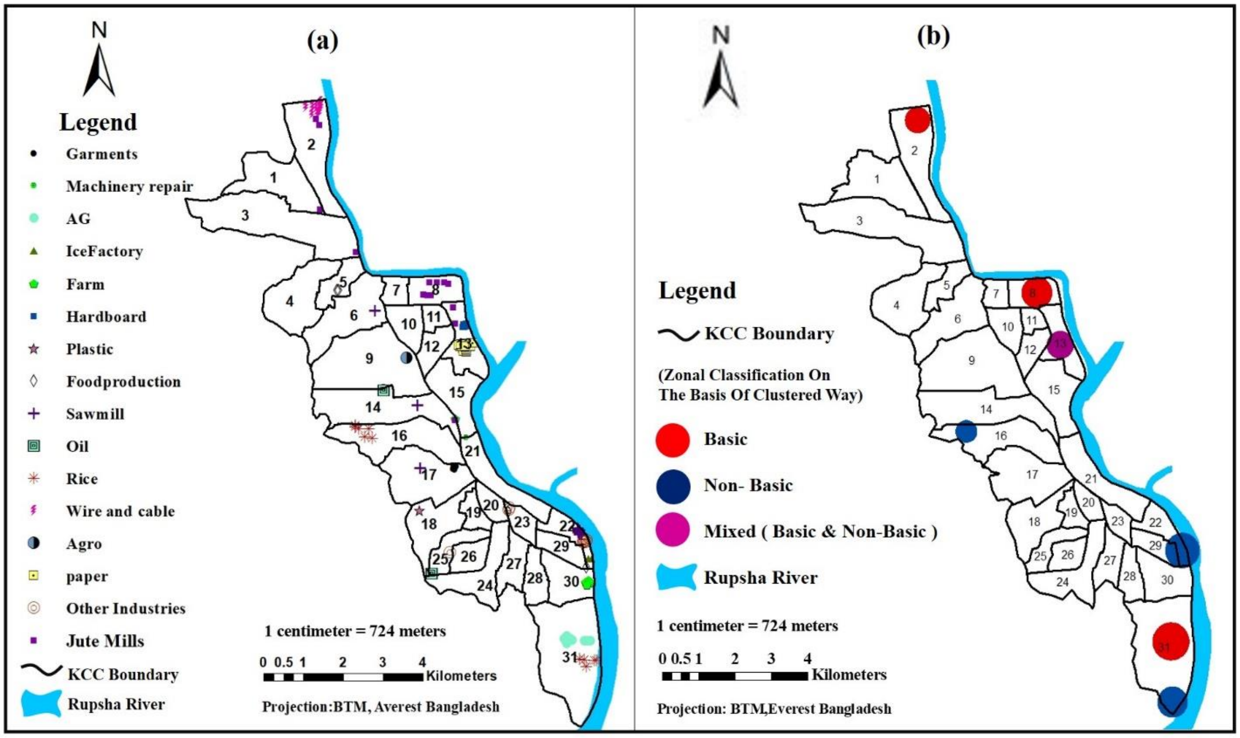

Figure 4 (a) Location of existing industries with the spatial extent; (b) Zonal Classification of the existing industries inside the KCC (Author, 2020)

3.4 Impact of Industrial Zones inside KCC

From questionnaire survey it is found that about 27% people prefer living nearby industrial zone and 73% people demurred living near industrial zone. Even 64.9% of the people think that they have safety issues living near industrial zones. According to their opinion 48.6% people are concerned about fire hazards, 35.1% people are concerned about chemical reaction and rest of them responded that they do not have any safety issues (Table 4).

Table 3 Service Facilities from Nearby Industry

Types of Facilities	Percentage
• Availability of Goods & Services	21.5%
• Lower Cost of Products	15%
• No Facility	63.5%

Source: Field Survey, 2020

Having industrial zone located near residential area or mixed areas such as residential-industrial zone has some advantages. It not only creates job opportunities for the residents but also aids economic growth of that particular area. It attracts other corresponding industries such a cable manufacturing factory would require factories that provides raw materials for example copper wire and plastic cover. A furniture making industry would require wood processing factories and raw woods for production. This will create an industrial agglomeration. The survey data shows almost 21.5% of the residents get easy accessibility to consumer goods and services due to residing near an industrial zone. 15% of the residents informed that cost of certain products are lower proximate to the area of production. Industries locating near residential area have some disadvantages too. Harmful gases from plastic manufacturing industries, cable factories, leather and shoe factories, jute mills has fatal effects on the health condition of residents. 17% of the residents complained about facing difficulties because of smoke and burning of coal and fossil fuel. Moreover, heavy machineries produce excessive noise pollution that detriments the condition of public health and environment. 48.6% of the inhabitants have acknowledged that they face noise pollution created from nearby industries. Industrial agglomeration can also cause heavy traffic congestion if traffic is not controlled systematically and if industries are sprouted abruptly without planning and provision. 10.5% of the residents have complained facing traffic congestion due to unplanned industries in residential zones. Fish, vegetable and raw ingredients processing industries may generate odor and thus pollute the surrounding environment. Another noteworthy pollutant is dust produced from industries causing several health hazards to the people. These issues can be solved if the industries start adopting SDGs goal of sustainability and innovation. In spite of the ongoing efforts of Department of Environment (DOE) in reducing industrial pollution, a number of industries still remain polluters. Because they do not have effluent treatment plants (ETP). Several industries including textile, garments and jute factories have been established without any attention to their environmental consequences. Major polluting sectors also consist of wire and cables, tanneries, brick kilns, cement, pulp and paper, chemical and ship-breaking yards. Although some industries have installed ETP they dump the waste and chemicals on land as solid waste. These ill practices are violation of sustainable development. The 7th FYP plan proposes a new approach to industrial waste management under which community, local institutions, news media and law enforcing agencies and relevant stakeholders will be engaged to mitigate pollution.

Table 4 Disadvantages for Nearby Industry Location

Types of Disadvantages	Percentage
• Noise	48.6%
• Smoke	17%
• Odor	9.3%
• Traffic Congestion	10.5%
• Dust	14.6%

Source: Field Survey, 2020

3.5. Analytic Hierarchy Process (AHP)

More practicability and utility are crucial for accurate result in applying different scientific methods especially different software in a project. Based on different criteria different methods are developing for example AHP follows (Table 5) mathematical logic. This method adopted geometric weighting to calculate normal weights .Then AHP method was tested in different geo-referenced decision making. Subjective judgment was used to get the criteria weights.

Table 5 AHP Calculation

Criteria	Temperature	Slope	Water body	Land Use	City Center	Rail way /Road	Structure/ Labor Cost	Normal Weight
• Temperature	1	1/6	1/8	1/5	1/6	1/5	1/7	0.2812
• Slope	6	1	1	5	7	5	5	2.7015
• Water body	8	1	1	7	7	7	7	3.0988
• Land Use	5	1/5	1/7	1	3	1	1	0.8860
• City Center	6	1/7	1/7	1/3	1	3	3	0.7408
• Rail way/ Road	5	1/5	1/7	1	1/3	1	3	0.6473
• Structures	7	1/5	1/7	1	1/3	1/3	1	0.5805
								Sum:8.9361

Source: Author, 2020

.

This Table 6 is identified as matrix A1. The normal weight of criterion is calculated by adding the scores of a row with power equal to the total number of criterion. A2 matrix is originated from dividing each of the normal weights by the summation of normal weights of matrix A1. Multiplying A1 and A2 matrix generates matrix A3. A4 matrix is the ratio of A3 matrix to A2 matrix.

Table 6 AHP Calculation

A2 Matrix (Weights)	A3 Matrix	A4 Matrix
0.0315	0.1826	5.8039
0.3023	3.5062	11.5980
0.3468	3.9181	11.2986
0.0991	0.5876	5.9268
0.0829	0.5170	6.2368
0.0724	0.3752	5.1794
0.0650	0.4548	7.0000
Total 1.000		Average: 7.5776

Source: Author, 2020.

From the table it can observed that the average value of A4 matrix is 7.57. That means the value of λ_{max} is 7.5776.

$$CI = \frac{\lambda \max - n}{n-1}$$

=7.5776 – 7/ 7-1

= 0.096

The derivation from consistency is provided by consistency index (CI). CI provides the deviation from consistency and then consistency ratio (CR) was calculated.

CR=0.096/ 1.35

= 0.0711 < 0.1

1.35 is the value of random index (RI). It is a randomly generated pair-wise matrix. The final step of AHP is to combine the following equation of suitability index (S)

$$S_i = \sum w_i * x_i$$

3.6. *Overall Suitability Analysis*

The results shown in Figure 5 (a) was obtained from using predefined GIS tools like polygon to raster, Euclidean distance, reclassify, weighted overlay and raster calculator. According to the results, it was seen that there are a very few suitable lands. Most of the lands are not suitable for building industries. Because Khulna City Corporation area is considered as build up area and there are a very few vacant lands. Individual thematic layers were multiplied by the respective priority vector obtained from the pair wise comparison matrix of Analytical Hierarchy Process. Suitability map of the region were classified from less suitable to most suitable based on the evaluation of the criteria. And also weightages were given to them at criterion level as well as attribute level. According to the analysis it is shown that about 10% land is most suitable for industrial location, about 7% land is moderately suitable and 83% land is not suitable for building new industries.

3.7. *Sensitivity Analysis (Suitable area after 5% increase in vacant land)*

Sensitivity analysis is usually done to check the uncertainties and variations of the criteria. Naturally uncertainty prevails while dealing with the problems of the real world. To analyze the situation in a better way sensitivity analysis was taken as an option to address the issues. This analysis is usually done because most of the time criterion values are provided by humans and have inherent bias towards some criteria selected in any of the problem considered for MCDM. Small changes were made in the values of priority vector such that the land use and value of the priority vector vacant land rises 5 percent and vector values remaining priority are reduced by 5 percent. According to Figure 5 (b) it was observed that after increasing the priority vector of land use land cover about 5%, the amount of most suitable and moderate suitable land for establishing industries has increased. The amount of most suitable land and moderate suitable land has raised up to 17% and 12% where there is a decrease in percentage of less suitable land.

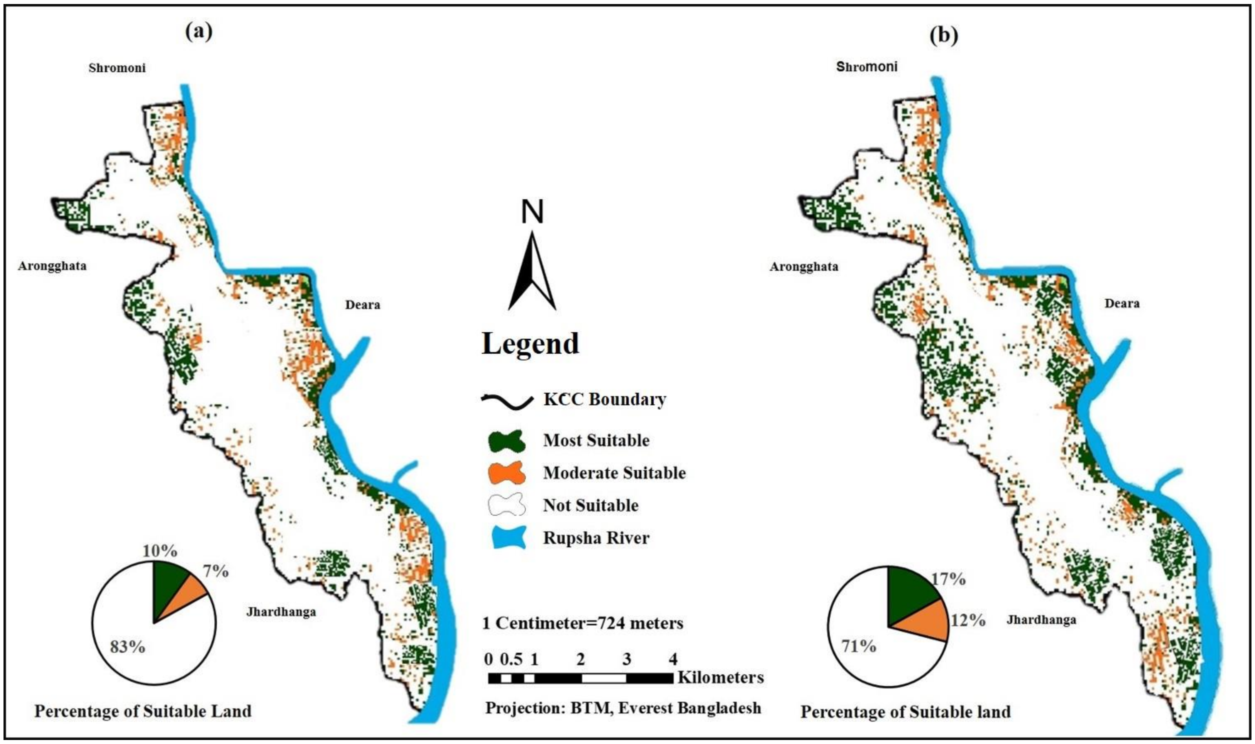

Figure 5 (a) Proposed suitable area inside the KCC (on the basis of existing land use); (b) Proposed suitable area inside the KCC subject to the uncertainty (For 5% increase in vacant land) (Author, 2020)

4. Way Forward to SDG's

The present condition of industrial location in Khulna City Corporation is somehow dissatisfactory in achieving its desired goals. Findings show that relocating industries to a suitable location has long-term advantages. As soon as the construction of Padma Multi-purpose Bridge finishes it will create a huge economic diversity in the southern region. Dhaka will be the mother city and Khulna will be the dormitory city as people will come here for work and leave after work. Thus, transportation of goods and services will be swift and economic condition will flourish. Considering all these if we can achieve new location for industrial setup we will be able to accomplish SDGs goal. The current location of industries are not quite effective for sustainable industrialization.

To modify this the industrial structures should be built considering its surrounding whether it is near residential zone, water bodies or near town periphery. In order to select suitable sites for industrial relocation in Khulna City Corporation, this target can work as a substantial goal. The current location of industries in KCC rarely maintained locational suitability. As a result long term sustainability of industries are not ensured. Thus, selecting suitable locations for industrial zone is vital in accomplishing SDGs 9th goal. KCC is lagging behind in achieving this goal of sustainable and resilient infrastructural location of industries. The findings show that most suitable area for establishing industrial zone in KCC is the north-east side of town periphery, the area along Bhoirab River. This will reduce the direct effect of industrial activities on residential areas and protect it from possible hazards. Moreover, selecting such sites will make the city more resilient to any harm emanating from industries such as chemical substances and explosives. These are all related to SDGs goal 9 which work towards building a resilient and inclusive environment for human habitat as well as economic development of the city simultaneously. Again, river side industrial sites have easy and effective transportation medium to distribute products efficiently and increase in input and availability of raw materials.

With climate change impacts the occurrence and degree of natural calamities are expected to increase with greater devastative effects not only on infrastructure but also on lives and livelihoods of people. Bangladesh will need to mainstream the possible impact of these natural blows in building infrastructure. Bangladesh also experiences damage caused by manmade disasters such as structure collapse and fire. In this regard, the mainstream has to be planned methodically based on scientific assessment of the impacts of climate change. Bangladesh has already begun to implement such projects. The implementation of such projects should be expanded and integrated under the Delta Plan 2100. The synopsis of achieving sustainable industrialization is as follows in Figure 6-

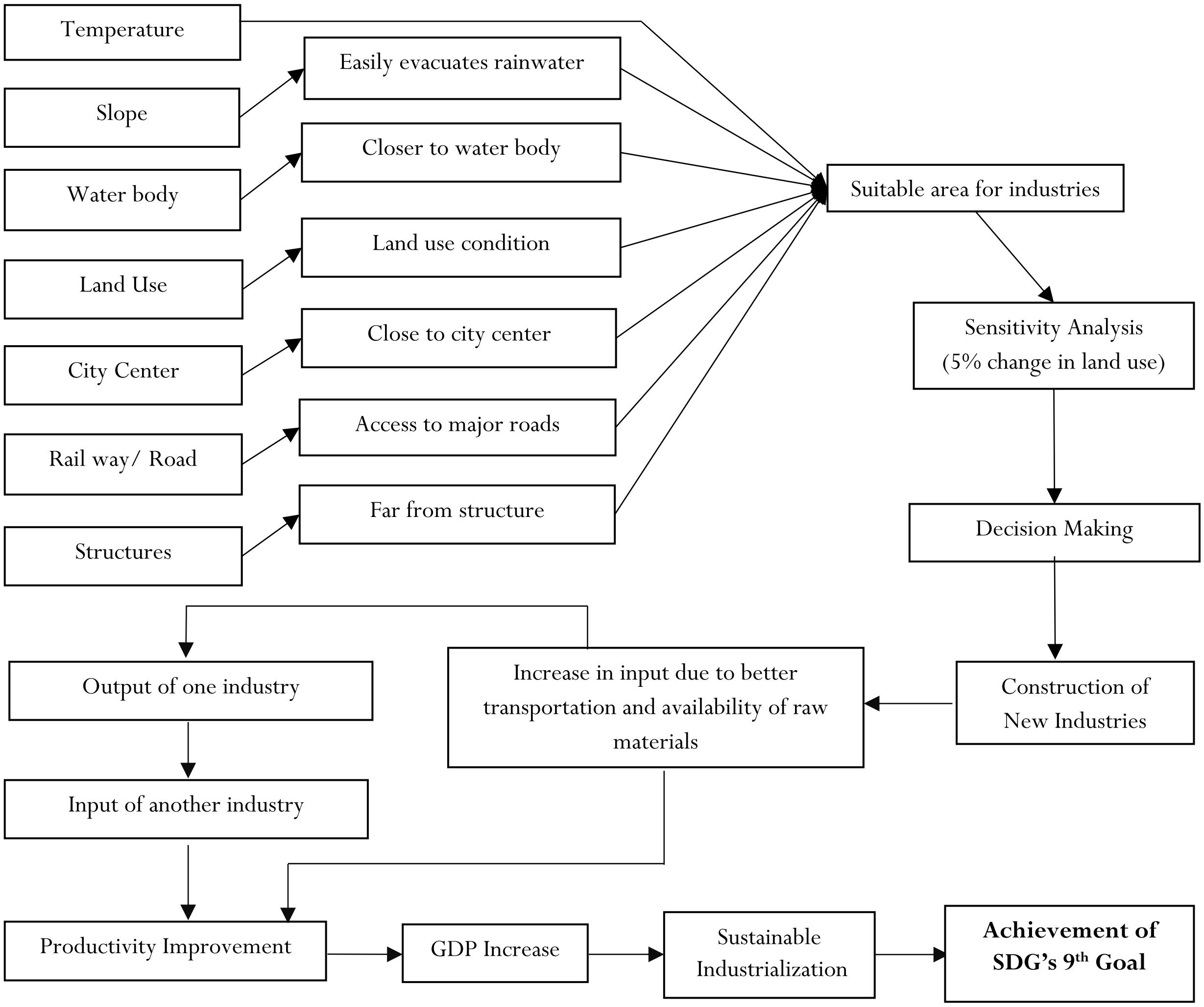

Figure 6 Conceptual framework for achieving SDG (Goal -9) (Author, 2020)

5. Discussion & Conclusion

With the development of Khulna city, it is becoming a hub of industries and after the construction of Padma bridge a connection will establish with Dhaka and other major cities. Also, for achieving inclusive and sustainable industrialization (UN's 9th goal), proper site selection is one of the major priorities. The spatial form of identification of potential industrial sites and the need to include the preferences of the decision maker in the analysis requires a combination of GIS and MCDA methods. Main factors being land use and land cover, distance from structures, city center, distance from water body, slope, viable road network to make the work easier at least in the initial stages. Existing location of industries was identified and according to the analysis results it was found that some of the industries are situated in suitable location and some of the industries are in unsuitable location. Evaluation process was conducted with the help of some expert opinions and personal perspective that provided the necessary judgment to fill the comparison matrix. Suitability maps were generated by using AHP. The search for potential industrial sites using different techniques gives us a better picture to assess the problems associated with it. Uncertainty is an inherited characteristic, while dealing with the problems of the real world. Therefore, a sensitivity analysis by modifying the weights of criteria to a certain percentage to estimate changes in the area within classes of convenience and to decide the right place was performed. After performing sensitivity analysis the amount of suitable and moderately suitable areas increases where the amount of less suitable land decreases. An analysis of land suitability based on GIS extends the use of operators overlap with the preferences of the decision maker. Some of the multi criteria methods have to be investigated later to get better results. Development of new computational methods in GIS environment makes it interesting to improve efficiency in the evaluation of the process of industrial establishment. However, selection of suitable industrial site will not only help to promote inclusive and sustainable industrialization and by 2030 but also it will help to raise industry's share of employment and gross domestic product.

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IJBES

International Journal of Built Environment and Sustainability
Published by Penerbit UTM Press, Universiti Teknologi Malaysia
IJBES 8(2)/2021, 103-113

Relationship between Window and View Factors in the Workplace: A SEM approach

Mercy Inikpi Achoba
Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia 81310 UTM Johor Bahru, Johor

Roshida Abdul Majid
Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia 81310 UTM Johor Bahru, Johor

Cyril Obinna Obiefuna
Department of Architectural Technology, Federal Polytechnic Idah, Kogi State, Nigeria

ABSTRACT

Office occupants' have always preferred workplaces that have windows that connects them to the outside. Window access to the outside can influence occupants' satisfaction with the combination of other workplace features. This study aims to identify the window and view factors relationship in the workplace, to confirm the reliability and validity of the measurement and structural model. Adopting a cross-sectional survey design, primary data from five offices in the Kogi State of Nigeria with 267 respondents were collected by using the convenience sampling method and analysis was performed with the Statistical Package for Social Science version 23 and AMOS 22.0 version as the modelling tool. The study identified eleven vital factors that are interrelated in the relationship between windows and view in the workplace. They are referred to as latent construct namely; Window distance (WDB), Seating arrangement (SAB), Room height (FHB), Office size (OSB), Window position (WPB), Window Sill level (WLC), Window size (SWC), Window type (TWC), View content (CVC), View satisfaction (VSC), and Occupants' satisfaction (SAT). The result showed a valid model using the Structural Equation Model, and the effect of the current workplace negligence on occupants'. This study improves the existing knowledge on the window and view relationship in the workplace, and provide suggestions for Facility Managers, Architects, and Interior Designers on maintaining a healthy workplace environment.

Article History

Received : *16 July 2020*
Received in revised form : *13 January 2021*
Accepted : *04 February 2021*
Published Online : *30 April 2021*

Keywords:

Window, View, Workplace, Occupants, Structural Equation Model

Corresponding Author Contact:

mercy.inikpi.achoba@graduate.utm.my

DOI: 10.11113/ijbes.v8.n2.667

1. Introduction

Office occupants' spend about one-third of their day in buildings. An office building mainly provides a workspace and an enabling environment for its occupants. The work environment is a combination of three environments which are technical, human, and organizational environments. The concern of the workplace environment is on the increase because about fifty per cent of occupants' lives are spent in an enclosed environment that significantly influences them. The workplace conditions greatly influence the degree to which environmental conditions influence occupants' satisfaction, well-being, and health (Aries, Veitch, & Newsham, 2010; Jamrozik et al., 2019). Therefore, the workplace should be treated with due importance, for it is the immediate surroundings of man which he controls for his survival (Al horr et al., 2016; Frontczak & Wargocki, 2011; Leder, Newsham, Veitch, Mancini, & Charles, 2016; Madu, Asawo, & Gabriel, 2017).

Studies indicate that the two most important factors to office occupants' are daylight and views provided by windows (Jamrozik et al., 2019). However, the most valued window benefit by building occupants' is the provision of view (Ozdemir, 2010). Windows are the transparent building elements that supply passive solar gain, ventilation, and view to the outside (Cuce, Young, & Riffat, 2015). Maximizing the benefits of windows requires been knowledgeable of the complexity of the human- window interactions (Salonen et al., 2014). The features of window views and social density are part of the physical characteristics of office experience (Aries et al., 2010). Many types of research have been carried out on window relationships within the context of human-environment (Collins, 1976; Butler & Biner, 1989); window size, shape, position preferences (D. l. Butler & Biner, 1989; Heerwagen & Orians, 1986); while some are centered on discovering the most significant contributions of windows (Dogrusoy & Tureyen, 2007). Even though the study on occupants' satisfaction has been done from different angles across disciplines, the phrase "occupants' satisfaction" is yet to have a clear definition in the built environment (Kwon, Remøy, & van den Bogaard, 2019). Window access to the outside can influence occupants' satisfaction with other features of the environment (Boubekri & Haghighat, 1993; Konstantzos & Tzempelikos, 2015).

Window views and its positive effect on occupants' well-being, health, and satisfaction have been continually recognized by researchers. The findings of such studies have created the need to understand the link between windows and people (Dogrusoy & Tureyen, 2007). Research shows that office occupants' prefer spaces with windows (Verderber, Grice, & Gutentag, 1987; Dogrusoy & Tureyen, 2007). In a nutshell, office occupants' place more value on views from windows than its other benefits and psychological functions. Some researchers opine that a view to the outside vegetation through a window results to positive psychological effects and healing rate is increased due to the presence of windows (Herzog, Kaplan, & Kaplan, 1976; Jiang, 2016; R. Kaplan, 1993; Ulrich et al., 1991). According to Kaplan (1993), occupants' having a window view of nature outside derive significant satisfaction, even without necessarily being in the natural setting. Window views can be aesthetically pleasing and provide a quick hiatus from office work (Leslie, 2003). The view from the window is connected to occupants' satisfaction within a room (Konstantzos et al., 2015)

1.1 Theoretical Background

A good understanding of theories related to windows and view is vital for the validation of the measurement model for this study. This study is based on two theories; Attention Restoration Theory (ART) and Stress Recovery Theory (SRT). The ART postulates that the concentration level of people gets better after spending time in nature or gazing at scenes of nature (Kaplan, 1987). An attention-restoring experience can be an undemanding activity, like just having a stare at nature (Hellinga, 2013). The SRT posits that humans' exposed to green scenery enhances their capacity to recover from stressful events (Roger S Ulrich, 1993). The two theories are complementary in dealing with windows that offer positive benefits to the office occupants' (Hartig et al, 2003). Nevertheless, their point of departure is in what urges occupants' towards restorative scene; in the case of ART, it is the mental fatigue, while SRT it is physiological stress (Berto, 2014). Kaplan, R. (1993), refers to windows with views of nature as micro-restorative settings that supply brief views with features of fascination, which are believed to lessen mental fatigue. Also, Hartig et al. (2003), opined that facilitating the recovery from stress requires windows to give occupants' a social and continuous visual connection to nature from indoors.

Having to connect occupants' with the view outside through windows has been related to occupant satisfaction (I Konstantzos & Tzempelikos, 2015; Ozdemir, 2010). Kwon et al. (2019), posits that occupants' satisfaction in an office is based on the window proximity to the workspace and the type of task performed. Occupants' satisfaction with the quality of the environment influences their perception of comfort and health (Sant'Anna et al., 2018). However, occupants' dissatisfaction may arise from physical workplace conditions such as desk position, office type, building orientation amongst others (Samani, 2015). Research on offices and occupants' have focused more on thermal and visual comfort, while the view aspect and its influence on occupants' satisfaction are least investigated (Konstantzos et al., 2015).

1.2 The Nigerian Situation

The increasing rate at which Nigerian Government offices are on the path of becoming an unhealthy environment needs urgent attention. Workplace environment being a place where most the occupants' spent most of their time ought to be kept healthy. Regrettably, the office design has been significantly affected by the rise in staff strength that has led to more workspaces in the shared offices. There is an alteration on the required social density for workplaces. Measures to suppress reoccurrence in newer office designs have not been made despite such alterations in the office use and capabilities (Adedayo, Oyetola, Anunobi, & Odine, 2015). Offices are becoming an unhealthy environment due to lack of space standards for office buildings in Nigeria (Zubairu & Olagunju, 2003). The impact of physical work environment on occupants' is under-researched as stated by Morrison & Macky, (2017), and modern offices rarely consider occupants comfort and satisfaction (Van Der Valk, Myers, Atkinson, & Mohring, 2015). Therefore, there is need for the unhealthy trend created in Nigerian Government workplaces be stopped.

1.3 Research Constructs and Hypothesis

The development of these research constructs was drawn from the ART and SRT theories that emphasize that in an environment a window is required for a view and also stated by Hartig, Mang, & Evans, (1991), that facilitating the recovery from stress requires windows to give occupants a visual connection to nature from indoors. The window, view, and workplace factors were considered as deduced from both theories. The workplace consists of the interrelationship existing between the occupants' and the work environment. Based on previous researches, window distance (Aries et al., 2010; Hellinga, 2013; Lindberg et al., 2018; Yildirim, Akalin-baskaya, & Celebi, 2007); seating arrangement (Lindberg et al., 2018; Ne'eman, Sweitzer, & Vine, 1984); room height (Ne'eman et al., 1984); office size (Butler & Steuerwald, 1991), are the workplace constructs. The understanding of the entangled interactions between humans and window is paramount for effective window benefits utilization (Salonen et al., 2014). The window constructs are window position (Butler & Steuerwald, 1991; Hellinga, 2013; Inan, 2013; Koohsari, Fayaz, & Kari, 2015; C Koranteng, Essel, & Nkrumah, 2015; Christian Koranteng, Nkrumah, & Essel, 2016); window sill level (Butler & Steuerwald, 1991; Inan, 2013; Koohsari et al., 2015); window size (Boubekri, Hulliv, & Boyer, 1991; D. L. Butler & Steuerwald, 1991; C

Koranteng et al., 2015); window type (Dogrusoy & Tureyen, 2007), while view constructs are view content and view satisfaction (Aries et al., 2010; Leather et al., 1998; Lottrup et al., 2015; Matusiak & Klöckner, 2016; Ozdemir, 2010). The view as stated by Lottrup et al., (2015), is a part of the portion of the workplace environment that continuously meets the occupant in the office.

This study aims to contribute to the understanding of the relationship between the workplace, windows and view factors with particular application to Nigeria, using Structural Equation Modelling. Based on the review of the literature, the following hypotheses are formulated;
H1-Window has a positive influence on the views received by the office occupants'.
H2-Window positively affects the workplace environment.
H3-Window positively influences the occupants' satisfaction

2.0 Materials and Methods

2.1 Method for Data collection

The survey method using questionnaire was used for the research. The questions were drawn from different researches (Aries et al., (2010), Dogrusoy & Tureyen, (2007), Hellinga, (2013) and Woo, (2010)). The scale used is a 5-point Likert scale. The content validity was achieved by engaging a team of specialized experts from the Built Environment. The team consisted of three Architects, two Landscape Architects, two Facility Managers, and one Building Technologist. The team were consulted based on the years of professional experience and availability to complete the task within the given time frame. Subsequently, their inputs were used to refine and finalize the questionnaire in terms of content and readability. The questionnaire is classified into four parts; Demographic data, workplace factors, windows and views factors, and occupants preferences. A pilot study was carried out before the field survey.

A Cross-sectional survey was carried out by distributing closed-ended questionnaires across five Government office buildings within Kogi State in Nigeria from July to September 2019. The data from the respondents was got by using a 5-point Likert scale with the range starting from 1= strongly disagree to 5= strongly agree. The sampling technique used for this study is the convenience sampling method. The inclusion criteria of participants were that eligible participants are those that work in shared-room offices and open-plan offices. The office types were grouped based on pre-defined categorization from Danielsson & Bodin, (2008). In total, 350 questionnaires were distributed but 331(94%) questionnaires were retrieved. Questionnaires with an incomplete response and missing data of more than 10% were excluded resulting in a total of 267 questionnaires of valid samples with a 76% effective rate. All responses were anonymous to protect the privacy of participants. Awang, (2015) stated that Hair et al (2011) accepts that the minimum sample size is 200. The demography of the respondents is as shown in Table 1.

Table 1 Demographics of valid respondents

Parameter	Value	Frequency	Percentage %
Gender	Male	166	62.2
	Female	101	37.8
Age	Less than 30	117	43.8
	31- 40	69	25.8
	41- 50	56	21.0
	51- 60	22	8.2
	Above 60	3	1.1
Educational Qualification	Secondary Education	6	2.2
	Tertiary Education	114	42.7
	Bachelors' Degree	111	41.6
	Masters' Degree	36	13.5
Duration of Service	Less than 5	99	37.1
	5- 10	82	30.7
	11- 20	68	25.5
	Above 20	18	6.7
Current Work Specification	Administrative Support	87	32.6
	Managerial / Supervisory	56	21.0
	Technical /Engineer/Professional	109	40.8
	Sales / Marketing	15	5.6
Total		267 Respondents	

3.0 Data Analysis Of The Survey

3.1. Justification For SEM Selection

Structural Equation Model (SEM) is a multivariate statistical method mostly used for studying relationships which exist and linking the latent constructs and the observed variables (indicators) in research (Qureshi & Kang, 2015). SEM's footing rest in both factor analysis and multiple regression analysis. There is the possibility of estimating multiple and interrelated dependence relationships with SEM, also representing unobserved concepts in relationships and display the measurement error (Hair et al, 2017). A sample size of at least 200 normally distributed data is recommended when using SEM (Hox & Bechger, 1999). This study got 267 responses, therefore SEM is applicable.

The two significant components of SEM are measurement model and structural model. The measurement model in SEM shows the estimated relationships between latent constructs and their observed indicators, while the structural model shows the estimation of the relationship between constructs. Confirmatory Factor Analysis (CFA) is a crucial part used to test the fitness of data for the hypothesized model (Chong, Nazim, & Ahmad, 2014). In this study, a preliminary analysis was performed with the Statistical Package for Social Science (SPSS) version 23 and AMOS 22.0 version as the modelling tool.

3.2 Kaiser-Meyer-Olkin (KMO)

When applying Likert scales it is important to use Cronbach's alpha coefficient in determining the reliability and consistency of the constructs. Using SPSS version 23, Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity were conducted and the results as shown in Table 2 revealed that .000 is significant, indicating that the correlation matrix is not individualistic and the data set is suitable and acceptable with the value of .851. Therefore, having a value above .6 as suggested by Kaiser, 1970 as cited by Pallant, J. (2016) indicates that factor analysis is appropriate.

Table 2 Results of KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.851
Bartlett's Test of Sphericity	Approx. Chi-Square	20850.995
	df	1953
	Sig.	.000

3.3 Confirmatory Factor Analysis

3.3.1 Construct Reliability

The Analysis of Moment Structures (AMOS) software version 22 was used for the Confirmatory Factor Analysis (CFA). The screening of the data was done to ensure univariate and multivariate normality and removal of outliers. The factors used for this research have Cronbach alpha all above 0.7, thus indicating a great level of internal consistency. The use of AMOS software also requires that reliability and validity test is first carried out before using the Structural Equation Model (SEM). Table 4 shows the results of reliability and validity analysis for the present study. Composite Reliability (CR) and Average Variance Extracted (AVE) of the latent constructs are all above the required 0.6 and 0.5 respectively (Z. Awang, 2015). The model fitness of the data used is determined by using at least one Fitness Index from each category of model fit (Holmes-Smith, 2006; Hooper, Coughlan, & Mullen, 2008; Parry, n.d.). The latent constructs are eleven as listed in Table 4.

3.3.2 Construct Validity

The CFA is a validating procedure in the Structural Equation Model (Awang, 2015). Items having low factor loadings in the model are removed to achieve Fitness Indexes. For this study, the CFA was run individually for each latent construct and variables showing low factor loadings were deleted, while identified pairs of redundant items through Modification Indices (MI) resulted in covariation between the errors of redundant items. Covariation constrains the redundancy effects thereby increasing the model fitness. The following are the variables with covariance; WDB3-WDB4, SAB2-SAB4, FHB1-FHB5, WPB3-WPB6, WLC3-WLC4, VSC3-VSC6. The deleted variables through individual CFA are; WDB6, SAB6, WPB4, WLC6, VSC4, SWC5, TWC2, TWC6.

The individual CFA was then pooled together to assess the measurement model of latent constructs. The initial measurement model contained eleven latent constructs that are inter-correlated, 56 observed variables, and with the measurement error shown on each indicator. The initial CFA iteration of the measurement model showed good factor loadings above 0.6 except for CVC2 and CVC4 which had low factors of < 0.6. The absolute fitness indices indicated a good fit; CFI is 0.945, IFI is 0.945, TLI is 0.941, P is 0.000, RMSEA is 0.052, and with a ChiSq/df =1.731. The second iteration after deleting the two low factor observed variables, the fitness indices showed RMSEA= 0.053, IFI=0.947, TLI=0.942, P=0.000, ChiSq/df=1.760. The following output was generated based on the response of the respondents. According to the literature, if the values of TLI, CFI, IFI, approach 0.95, then the models are a good fit (Bentler & Bonett, 1980). The composite reliability (CR) score, constructs Cronbach's alpha, and the average variance (AVE) indices were used to determine convergent validity. Preferably, CR should be higher than AVE (Awang, 2015).

Table 3 Summary of the fitness indices results for the measurement model

Category's Name	Parsimonious Fit			Absolute fit	Incremental fit	Incremental fit	Absolute fit
Fitness Indexes	Chi-square	df	Chisq/ df	CFI	IFI	TLI	RMSEA
Acceptance level	Chisq/ <3.0			CFI >0.90	IFI >0.90	TLI >0.90	RMSEA <0.08
Initial value	2464.521	1424	1.731	.945	.945	.941	.052
Revised value	2318.461	1317	1.760	.947	.947	.942	.053
MODEL IS ACCEPTED							

Table 4 Results of Reliability and Validity Analysis

Item description (Construct)	No of Items	Variables	Factor Loading		Cronbach's Alpha Value Above 0.7	Composite Reliability (CR) Above 0.6	Average Variance (AVE) Above 0.5
			Initial	Revised			
WDB- Window distance	WDB1	The window is too close to workspace	.98	NO MODIFICATION	0.931	0.943	0.772
	WDB2	Window distance is less than 2 meters	.95				
	WDB3	Window distance is between 2-4 meters	.76				
	WDB4	Window distance is above 4 meters	.69				
	WDB5	You are satisfied with window distance	.97				
SAB- Seating arrangement	SAB1	Workspace is arrangement is a distraction	1.00	NO MODIFICATION	0.932	0.969	0.862
	SAB2	Having a clear view from workspace	.81				
	SAB3	Near an exterior wall	.97				
	SAB4	Near a window	.87				
	SAB5	Near the core	.97				
FHB- Room height	FHB1	Floor to ceiling is too high	.88	NO MODIFICATION	0.973	0.972	0.854
	FHB2	Space above when seated negatively affects	.93				
	FHB3	Height affects the concentration level	.96				
	FHB4	Height negatively affects the window size	.97				
	FHB5	Indifferent about the room height	.80				
	FHB6	Height negatively affects the office shape	.99				
OSB- Office size	OSB1	Office size is adequate	.85	NO MODIFICATION	0.935	0.935	0.707
	OSB2	Office size is attractive	.78				
	OSB3	Size is suitable for workspace arrangement	.89				
	OSB4	Size appears to be narrow	.84				
	OSB5	Shape is rectangular	.81				
	OSB6	Satisfied with the office size	.87				
WPB- Window position	WPB1	Window position is centralized in the wall	.80	NO MODIFICATION	0.968	0.962	0.837
	WPB2	The window is on the external wall	1.00				
	WPB3	Window position is adjacent my workspace	.86				
	WPB5	Window position is behind my workspace	.98				
	WPB6	Window position positively affects occupants	.92				
SWC- Window sill level	WLC1	Sill level negatively affect window view	.73	NO MODIFICATION	0.929	0.925	0.715
	WLC2	Sill level serves as protection when seated	.96				
	WLC3	Sill level is above 900 meters	.77				
	WLC4	Sill level allows for a clearer view	.79				
	WLC5	Satisfied with the height of the window sill level	.95				
SWC- Window size	SWC1	Window size is sufficient for the office	.85	NO MODIFICATION	0.917	0.913	0.677
	SWC2	Window size provides adequate view	.80				
	SWC3	Window size causes distractions	.78				
	SWC4	Window size is too large	.79				
	SWC6	Window size positively affects occupants	.89				
TWC- Window type	TWC1	Window type has clear glass for viewing	.91	NO MODIFICATION	0.919	0.904	0.707
	TWC3	Window type is operable	.95				
	TWC4	Window type is attractive	.65				
	TWC5	Window type has positive effects on occupants	.83				
CVC- View content	CVC1	View contains sky, showing clouds from my seat	.98	.97	0.860	0.977	0.934
	CVC2	It is a contains sky, landscape, and neighbourhood	.51	DELETED			
	CVC3	View contains the landscape (grasses, shrubs, trees)	.97	.97			
	CVC4	The view contains forest and bushes	.38	DELETED			
	CVC5	View contains buildings, car parks, roads	.96	.96			
VSC- View satisfaction	VSC1	Viewing scenes from the window is refreshing	.94	NO MODIFICATION	0.916	0.924	0.710
	VSC2	You are satisfied with the view from your seat	.68				
	VSC3	Viewing the scenery outside makes you relaxed	.84				
	VSC5	View is affected by workplace position	.87				
	VSC6	You often look out through the window	.86				
SAT- Occupants' satisfaction	SAT1	My work is simple and demands little concentration.	.78	NO MODIFICATION	0.926	0.926	0.717
	SAT2	My work requires deep thought and concentration.	.79				
	SAT3	I can accomplish a great deal each day.	.82				
	SAT4	I feel stressed concerning my work.	.97				
	SAT5	I regard my work as interesting and stimulating.	.86				

3.4 Structural Model

The structural model represents the relationships existing between the latent constructs. Based on the theory, the latent constructs from the measurement model were classified into three second-order latent constructs namely; WINF (Window factors), WFAC (Workplace factors), VIEF (View factors), and eleven sub-latent constructs. Using AMOS, the process of validation of the model is required for the transformation of the measurement model into a structural model for analysis. Table 5 shows the results for both the initial and modified structural equation model for the windows and views relationships in the workplace. The initial output had the following: Chi-square= 3611.382, df =1370, Ratio =2.636, CFI = .881, IFI= .881, TLI= .875, RMSEA= .078. Further adjustment was carried out to ensure the fitness of the model. Thus, three items with their error variances were deleted based on the output of the Modification Indices viz: VSC5, VSC1, and TWC3. Consequently, the values of the modified model are: Chi-square=2734.607, df=1217, Ratio=2.247, CFI= .910, IFI= .910, TLI= .906, RMSEA= .068. The summary of factor loadings and the validity of the constructs of windows and view relationship in the workplace is shown in Table 6.

Table 5 Summary of Fitness indices results for the structural model

Category's Name	Parsimonious Fit			Absolute fit	Incremental fit	Incremental fit	Absolute fit
Fitness Indexes	Chi-square	df	Chisq/df	CFI	IFI	TLI	RMSEA
Acceptance level			Chisq< 3.0	CFI >0.90	IFI >0.90	TLI >0.90	RMSEA <0.08
Initial value	3611.382	1370	2.636	.881	.881	.875	.078
Revised value	2734.607	1217	2.247	.910	.910	.906	.068
MODEL IS ACCEPTED							

Table 6 Summary of factor loadings and validity

Code	Item description (Construct)	No of Items	Factor loading		Composite Reliability (CR) Above 0.6	Average Variance (AVE) Above 0.5
			Initial	Revised		
Workplace factors	WDB (Window distance)	WDB1	.98	.98	0.935	0.748
		WDB2	.94	.94		
		WDB3	.73	.73		
		WDB4	.66	.65		
		WDB5	.97	.97		
	SAB (Seating arrangement)	SAB1	1.00	1.00	0.963	0.841
		SAB2	.75	.75		
		SAB3	.98	.98		
		SAB4	.84	.85		
		SAB5	.98	.98		
	FHB (Room height)	FHB1	.92	.92	0.981	0.895
		FHB2	.95	.94		
		FHB3	.97	.97		
		FHB4	.98	.98		
		FHB5	.87	.87		
		FHB6	1.00	.99		
	OSB (Office size)	OSB1	.90	.90	0.958	0.793
		OSB2	.84	.84		
		OSB3	.92	.92		
		OSB4	.89	.89		
		OSB5	.87	.87		
		OSB6	.92	.92		
Window factors	WPB (Window position)	WPB1	.91	.91	0.982	0.915
		WPB2	1.00	1.00		
		WPB3	.92	.92		
		WPB5	.99	.99		
		WPB6	.96	.96		
	WLC (Window sill level)	WLC1	.91	.91	0.972	0.874
		WLC2	.99	.99		
		WLC3	.89	.89		
		WLC4	.90	.90		
		WLC5	.98	.98		
	SWC (Window size)	SWC1	.91	.91	0.946	0.779
		SWC2	.86	.86		
		SWC3	.85	.85		
		SWC4	.86	.86		

		SWC6	.93	.93		
	TWC (Window type)	TWC1	.96	.96	0.923	0.801
		TWC3	.97	DELETED		
		TWC4	.81	.82		
		TWC5	.91	.90		
View factors	CVC (View content)	CVC1	.97	.97	0.972	0.922
		CVC3	.96	.97		
		CVC5	.97	.94		
	VSC (View satisfaction)	VSC1	.94	DELETED	0.862	0.680
		VSC2	.68	.66		
		VSC3	.84	.87		
		VSC5	.87	DELETED		
		VSC6	.88	.92		
Occupants' satisfaction	SAT (Occupants' satisfaction)	SAT1	.77	.77	0.940	0.758
		SAT2	.84	.83		
		SAT3	.86	.86		
		SAT4	.98	.98		
		SAT5	.90	.90		

4.0 Discussion of Findings

The final output in Figure 2 shows the interaction outcome of all the constructs in the path diagram. This research adopted standardized regression weight alongside squared multiple correlations with the value of R2, due to its benefit of having a better interpretation of the entire interactions of the constructs in the model. As stated in Kwon & Remøy, (2019), R2 shows the percentage of variation in the independent variables. Hence, the explanation of the model gets better as the R2 value gets higher. Generally, R2 values are described as follows; 0.75 as strong, 0.5 as moderate, and 0.25 as weak (Henseler, Ringle, & Sinkovics, 2009; Wong, 2013).

In Table 3, all Fitness Indexes achieved the required level thereby indicating the validity of the constructs for the model. The model in Table 7 shows that the p-values are all highly significant having $p<0.005$. Figure 2 output reveals that the correlation between the constructs are below the threshold of 0.85 indicating that redundancy does not exist among the components. All factor loadings are positive and with high values indicating that all items are important in measuring the constructs respectively. The R2 for WFAC sub-constructs shows OSB (.35) and FHB (.34) as moderate, while SAB (.18), and WDB (.16) were lower.

The low output for SAB and WDB is an indication that the data set used is reflecting the degrading current situation in shared-room and open-plan offices in Nigeria as regards to the workplace seating arrangement and their proximity to the windows. According to Oseland (2009), the current trends in building reveals that psychological factors are generally not fully considered. VIEF sub-constructs showed R2 for CVC (.93) to be strong, and VSC (0.05) as quite weak. This weak R2 value could be attributed to the office occupants' not being satisfied with the content of the present view available from the windows since the majority of the offices are surrounded by a built view. Research has shown that people prefer natural view overbuilt view (Hellinga, 2013). Also, some studies have opined that the information content of a window view is a determinant for views being preferred over others (R. Kaplan & Kaplan, 1989). In the office setting, having access to natural environments has a restorative effect on attention.

The WINF sub-constructs also revealed R2 as follows; WPB (.39), WLC (.51), SWC (.34), and TWC (.94). The TWC shows an R2 strong value indicating that the office occupants are satisfied with Window type. WPB and SWC reveal values that are within the moderate range, notwithstanding these values indicate that the window position and window size do not contribute strongly enough to the psychological satisfaction of the office occupants. Windows should be positioned to promote physical and psychological health (Moore, 1981; R. S. Ulrich, 1984). Providing a comfortable working environment is salient to allow the office occupants' focus on their task, thereby ensuring the quality of life at workplace and better performance of occupants' (Kamarulzaman et al,2011).

The overall R2 for the model is .53 meaning that the model has a moderate value as it captures 53% of the estimate on WINF by including VIEF, WFAC and SAT. It proves that the existing relationship between windows and view in this model is not strong. As stated in Thompson & Bruk-Lee (2019), Organizations should proffer design solutions whereby the physical work environment will allow occupants' have maximum access and exposure to nature in the office. Several studies have shown that windows and views through the window promote physical and psychological health, with these natures' healing abilities it is expedient to ensure occupants are exposed to nature for improved wellbeing and strain reduction (Thompson & Bruk-Lee, 2019).

The model is to reveal the relationship that exists between windows and views in the workplace to discourage the abuse of social density and lack of space standards policy that is gradually causing havoc in the Nigerian Government offices whereby the importance of occupants having access to an outside view is undermined. It is usually presumed that better work outcomes are produced by office occupants' who are more satisfied with the physical environment (Kamarulzaman et al., 2011).

Table 7 shows that the three research hypothesis H1, H2, and H3 are significant and have positive effects on window factors. Therefore, the hypotheses are all supported.

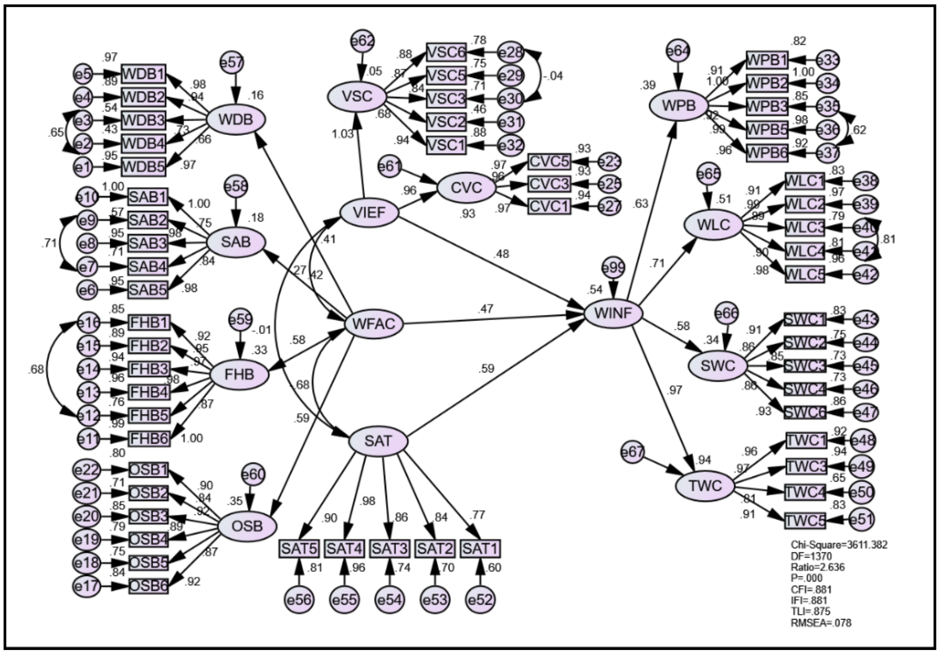

Figure 1 Initial Structural Equation Model of Windows and view relationship

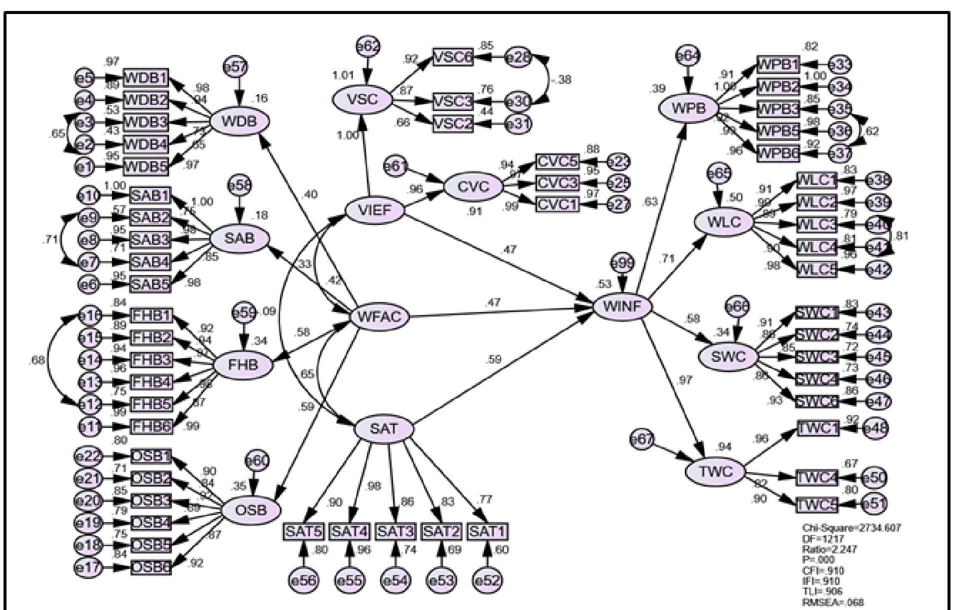

Figure 2 Modified Structural Equation Model of Window and View Relationship

Table 7 Significant Effect of Window and View Relationship in the Workplace

Construct	Path	Construct	Estimates	S.E.	C.R.	P
WINF	<---	VIEF	.605	.039	15.496	***
WINF	<---	WFAC	.689	.038	17.967	***
WINF	<---	SAT	.862	.024	35.206	***
WDB	<---	WFAC	.605	.039	15.496	***
SAB	<---	WFAC	.689	.038	17.967	***
FHB	<---	WFAC	.862	.024	35.206	***
OSB	<---	WFAC	.983	.020	50.048	***
WPB	<---	WINF	.685	.033	20.615	***
WLC	<---	WINF	.916	.020	45.123	***
SWC	<---	WINF	.594	.038	15.600	***
TWC	<---	WINF	.968	.014	68.458	***
VSC	<---	VIEF	.992	.017	58.626	***
CVC	<---	VIEF	.911	.037	24.316	***

5.0 Conclusion

Windows in the workplace environment are important to the occupants' for satisfying both physical and psychological human needs. The visual connection with nature through the window positively influences the occupants' satisfaction in the workplace. This study identified the influential components of windows and view in the workplace model. The analysis provides the relationship that is focused on Government office occupants' in Nigeria particularly in Kogi State. The outcome of their relationships shows that SAB (seating arrangement) and WDB (window distance) having lower R2 is an indication that the current trend of neglecting workspace arrangement and proximity to windows is breading an unhealthy environment for its occupants'. The overall R2 for the model is a bit above 50%, this is an indication than urgent measures for sustaining a healthy workplace environment should be instituted. The R2 value 53% may have been better if the necessary conditions for the workplace were met.

The findings of this study hypothetically improve the existing literature on the workplace environment and the importance of window view out, while it also provides practical suggestions that will assist in the policy making on improvement on workplace design and also, for effective monitoring and enforcement of office space allocation standards.

The findings in this study will provide suggestions for Facility managers, Interior designers, Architects, and other Building stakeholders for the effective implementation and adherence of space standards in Government office buildings.
The study focused on data from Government offices in Nigeria particularly offices that have more than one workspace, therefore the conclusions may differ for other Countries.

Conflict of interest

The authors declare that there is no conflict of interest.

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International Journal of Built Environment and Sustainability
Published by Penerbit UTM Press, Universiti Teknologi Malaysia
IJBES 8(2)/2021, 115-126

Defining the Building Blocks and the Priority Areas for Cooperation Under the Belt and Road Initiative

Yaktor Joshua Inusa
Department of Architecture, Faculty of Environmental Sciences, University of Jos, Jos 90001, Plateau State, Nigeria

Doris Hooi Chyee Toe
Faculty of Built Environment and Surveying, Universiti Teknologi Malaysia, 81310 UTM Skudai, Johor, Malaysia

Kum Weng Yong
KW Yong Architect, 70300 Seremban, Negeri Sembilan, Malaysia

ABSTRACT

The Belt and Road Initiative (BRI) is a China's endeavour to globally connect the countries along two major routes. This paper examines the keywords defining the building blocks and priority areas under the BRI and their relationship in order to foster a practical understanding of the BRI for enhancing regional cooperation and connectivity along the routes. The methodology employed was a systematic literature review involving four stages. Firstly, a broad search in the Scopus database (2016-2020) using BRI or similar terms returned n=1,710 articles which were further limited using the keywords: building blocks, priority areas, policy coordination, infrastructure connectivity, unimpeded trade, financial integration and people-to-people exchange. Other keywords considered were community and Silk Road. The articles were then screened and assessed resulting in 155 articles reviewed in this study. The review reveals that while the building blocks are the aim motivating the BRI, hence the spirit behind it, the five priority areas provide practical methods through which China and other countries along the Belt and Road routes will focus their collective development. The relationship between the two aspects owes to the fact that people are involved at all spheres of the initiative bringing about emphasis on the people-to-people exchange which is a core part of social dimension in sustainable development. In contribution, this paper presents a unique perspective for looking at the BRI for a focused discussion of its cooperative framework which could serve as a foundation for further research in various sectors.

Article History

Received: *19 July 2020*
Received in revised form: *09 January 2021*
Accepted: *04 February 2021*
Published Online: *30 April 2021*

Keywords:

Belt and Road Initiative, Green Development, Peace, Regional Cooperation and Connectivity, Shared Global Community, Silk Road

Corresponding Author Contact:

doristhchyee@utm.my

DOI: 10.11113/ijbes.v8.n2.671

1. Introduction

As a global project, the Belt and Road Initiative (also known as One Belt One Road) is a China's brain child to connect the countries along two major routes – the "Silk Road Economic Belt" and the "21st Century Maritime Silk Road" (Amighini, 2017a; Huang, 2016; Lagutina, 2017; Mingjiang Li, 2015; Youfa Wang et al., 2017). This also came to promote the globalization and mutual inclusiveness which are lacking due to growing gaps in development and rising protectionist and nationalist stance (Kikuchi, 2018; Y. Li, 2017; W. Liu, 2016; Magri, 2017; Richet et al., 2017). It is a complete scheme for fostering socio-economic collaboration among countries along the Belt and Road region and it is beyond just constructing roads, railways and port facilities (W. Liu, 2016). Strategies similar to the Belt and Road Initiative can be perceived as a product of competitions between policy-makers on the local ground confronted by restrictions from home institutions and society and those in the global arena facing universal restrictions (Y. Li, 2017;

Ngoei, 2018; Y. Qi et al., 2018).

As one of major cornerstones of the Belt and Road Initiative (BRI), the "Silk Road Economic Belt" (SREB) is a reaction to the long deliberated integration process in Eurasia via Russia and others among the largest republics in Central Asia, which eventually resulted in the Eurasian Economic Union (EEU) establishment in 2015 (Amighini, 2017b). The SREB has three routes: (1) Northwest China and Northeast China to Europe and the Baltic Sea through Central Asia and Russia; (2) Northwest China to the Persian Gulf and the Mediterranean Sea, passing through Central Asia and West Asia; and (3) Southwest China through the Indochina Peninsula to the Indian Ocean (Office of the Leading Group for the Belt and Road Initiative, 2017). With a population of about 3 billion, the SREB contains a total area of 50 million square kilometers (Xu et al., 2017).

Meanwhile, the "21st Century Maritime Silk Road" (MSR) which is the second of the two key pillars (D. Chen and Yang, 2018) starts from (1) coastal ports of China crossing the South China Sea to the Indian Ocean, stretching to Africa and Europe; and (2) coastal ports of China via the South China Sea to the Pacific Ocean (Huang, 2016).

Table 1. *Keywords defining the Belt and Road Initiative*

Keywords Category	Keyword	Source
A. Outline	1. "Silk Road Economic Belt" 2. "21st Century Maritime Silk Road" 3. "Spirit of the Silk Road" 4. "Silk Road Fund" 5. "Asian Infrastructure Investment Bank" (AIIB) 6. "Steering Group for BRI" 7. "Vision and Actions" 8. "Five-pronged approach"	(Amighini, 2017a; CCTV, 2017; Huang, 2016; Lagutina, 2017; Mingjiang Li, 2015; Na-Xi et al., 2019; Ying Wang and Chou, 2020; Youfa Wang et al., 2017)
B. Building Blocks	1. "Community of shared interests" 2. "Community of shared responsibilities" 3. "Community with a shared future" 4. "Silk Road to green development" 5. "Silk Road for health cooperation" 6. "Silk Road to innovation" 7. "Silk Road to peace"	(CCTV, 2017; Dunford and Liu, 2019; Khan et al., 2018; Zeng, 2016)
C. Priority Areas for Cooperation	1. "Policy coordination" 2. "Infrastructure connectivity" 3. "Unimpeded trade" 4. "Financial integration" 5. "People-to-people exchange"	(CCTV, 2017; Dunford and Liu, 2019; Huang, 2016; Teo et al., 2019; Valderrey et al., 2020; Ying Wang and Chou, 2020; Yin, 2019)
D. Economic Corridors	1. "China-Mongolia-Russia Economic Corridor" (CMREC) 2. "New Eurasian Land Bridge" (NELB) 3. "China-Central Asia-West Asia Economic Corridor" (CCWAEC) 4. "China-Indochina Peninsula Economic Corridor" (CICPEC) 5. "China-Pakistan Economic Corridor" (CPEC) 6. "Bangladesh-China-India-Myanmar Economic Corridor" (BCIMEC)	(CCTV, 2017; Dunford and Liu, 2019; Hussain, 2017; Iqbal et al., 2019; Jeganaathan, 2017; Menhas et al., 2019; Pradhan, 2018)
E. Cooperation Mechanisms	1. "Shanghai Cooperation Organization" (SCO) 2. "China-ASEAN (10+1) Cooperation" 3. "Asia-Pacific Economic Cooperation" (APEC) 4. "Asia-Europe Meeting" (ASEM) 5. "Asia Cooperation Dialogue" (ACD) 6. "Conference on Interaction and Confidence-Building Measures in Asia" (CICA) 7. "China-Arab States Cooperation Forum" (CASCF) 8. "China-Gulf Cooperation Council (GCC) Strategic Dialogue" 9. "Greater Mekong Subregion (GMS) Economic Cooperation" 10. "Central Asia Regional Economic Cooperation" (CAREC) 11. "Cooperation between China and Central and Eastern European Countries" (16+1) 12. "Forum on China-Africa Cooperation" (FOCAC)	(Allison, 2018; CCTV, 2017; Han et al., 2018; Jeganaathan, 2017; Na-Xi et al., 2019; Pepermans, 2018; Svetlicinii, 2018; Zeng, 2016)

F. Projects Underway	1. "China-Belarus Industrial Park" 2. "Gwadar Port Free Zone" 3. "Colombo Port City" 4. "China Railway Express to Europe" 5. "Jakarta-Bandung railway" 6. "China-Laos railway" 7. "China-Thailand railway" 8. "Mombasa-Nairobi railway" 9. "Addis Ababa-Adama expressway" 10. "Karot hydropower project"	(CCTV, 2017; M. H. T. Chan, 2018; Das, 2017; Dunford and Liu, 2019; Garlick, 2017; Hu, 2019; Iqbal et al., 2019; Lechner et al., 2018; Noel Dussort and Marchetti, 2019; Panthamit and Chaiboonsri, 2020; Rowedder, 2020)

The Office of the Leading Group for the Belt and Road Initiative (2017) considers this decription as two main routes of the 21st Century MSR. The 21st Century MSR will pass the Eastern shores of the Arabian Peninsula across the Red Sea and the Suez Canal to the Mediterranean Sea (Fasulo and Talbot, 2017).

Seeing China's ambition of extending its reach globally through this initiative, it is important to ask; what are the building blocks, and the areas of focus of the BRI? And how are they related to foster the understanding of the BRI? Table 1 shows the keywords that describe the BRI. To some extend, these keywords give a comprehensive outlook of the intiative. These important keywords are grouped under six categories – outline, building blocks, priority areas for cooperation, economic corridors, cooperation mechanisms, and projects underway. Among these categories, the building blocks and the five priority areas for cooperation are fundamental to the understanding and implementation of the BRI as enshrined in NDRC (2015). So, it is important to focus on the "building blocks" and "priority areas" for cooperation to foster better understanding of the BRI. This paper seeks to examine the "building blocks" and the five "priority areas" for cooperation of the BRI and discuss their relationship.

2. Methodology

The methodology for this study employed a systematic literature review procedure as illustrated in Figure 1. This approach involved four stages. Firstly, a search was conducted using the broad topic and the Boolean operator as follows: "Belt and Road Initiative" OR BRI OR "One Belt One Road" OR OBOR from 2016 to 2020. This returned 1,710 (research, review, and conference) articles which were then further limited by keyword search within the result. These keywords employed were building blocks (n=9), priority areas (n=3), policy coordination (n=20), infrastructure connectivity (n=4), unimpeded trade (n=12), financial integration (n=18) and people-to-people exchange (n=21).

Other keywords considered were community (n=320) and Silk Road (n=728) which were further narrowed by specific keyword search. These keywords returned results as follows: shared interests (n=3), shared responsibilities (n=1) and shared future (n=24) within the term community, and green development (n=12), health cooperation (n=6), innovation (n=145) and peace (n=106) within the term Silk Road. Overall, the first stage returned a total of n=384 articles.

Secondly, the next stage involved removal of duplicates and subsequent screening of the articles. Having removed the duplicates, the number of articles included were n=310. Furthermore, these articles were screened based on the related titles. Also, articles outside the search limit were screened. Therefore, the number of articles included based on related title and those screened outside the search limits were n=221 and n=27 respectively; these were further assessed.

In the third stage, these articles were assessed and included based on their relevance and contribution to this study. The articles included after the assessment were n=134 for those from Scopus database from 2016 to 2020 and n=21 for those outside the limit. Finally, the fourth stage involved the review of the articles. The total number of the articles reviewed were n=155 which distribution is presented in Figure 2; also, as shown in the figure, n=94 articles were cited.

3. The Building Blocks Of The Belt And Road Initiative

The keywords that explain the building blocks of the BRI are as follows: "community of shared interests" (Dunford and Liu, 2019), Other keywords considered were community (n=320) and Silk Road (n=728) which were further narrowed by specific keyword search. These keywords returned results as follows: shared interests (n=3), shared responsibilities (n=1) and shared future (n=24) within the term community, and green development (n=12), health cooperation (n=6), innovation (n=145) and peace (n=106) within the term Silk Road. Overall, the first stage returned a total of n=384 articles.

Secondly, the next stage involved removal of duplicates and subsequent screening of the articles. Having removed the duplicates, the number of articles included were n=310. Furthermore, these articles were screened based on the related titles. Also, articles outside the search limit were screened. Therefore, the number of articles included based on related title and those screened outside the search limits were n=221 and n=27 respectively; these were further assessed.

In the third stage, these articles were assessed and included based on their relevance and contribution to this study. The articles included after the assessment were n=134 for those from Scopus database from 2016 to 2020 and n=21 for those outside the limit. Finally, the fourth stage involved the review of the articles. The total number of the articles reviewed were n=155 which distribution is presented in Figure 2; also, as shown in the figure, n=94 articles were cited.

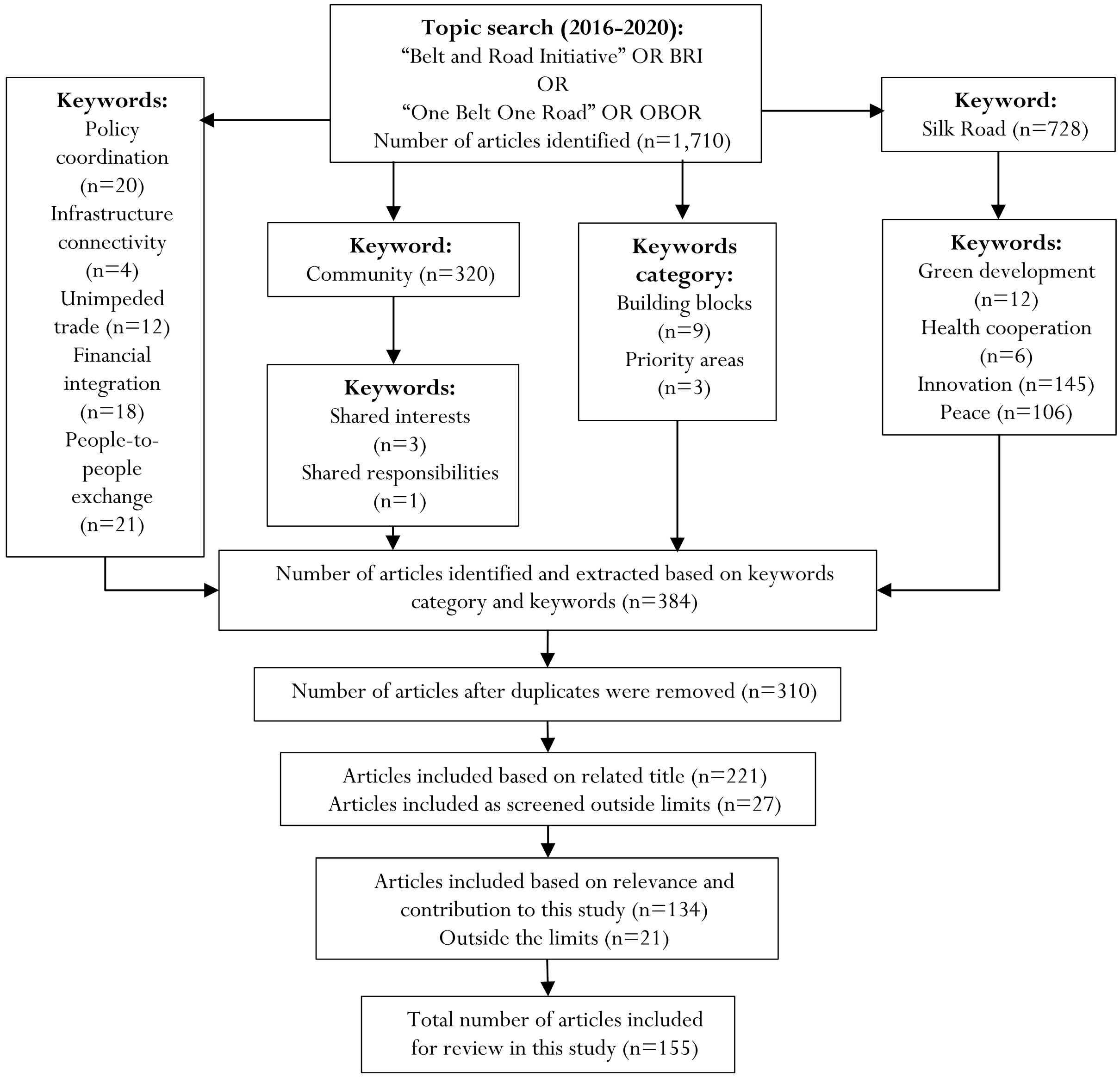

Figure 1.*Stages of the review procedure*

4. The Building Blocks Of The Belt And Road Initiative

The keywords that explain the building blocks of the BRI are as follows: "community of shared interests" (Dunford and Liu, 2019), "community of shared responsibilities", "community with a shared future" (Akçay and Qingye, 2020; Dong et al., 2018; Hu, 2019; Khan et al., 2018; A. Liu and Guan, 2017; Nordin and Weissmann, 2018; Xiangyang, 2019; Zeng, 2016; Y.-J. Zhang et al., 2020), Silk Road to green development, Silk Road to innovation, Silk Road to peace, and Silk Road for health cooperation (CCTV 2017).

Figure 3 shows the connection of the building blocks with the initiative. As seen in the figure, BRI aimed at developing a global community of shared interests, responsibilities, and with a common future along the Silk Road with the attributes of green development, innovation, peace, and health cooperation. This relationship is considered to be the spirit behind the BRI (NDRC, 2015). When successfully implemented, the BRI is expected to impact the Silk Road and its interconnected regions and subsequently improving the quality of the settlements (Dong et al., 2018; Dunford and Liu, 2019; Hu, 2019; Khan et al., 2018; Zeng, 2016).

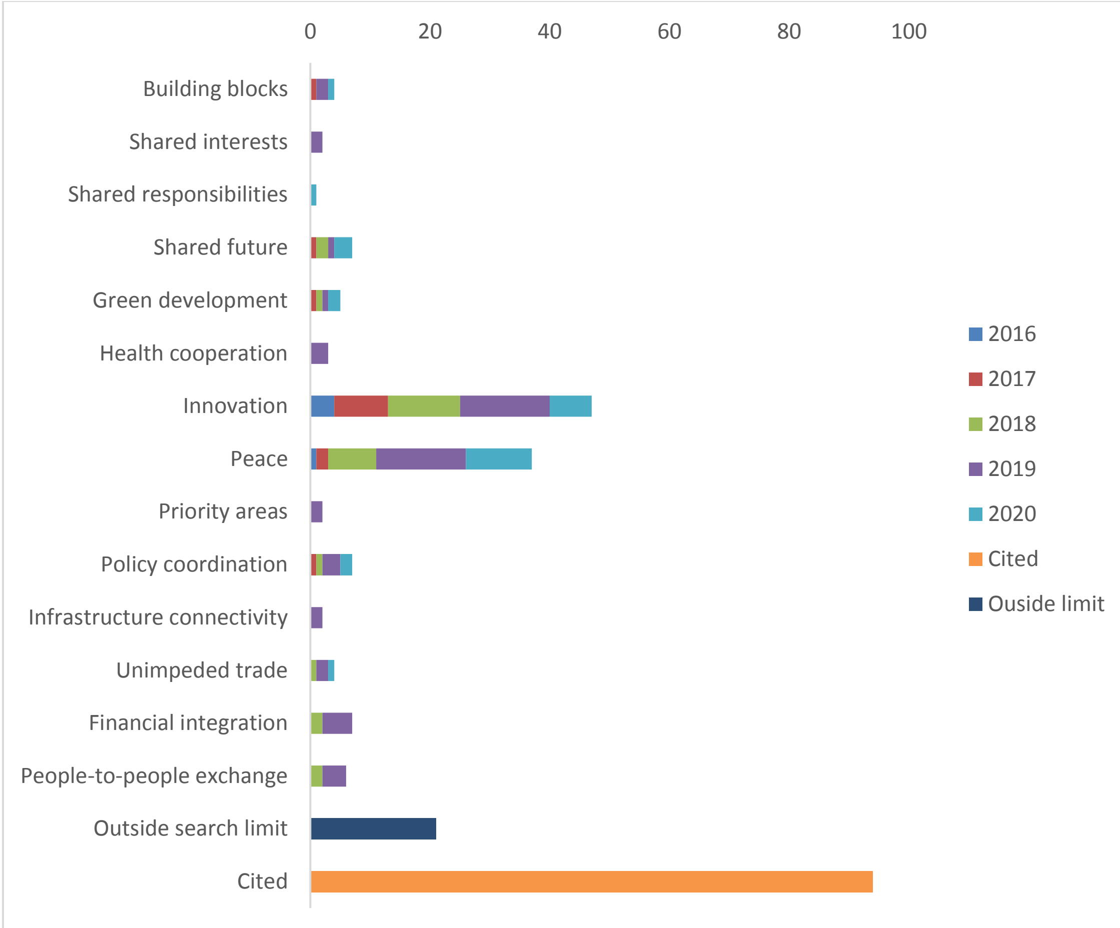

Figure 2. *Distribution of articles reviewed and the number of cited articles in this study*

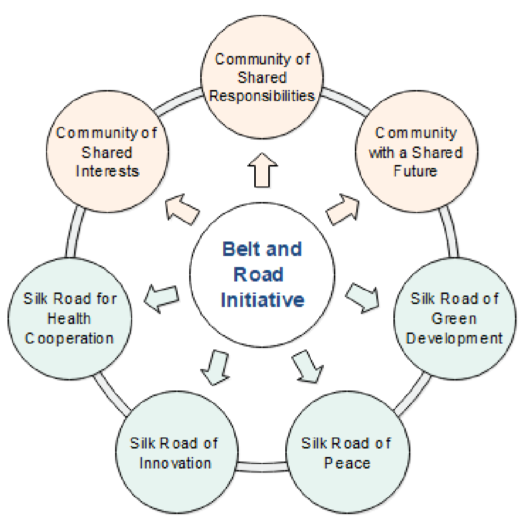

Figure 3. *The building blocks of the Belt and Road Initiative*

4.1 Community: Shared Interests, Responsibilities And Future

In terms of community, three building blocks are identified (Figure 3). Firstly, building a "community of shared interests" is one of the three targets of the BRI, which encourages joining hands to make a brighter future for all countries as the basic interests of mankind are necessary to each country (Liu, 2016; Office of the Leading Group for the Belt and Road Initiative, 2017; Khan *et al.*, 2018). Through the development of a high-speed railway, the network of the coordinated channel and additionally the limit and efficiency of transport would be enhanced, in this way elevating China to frame a "community of shared interests" alongside different countries and regions (Shao et al., 2017). Furthermore, the reciprocal interdependence among the individuals with division of labour results into a "community of shared interests" because the individual's prosperity depends not only on the effort of each but on that of the participants collectively (Dunford and Liu, 2019).

Secondly, forming a "community of shared responsibilities" along with shared interests and common destiny (Zeng, 2016) highlight economic related coordination, socio-cultural extensiveness (A. Liu and Guan, 2017) and environmental control (W. Liu, 2016), which collectively make up the three pillars of sustainable development.

The BRI is a gigantic project from China, aiming at encouraging a base for diversified cooperation and achieving win-win outcomes through shared responsibilities (Y. Li, 2017). Although some exceptions may occur, globalisation is about shared standards which are basic bits of the World Trade Organization (WTO) talks and assertions (Richet et al., 2017).

Finally, the initiative gives new impulse to the building of a community with a shared future for humankind (Dong et al., 2018; Lagutina, 2017). It exhibits a positive vision that the "Chinese Dream" is interconnected with the world dream and all countries cooperate to produce a human community of shared destiny (Khan et al., 2018; Nordin and Weissmann, 2018; Office of the Leading Group for the Belt and Road Initiative, 2017; Pendrakowska, 2018; Xiangyang, 2019) and to attain reciprocal benefits and win-win outcomes (Hu, 2019). Parties might cooperate to make a brighter future for all countries as the regular interests of mankind are crucial to each country and nation and rely upon the advancement of a global community of shared future (Jones, 2020; Office of the Leading Group for the Belt and Road Initiative, 2017). Two core connected components, shared development and shared future, form the basis for this joint globalisation (Khan *et al.*, 2018). Likewise, a significant aspect of the Chinese model of building a community with a shared future for all people is global environmental cooperation (Dong et al., 2018). Energy collaboration is a crucial support and foundation for the BRI, and it is beneficial in promoting stable global energy market and the green energy revolution in BRI nations (Y.-J. Zhang et al., 2020).

4.2 Silk Road: Green Development, Innovation, Peace And Health Cooperation

In terms of Silk Road, four building blocks are recognized (Figure 3). Firstly, tightening involvement on ecological and environmental protection (Minjie Li et al., 2019; Teo et al., 2019), China is committed to building a green Silk Road (Jones, 2020; Office of the Leading Group for the Belt and Road Initiative, 2017). To Belt and Road cooperation practices, China "applies a green development philosophy" which shares its newest ideas, technologies, ecological restoration and progress, environmental protection, and pollution prevention and control, thereby actively fulfilling its responsibilities on crucial matters like sustainability and climate change (Dong et al., 2018; Office of the Leading Group for the Belt and Road Initiative, 2017; Suocheng et al., 2017; Xiheng, 2019). Suocheng *et al.* (2017) suggest that activities relating to tourism be organised particularly at the settlement (city, town or municipal) level as "green development" element. China, with National Agency for International Development Cooperation (NAIDC), is to additionally advance "green development under BRI and environmental diplomacy" (Dong *et al.*, 2018, p. 6). For the unnecessary and mediocre investing nations, and to encourage the China's thermal power green development, pertinent economic, political and environmental hazard preventive and safety procedures should be reinforced (Yao et al., 2019).

Secondly, it is clear that China is the "world's second largest economy" with ability to move forward along the orbit of innovation (Lagutina, 2017). Professional mobility from home and diaspora can be effective vehicles for skills exchange, and for a sending nation, diaspora can be a vital source as well as a driver of research and innovation, technology exchange (Khan et al., 2018; Teo et al., 2019), and skills enhancement (Broadman, 2007; Z. Liu and Xin, 2019). In addition, a path to innovation entails deepened collaboration in frontline disciplines like the artificial intelligence, digital economy, nanotechnology, quantum computing, cloud computing, big data and smart cities (Dunford and Liu, 2019; Feng et al., 2019; Gui et al., 2019). Likewise, modernizing industries through innovation as well as spatial change, and searching new local and global markets are two main solutions to China's pursuit of new-normal period growth (W. Liu and Dunford, 2016; S.-Z. Qi et al., 2019; Saud et al., 2020). As the export market was hit after the beginning of the 2008-2012 global economic depression, joint policies were being implemented in line with innovation, and other similar development issues in China (Das, 2017; Durrani and Forbes, 2018; Jeganaathan, 2017). For example, "China already has an ambitious plan in its Industrial Masterplan 2025 [which] aimed at bringing at least 10 industries to world leadership" (Heiduk and Sakaki, 2019; Sheng, 2017). As a significant innovation in technology in the late 20^{th} century, the high-speed rail emergence has substantially decreased the travelling time among regions, suggesting considerable improvements at the transportation infrastructural level (F. Li et al., 2020). Innovation and globalisation encourage an inclination towards cooperative alliance and strategic connections among countries (Rauf et al., 2018; Z. Zhang et al., 2019). However, the long-standing economic development factors like innovation in science and technology as well as investment in staff training have been overlooked, and the long-standing economic development of participating nations is influenced (Sun et al., 2019; Wu et al., 2020).

Thirdly, maintaining closer economic ties, and deepening political acceptance; enhancing cultural bonds; encouraging civilizations to learn from one another and develop together; and promoting "mutual understanding, peace and friendship among people of all countries" are the official objectives of the BRI (S. I. Chan and Song, 2020; Cheng, 2016; Khan et al., 2018; Zeng, 2016). Cardinal to the aforementioned, the design of BRI is to foster "regional peace and prosperity" and inhibit conflict between bordering countries (Blah, 2018; Dunford and Liu, 2019; Farooq et al., 2019; Pepermans, 2018). For example, the government of China published its earliest "China's Arab Policy Paper" in January 2016; this appraised the development and demonstrated the driving principles of the Sino-Arab connection, while setting out a plan for win-win cooperation and restating "China's dedication to peace and stability in the Middle East" (J. Chen et al., 2018). Similarly, the BRI must endeavor to change the "Euro-Asia Great Game" from one that risks another major war to a sequence of gradual moves towards peace for more growth for the future generation (Sheng, 2017). Until now, China has avoided countries that are not peaceful and safe but with the exception of a few which it had earlier established strategic alliance before the BRI was established; Pakistan is one of these countries (Cheng, 2016; Heiduk and Sakaki, 2019).

Lastly, added to the BRI, China places premium to advancing participation among the related countries in the anticipation and control of infectious illnesses, restorative framework and approaches, healthcare education, staff training and interactions, and customary medicine (Office of the Leading Group for the Belt and Road Initiative, 2017; Youfa Wang et al., 2017). As the BRI has pursued developing a new center for health cooperation (branded the Healthy Silk Road), the justification to expand and strengthen connectivity globally will produce a substantial increase in people mobility which may heighten risk of spreading communicable diseases (Gostin, 2018; Gu and Qiu, 2019; J. Li et al., 2019; Murphy, 2018; Tang et al., 2017). Health cooperation among nations plays an essential role under the BRI (Qian et al., 2019). Health is a requisite requirement in promoting humanities in all development processes; it is an essential condition for socio-economic development (J. Li et al., 2019).

5. The Priority Areas For Cooperation Under The Belt And Road Initiative

The priority areas for cooperation are five and they define the implementation methods of the BRI and at the same time give the BRI a focus (Ndzendze and Monyae, 2019). In NDRC (2015), countries along the Silk Road are encouraged to focus on these areas for their development and connectivity in line with the initiative (S. I. Chan and Song, 2020; Yinghui and Teng Teng, 2019).

Figure 4 shows the relationship of the five priority areas for cooperation and the BRI. Though the success of the initiative depends on the influence of the five priorities (Hughes et al., 2020; Jones, 2020), emphasis must be laid on the appropriate areas at a particular point in time according to contextual needs. When the priority areas are well articulated and implemented, they will impact the Belt and Road region, thereby exhibiting the success and quality of the BRI. By 2015, the implementation of the BRI had reached five years, "while the theoretical and empirical research on it is an emerging hot topic in current literature" (Y. Chen et al., 2019).

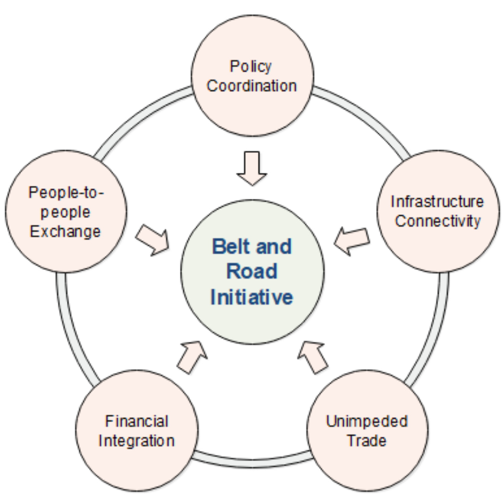

Figure 4. *The five priority areas of the Belt and Road Initiative*

5.1 Policy Coordination

Policy coordination among the countries in the Silk Road regions (Cheng, 2016) provides serious stability to the major economic endeavors (D. Chen and Yang, 2018). It is also an important factor in facilitating the harmonization of the implementation of issues regarding the other priority areas (Jones, 2020; Song, 2019; Sun et al., 2020). Policy coordination expects that nations along the "Belt and Road corridor" collectively create plans for development and measures to advance cross-border or regional cooperation through equitable consultation to resolve difficulties arising from cooperative undertakings (Valderrey et al., 2020; Ying Wang and Chou, 2020). Furthermore, policy coordination with capacity building under the BRI agenda can support certain BRI nations with fragile governance capacities improve their capabilities in managing environmental threats (Xiheng, 2019).

5.2 Infrastructure Connectivity

Infrastructure connectivity is a critical element of the BRI which is all-embracing in scope covering other areas (Huang, 2016; NDRC, 2015). The main focus of infrastructure connectivity are the "six means of communication" namely rail, highways, marine transport, aviation, pipelines, and aerospace integrated information network (Jones, 2020; Office of the Leading Group for the Belt and Road Initiative, 2017; Valderrey et al., 2020; Ying Wang and Chou, 2020). Infrastructure connectivity, being a "logistics-enabling factor", encompasses establishing an infrastructure web linking several sub-regions in Asia with other Asian parts, Africa and Europe (Ying Wang and Chou, 2020). Also, infrastructure connectivity is the fundamental guarantor for improving the sustainable development level in the Belt and Road region (Yin, 2019). Therefore, one can suggest that policymakers engaged in the BRI should focus on collectively developing smooth, efficient and secured transportation routes, linking main ports along the Belt and Road, while recognising that facilities construction for infrastructure connectivity can boost "logistics networks" (Valderrey et al., 2020; Ying Wang and Chou, 2020).

5.3 Unimpeded Trade

Trade facilitation, technical standards, improving customs regimes, and harmonization of regional trade agreements (Broadman, 2007) are main contributors for unimpeded trade (Yilmaz and Changming, 2019). Trade and investment cooperation is a "major task" in building the Belt and Road (Cheng, 2016), as well as driving force of the economy of the Silk Road countries (Wu et al., 2020). The institution of unimpeded trade along the Belt and Road is an important issue in the framework of aiding trade relationships; it was ranked the most important factor for logistics advancement under the BRI (Ying Wang and Chou, 2020). "Commissioning of new railway lines enhances trade facilitation in a more basic way" (Y. Li, 2017). Unimpeded trade is the keystone of the BRI and stands for trade liberalisation, trade barrier removal and free commerce promotion (Song, 2019; Taidong, 2019; Valderrey et al., 2020). Efforts to eradicate the trade environmental impact will be crucial to the enduring cooperation between China and nations along the Belt and Road while promoting unimpeded trade (Cuiyun and Chazhong, 2020).

5.4 Financial Integration

Financial integration (Amighini, 2017b; D. Chen and Yang, 2018) serves as a cornerstone of the BRI (Cheng, 2016; Huang, 2016). The BRI will operate on a broad range of cross-border financial policy issues like currency convertibility and settlement, Asian bond market and China-ASEAN Banking Consortium. The initiative anticipates to enhance Asian monetary stability (Huang, 2016; Ying Wang and Chou, 2020). For instance, the Philippine Central Bank in October 2017 formally included the renminbi as to its international currency reserves thereby joining over 50% of BRI nations that have earlier adopted this approach (Rabena, 2018). Additionally, bilateral and multilateral cooperation financial system can be improved through finance institutions for regional development like the Asian Infrastructure Investment Bank (AIIB), the Silk Road Fund and the Brazil, Russia, India, China, and South Africa (BRICS) New Development Bank (Ying Wang and Chou, 2020). Financial integration, possibly, the most attractive BRI benefit is the prospective ease of obtaining finance from the funding institutions sustaining the initiative; member nations may be granted long-term loans under satisfactory situations for infrastructure and other project investments towards modernising facilities and improving the economy locally (Valderrey et al., 2020).

5.5 People-To-People Exchange

As the BRI aims to improve connectivity among Asia, Europe, and parts of Africa in the five priority areas, people-to-people exchange is crucial (Amighini, 2017b; NDRC, 2015). In providing public support, infrastructure and facilities, it naturally relates to the two aspects of interactions among the people and governments within the regions to facilitate policy coordination (Cheng, 2016). Cross-border tourism, disease control, joint research facilities for laboratories and political parties and parliamentary ties are also crucial means of facilitating mutual agreement and trust (Huang, 2016; Valderrey et al., 2020). The authorities of BRI stress the need to establish people-to-people exchange (Valderrey et al., 2020; Yuniarto, 2019). People-to people- exchange, for example, should take foreign communities or documented immigrants into cognisance as against the number of nations that a bearer of a particular passport may visit (Valderrey et al., 2020). In real situation, interaction is possibly the area with less outcomes to this day as many people are hesitant to accept immigrants in their countries, particularly because of cultural differences; also, there is a prevalent fear that immigrants may deny the locals jobs and opportunities (Valderrey et al., 2020).

6. Discussion

The questions in this research were "what are the building blocks, and the areas of focus of the BRI? And how are they related to foster the understanding of the BRI?" Having considered what the building blocks and the priority areas for cooperation of the BRI are, the question on how they are related to foster the understanding of the BRI is pertinent.

The aim of the BRI is to build a Silk Road community of shared interests, responsibilities and with a common future to exhibit the quality of green development, innovation, peace, and health cooperation. To achieve this, the BRI emphasises on focusing attention on the five priority areas for cooperation which can be considered as its implementation methods. Therefore, it can be hypothesised that when the five priority areas for cooperation are implemented appropriately, it will influence the BRI which will in turn affect the Silk Road regions as a global community to exhibit the qualities mentioned ealier.

These qualities are the indicators of the success of the BRI. Liu (2016) considers building a community of shared interests, responsibilities and with a shared future as "three targets," which presents economic incorporation and cultural abundance. The Office of the Leading Group for the Belt and Road Initiative (2017) has stressed the need for all Silk Road countries to forge a closer community of a shared future-oriented development model, sustain the open universal economy, and search for fresh sources for progress. For example, "in building the China-Mongolia-Russia Economic Corridor, China has been working vigorously to raise awareness of green development" (Office of the Leading Group for the Belt and Road Initiative 2017, p 37). The advent of global production operations has changed the world market into a place where there is very rapid innovation with striking decreases in product prices, rapid improvements in qualities, quick replacement of older product with new ones, and a premium on the rapid digital communication ability (Broadman, 2007). As social and political instability has profound economic bases, finding new enduring growth facilitators is exigent for a sustainable revival of the global economy and lasting peace (Y. Li, 2017). "Health indicators and social, economic, and environmental factors" (Wang et al. 2017) are cardinal to the success of the BRI.

As the initiative's aim is to strengthen infrastructure, achieve technical standardization and progressively form a facilities network to link the Silk Road regions in Asia, Europe and Africa (Huang, 2016), policy coordination is crucial for the successful implementation of the BRI. Removing barriers to facilitate investments is important to unimpeded trade. When financial cooperation and support are emphasized, economic growth is eminent (Huang, 2016). Policy coordination requires people's cooperation to succeed. Therefore, people-to-people exchange must be encouraged as it is one of the "two aspects of relationships among the people and governments within the regions" (Cheng, 2016) to make the initiative successful.

The building blocks forming the composition of the BRI are the communities and the routes. By way of analogy, just as a blue print contains the details of the components for constructing a building, the BRI is the "blue print" with specifications of the communities and routes as its building blocks for developing the Silk Road. As the components of the building are joined by different means depending on the part, so the communities and the routes which are the building blocks of the BRI could be joined by means of transportation and communication. For these to be realized, countries along the Silk Road have to focus on the five priority areas for cooperation under the BRI. Looking at this from the point of sustainable development, the relationship between the building blocks and the five priority areas (both within the confines of environmental and economic dimensions) can be seen in the involvement of people (social dimension) at all spheres of the initiative for various purposes.

The building blocks on the one hand include communities (inhabited by people) connected by routes through which people move and communicate. On the other hand, the five priority areas which include policy coordination, infrastructure connectivity, unimpeded trade and financial integration involve people's interactions as discussed earlier. Therefore, it is implied that people-to-people exchange of the five priority areas stands as an essential link between the building blocks and the priority areas. Furthermore, the significance of the people-to-people exchange has been demonstrated in a detailed and systematic content analysis of documentary videos (CCTV, 2016) comprising more than 200 episodes from 2016 to 2018. As part of a broader research along with this study, the detailed and systematic content analysis presents that although all of the five priority areas of the BRI were covered in the interviews with the locals, more than 80% of the documentary database focused on the core framework of people-to-people exchange in all continents.

7. Conclusions

Having examined community of shared interests, responsibilities and with a shared future along the Silk Road to green development, innovation, peace and for health cooperation as building blocks of the BRI, this paper also considered the initiative's five priority areas which are policy coordination, infrastructure connectivity, unimpeded trade, financial integration and people-to-people exchange. While community and Silk Road as the building blocks remain the aim and likewise define the true spirit of the BRI, the five priority areas for cooperation are the implementation methods giving the BRI a focus for member countries to channel their resources in developing the region. Therefore, the building blocks and the five priority areas work together for the implementation of the BRI to bring about a win-win achievement, where emphasis is laid on making a green, peaceful and well-connected global community without deviation from the main agenda. The relationship between the two aspects owes to the fact that people are involved at all spheres of the initiative bringing about emphasis on the people-to-people exchange which is a core part of social dimension in sustainable development.

As a contribution, this paper explained the Belt and Road Initiative in a unique way from two main clusters of the keywords and their relationship in order to focus discussion on its cooperative framework which could serve as a basis for further research in various sectors. However, the extent to which the five priority areas are achieved is a subject of further research which could be done in the context of "projects underway". Also, the priority areas have potentials to drive the implementation of the BRI and require further research. This could be done by investigating the unique importance of people-to-people exchange to the BRI and its usefulness in modelling for the sustainable development of the Silk Road community.

Acknowledgements

This research is sponsored by a grant of the Research University Grant Scheme (No. Q.J130000.2521.19H13), Universiti Teknologi Malaysia. The authors also especially thank Dr. Kang Tong Hum and Railway Assets Corporation (RAC), Malaysia.

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