INTERNATIONAL JOURNAL OF BUILT ENVIRONMENT & SUSTAINABILITY

eISSN 2289-8948

Vol 9, No 1 (2022)

https://ijbes.utm.my/

UTM
UNIVERSITI TEKNOLOGI MALAYSIA

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

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

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

IJBES

Vol. 9, No. 1, 2022

Table of Contents

Articles

UTM UNIVERSITI TEKNOLOGI MALAYSIA

IJBES

International Journal of Built Environment and Sustainability
Published by Penerbit UTM Press, Universiti Teknologi Malaysia
IJBES 9(1)/2022, 1-10

Biomimetic Architecture Towards Bio Inspired Adaptive Envelopes: In Case of Plant Inspired Concept Generation

Nazgol Hafizi
Eastern Mediterranean University, Faculty of Architecture, Department of Architecture, Famagusta, Cyprus, Via Mersin 10.

Mojtaba Karimnezhad
Eastern Mediterranean University, Faculty of Architecture, Department of Architecture, Famagusta, Cyprus, Via Mersin 10.

ABSTRACT

In recent decades, the value of architecture become more due to its importance for reducing detrimental effects on the environment and natural capital. To minimize the building's impact on the environment, architectural designs should be highly incorporated into the environment rather than behaving as a separate element focused on a single issue. To address this problem, different methods and design approaches have been introduced. However, exploring the natural solutions for survival can provide invaluable data which can address the human-caused problems. Throughout decades, nature has been survived and evolved. Biological solutions due to their adaptability and multi-functionality are great source of inspiration. This article with help of content analysis method aims to review the concept of biomimetic design in architecture. And proposes plant-inspired solutions for envelope design which can play significant role on buildings' energy efficiency. Thus, the plant-inspired concepts to be integrated on adaptive envelopes were studied. And a framework for concept generation introduced. Furthermore, a case study on an existing building envelope in the Mediterranean climate region presented and two plant-inspired techniques proposed and conceptually applied.

Article History

Received: *09 May 2021*
Received in revised form: *04 October 2021*
Accepted: *15 December 2021*
Published Online: *31 December 2021*

Keywords:

Biomimicry, Energy efficiency, Bio-inspired, Adaptive envelope, Plant-inspired concepts.

Corresponding Author Contact:

Nazgol.hafizi@emu.edu.tr

DOI: 10.11113/ijbes. v9. n1.820

1. Introduction

Environmental disruption and current climate change are closely linked to human activities. Social, ecological, and financial crises are becoming more frequent and severe, highlighting the new global vast range of challenges. Much of the world's population has experienced water shortages, lost living standards, and social and cultural instability. (Williamson, et al., 2003). Within this fact, in past years, one of the significant challenges in the area of architecture is the issue of energy efficiency and the effects of building construction on sustainability. After the 1970s energy crisis and till the 1992 Rio Earth Summit, sustainability in architecture eventually defined. Sustainable building has minimum impacts on the environment, increases energy efficiency, and decreases economic impacts (OECD, 2002). But, a question arises here, has the application of this concept to architecture been successful?

Ongoing architectural developments related to sustainability and green design is not enough yet to be effective. As Bill Reed in

2009 discussed, “we could have a world full of LEED platinum buildings and still destroy the planet". He explains that the green buildings have been developed regarding sustainability concerning the standards, but they are not fully fulfilling the green design criteria and are just simply “less bad” (kou, 2013).

However, biological evidence demonstrates the natural world's evolution, adaptation, and development over centuries, which is the basis for its survival. They can be used as a database to learn about and solve human-caused challenges in a long-term manner (Jin and Overend, 2014). Using the natural world as a source of inspiration and problem solving introduced new terminology to architectural design called ‘biomimetic’. The biomimetic desgin main objective is to learn from nature and discover the solutions that nature employs. It does not have to be about repeating the concept but rather about being inspired by it and putting it to good use. These solutions will aid architectural design and research in different scales (Pedersen Zari, 2007).

In the other hand, the building envelope is one of the main components that biomimetic solutions can be applied to and enhance overall sustainability. Envelopes are among the most critical elements in architectural design because of their control of energy flow, extensive use of materials, high maintenance costs, and occupant satisfaction (Schittich, 2001). A recent suggested alternative for envelope design, represents a new approach based on successful examples found in nature. In this scope, one of the althernatives is plant-ispired envelope design which is the main focus of this study. Current construction methods and advancements in materials science open up a whole range of possibilities for an innovative plant-inspired building envelopes that will communicate more with the environment (Mlecnik et al. 2012). Thus, in this study it has been tried to:

- presents an in-depth literature review over theory of biomimetic design in architecture,
- presents a plant-inspired concept generation,
- presents two plant-inspired techniques for envelope design in mediterranean region to reduce energy consumption.

By covering the aims of the study, this article put forward an approach which can be used for furthur studies in this field both in practice and research.

2. Methodology and Scope of Research

The study with content analysis methodology presents a review of current studies concentrating on biomimetic architecture and envelope design. Through out the concent analysis within the first step of the study, the theory of biomimetic design approach for architeture been reviewed. With screening the main scholars works, the principles of biomimetic design been decussed, and accordingly biomimetic design approach as a promissing solution for energy efficiency of the buildings been highlighted. Since, building evnelopes play a major role in energy efficiency and overal sustainability of the building, in the second stepo, study been focused on evnelope design and biomimetic design. With furthur content analysis, plant-insipired approach as one of the biomimetic design methodes for envelope design been intoduced. The intoduced plaint-inspired adaptive envelope highlighted as one of energy efficient solutions. As one of the main outcomes of the study, after in-depth content reviews, a framework been proposed for concept development of plant-inspired adaptive envelope design. Lastly, through data collections (plant examples) data been evaluated according to mediterranean climatic characteristics and through a qualitative case study two solutions put forward for plant-inspired evnelope design in this region. Implementing the plant-inspired approach to the Faculty of Education and Central Lecture Hall building at the Eastern Mediterranean University in Cyprus aims to demonstrate the impact of this application on improving the building's energy efficiency and resource consumption. Following Figure 1, is illustating the stages of methodological approach.

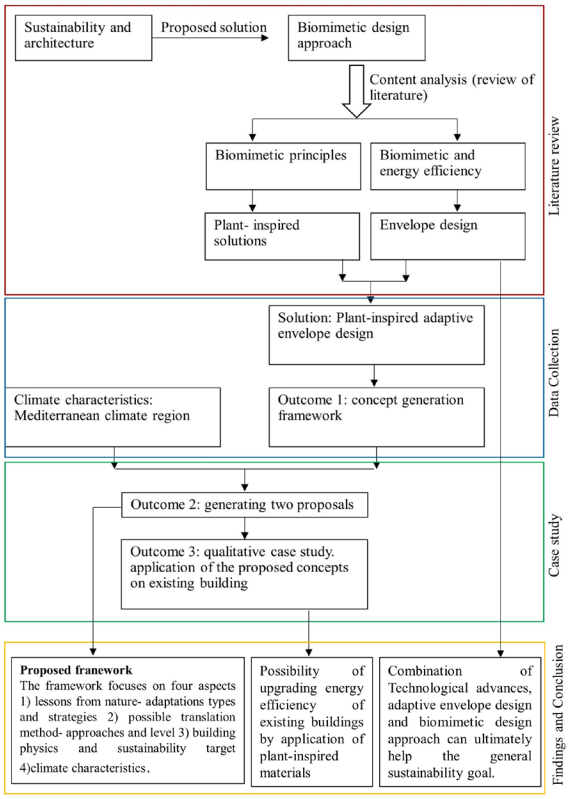


Figure 1 stages of methodological approach of the study

In order to carry out the content analysis of the study, the selected articles from online sources, had meet the scope of this study and fall into the focus of study. Following Figure 2, is illustating the scope of the study and main focus area. Aspects and researches not meeting the highlighted keywords are fall out of the scope of the study and has not been reviewed.

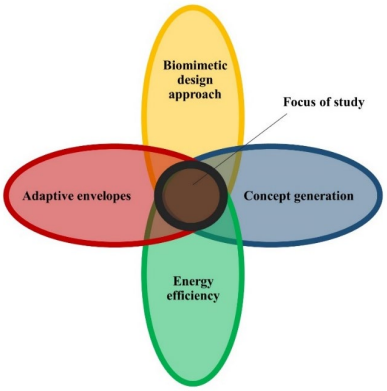


Figure 2 Scope of study

3. Literature Review: Biomimetic Design

Biomimetic is a recent discipline whose aim is to learn from nature and imitate it to discover solutions to human-caused problems. The literal translation of biomimetic terminology comes from the two Greek works of bios (life) and mimesis (imitating). The evolution and survival of the natural world over 3.8 million years is proof of natural solid ecosystem adaptation to change, and this is the most critical lesson for sustainability. While biomimetic is a new term that has only recently been applied to architecture, the use of this approach dates back a long time. Nature has long been a source of inspiration for humans, as shown by human history. Later architects, such as Antonio Gaudi and Frank Lloyd Wright, used a similar style in their designs, but this time with more abstract context and complexity. The principle of biomimetic design has emerged in architecture due to such designs (Vincent et al., 2006).

According to the Biomimicry Institute, biomimicry can be defined as "an approach to innovation that seeks sustainable solutions to human challenges by emulating nature's time-tested patterns and strategies. The goal is to create products, processes, and policies—new ways of living—that are well-adapted to life on earth over the long haul."

Biomimetic is a multidisciplinary methodology at the intersection of three disciplines, possibly requiring knowledge from biologists, biophysicists, and material science. Communicating between these disciplines provides enlightenment about the challenges and potential answers. The method of simulating a natural world is similar to that of translation. Nature's necessary solutions for survival should be translated to suit the human-made environment. The end product of this translation method does not necessarily provide the exact and equivalent impression of the organism that inspired it. Still, it does have a functional concept that is similar (Pedersen Zari, 2007).

Due to its complexity and multidisciplinary, the biomimetic design approach presents many barriers that should be studied to translate the natural solutions to architectural designs. Thus, understanding biomimetic design principles; 1) adaptation types, 2) design approaches, 3) adaptation levels, and 4) strategies (illustrated in Figure 3) has extra importance (Feuerstein, 2002; Aldersey-Williams, 2003).

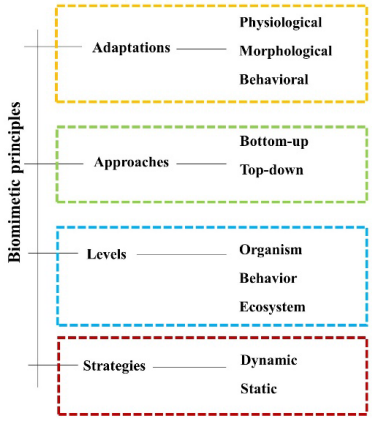


Figure 3 biomimetic principles (authors, 2021)

3.1. Biomimetic Principles

Principles of biomimetic method within various scales were developed by studies such as Zari in 2007 biomimetic architecture. These studies provide a greater understanding of the working mechanisms of the natural world. It is possible to provide architectural design solutions only if we have explicit knowledge of the natural world.

Nature adaptation- Natural adaptation is the phase by which species conform to their surroundings to survive. This adaptation can be perceived within three scales of morphological, physiological and behavioural. Morphological or structural adaptation refers to the changes in the organism body. In contrast, the physiological adaptation focuses on 'how' the changes happen, which refer to chemical changes. Lastly, behavioural adaptation refers to how an organism responds to the environment to help them survive (Kuru, et, al., 2018).

Biomimetic approaches- To transfer the knowledge from nature to architectural design, two primary approaches have been proposed in the literature. In a top-down or problem-based approach, the design process begins by identifying the problem. In this approach, the planner or architect identifies the problem and searches for a solution in nature; as they discover an organism that has solved a similar problem, they abstract the solution and apply it to their design problem. The method is reversed in a bottom-up or solution-based approach. Designers of this approach have experience of specific biological researches, which influences their design. So, aside from specifying the issue, their initial design is based on their biological understanding (Zari, 2007). The two approaches and examples of them illustrated in Figure 4.

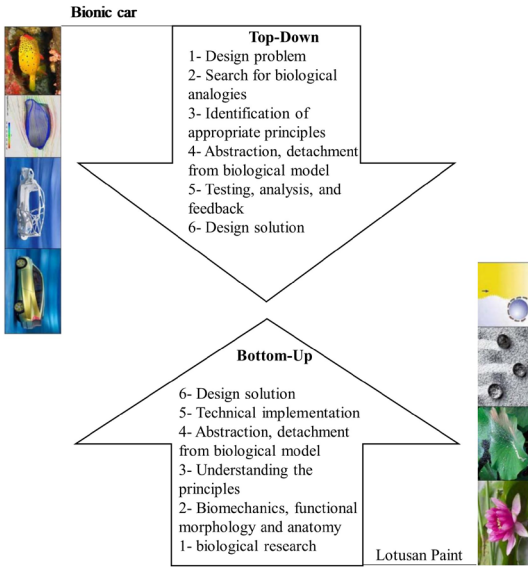


Figure 4 Biomimetic approaches and examples of each (Aziz, 2016)

Biomimetic levels and dimensions- Organism or structure' is the first level of biomimetic architecture. Nature creates a complete picture of rich and diverse forms. These forms can survive the environment's changing conditions. Structures are designed to replicate a single entity at the organism level. At the behaviour level, the action of the individual is mimicked, not the organism itself. Similarly, it might be possible to replicate the relationships between organisms or species. Ecosystems mimicry (or eco-mimicry) is an essential aspect of biomimicry(Figure 5). The benefit of designing at the ecosystem level is to combine the other two levels of biomimicry. These three levels can be applied to different dimensions (sub-levels) of design; From, Material, Construction, Process, Function (Zari,2007)

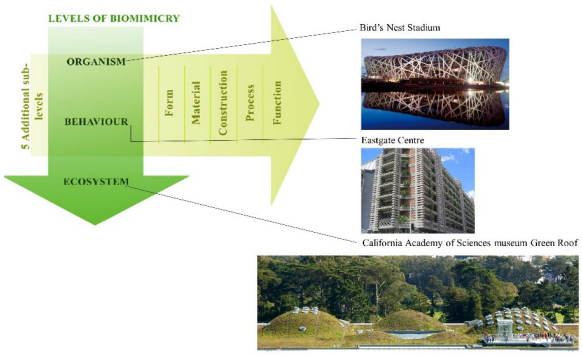


Figure 5 Levels of biomimetic (Zari,2007, ammanded by authurs, 2021)

Biomimetic strategies- natural environment has two strategies or techniques for adaptation, dynamic or static. The two strategies can happen on two scales of macro or micro. The dynamic adaptation is usually in macro-scale presents a motion. On the other hand, the static adaptation strategy happens in the properties of materials that are micro-scale (López, et, al., 2017).

Understanding the biomimetic principles is the first step towards generating concepts for problem-solving. The second step is formulating the purpose of concept generation. Biomimetic can respond to different problems such as global warming and climate change, economic enhancement, energy consumption reduction, etc. This study has focused on the energy efficiency goal for building design with a biomimetic approach.

3.2. Energy Efficiency And Biomimetic Design

Buildings account for over half of all energy consumption, according to the International Energy Agency. This reality emphasizes the importance of proposing approaches that reduce building energy use and contribute to the ultimate sustainability target. Nature seems to use low-energy methods, implying that various biological species could be investigated as a source of novel strategies for minimizing Operational Energy. Biomimicry has been recognized as a ground-breaking design method for enhancing energy-efficient design in the same way (Herring and Roy, 2007). Together, recent technological advancements and nature as a source of problem-solving will offer architectural solutions to solve the high energy consumption challenge.

Termite mounds are a well-known natural example of energy efficiency that their air conditioning units circulate hot and cold air between the mound and the outside environment. Mick Pearce built Eastgate Centre (Figure 6) in 1990, based on the termites' Process. It has about 350,000 square feet of office space and shops. It consumes 90% less energy than a building of comparable scale in the same climatic condition. This natural example suggests that other species could be better builders than humans. The Eastgate Center, for example, demonstrates that biomimetic can be a viable option for improving building energy usage (Annon, 2005).

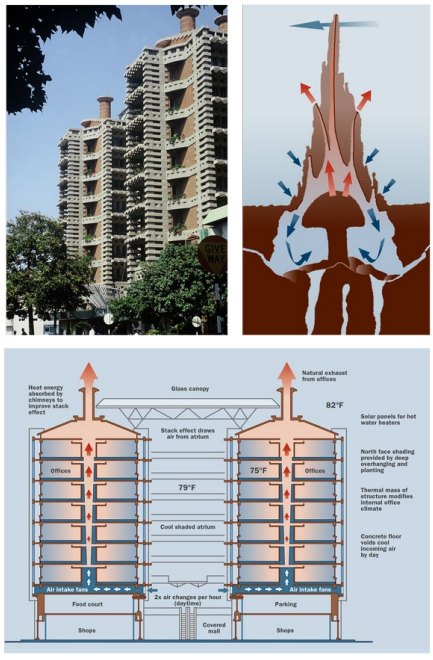


Figure 6 The Eastgate Center and inspiration from Termites mounds (Annon, 2005).

Natural lighting, natural ventilation, heat gain, and heat loss can be improved with biomimetic solutions. Not only can a building's energy performance change as a result of these solutions, but the quality of the indoor environment would also improve, which would have a significant impact on occupant satisfaction. Building envelopes are the essential factor for a building's energy efficiency. The use of biomimetic solutions on building envelopes will improve the building's energy efficiency.

3.3 Adaptive Envelopes

According to Ferguson et al. (2007), adaptability is described as a tool that can provide a particular purpose based on a set of parameters and can adjust physically with time. The ability of the building envelope to adapt and respond to changes in its environment, such as solar radiation, wind, temperature, and rainfall, is unique among building elements. Compared to buildings with static design envelops, this capability can reduce energy consumption and increase energy efficiency (Loonen et al. 2011).

The definition of adaptive envelope defined by Loonen et, al in 2013; 'adaptive envelopes can repeatedly and reversibly change its functions, features or behaviour over time in response to changing performance requirements and variable boundary conditions. By doing this, the building shell effectively seeks to improve overall building performance in terms of primary energy consumption while maintaining acceptable thermal and visual comfort conditions.'
The adaptable envelope not only serves as a barrier between the inside and outside of the building, but it also serves as a temperature arbitrator and balancing interior comfort (Wigginton and Harris 2002). The building envelope should respond as a solution for the whole year; it might not have the best performance, but it should solve a wide variety of problems (Bakker et al. 2014).

Many different types of adaptive envelopes with different adaptation scales developed in recent years due to technological advancement. A wide range of adaptive envelopes include; kinetic, dynamic, intelligent, and so on. Biomimetic or bio-inspired envelopes are one of the adaptive envelope varieties. The bio-inspired envelopes and concept generation from plants are the subject of this research.

3.3.1 Biomimetic/ bio-inspired adaptive envelope

Both research and architecture practice show a need for further projects based on the bio-inspired envelope definition. Braun is one of the pioneers who researched a wide variety of bio-inspired building envelops design, over 45 models. Still, because of their multi-functionality and sustainability, the skin of plants and humans remain the most upstanding models and sources of inspiration. Plant and human's skin is the most straightforward imitation source for adaptive envelopes. Skin is an organism of the natural world that responds to various factors, has various functions, and is self-regulating. It is admired, but also tricky, to transmit these properties as metaphors to building envelopes.

Biomimetic methods are most often used in nature to regulate adaptation by using intrinsic properties of materials as actuators and are restricted to responding to environmental stimuli beyond those thresholds rather than the indoor environment or user experiences (Tabadkani, et,al, 2021). Bio-inspired adaptable envelope configuration can be viewed on three different scales and functional stages. Bio-inspiration can occur at various spatial scales, ranging from material, envelope components to the whole structure. According to biomimetic literature, bio-inspiration can be categorized into three aspects: form, function, and Process (Loonen et al. 2014).
Since it explicitly identifies with replication of the morphological appearance of the natural structure or living organism, form is the most straightforward type of bio-inspired architecture. Then there's the function, which mimics the simple organic framework in that it's more concerned about what the envelope does than with how it looks. Finally, Process, the third aspect of bio-inspiration, is an essential component in many biomimicry highlights. However, it is most often seen in building relationships on the urban or regional scale rather than individual buildings (Pedersen Zari 2010).
As mentioned earlier, the inspiration for a biomimetic envelope can be from any biological species. For this study, exclusively plants have been selected as an inspiration source. The study tries to understand the adaptation solutions from plants and later presents a framework for generating applicable adaptive concepts for building envelopes from plants' adaptation solutions.

3.3.2 Plant-inspired adaptation solutions

The static position of plants forced them to develop a protection structure against harsh environmental conditions such as temperature change, extensive sun direction, rain, etc. Due to the climatic changes, natural adaptation occurred over time to respond to critical environmental changes. Therefore, evolvability and adaptation are essential characteristics of plants for survival. In the sense of immobility and being exposed to various environmental conditions, buildings and plants share the same identity. Thus, understanding the adaptability of plants can propose methods and techniques to help buildings be more responsive to environmental conditions and more sustainable (Mazzoleni 2010).

As discussed in the biomimetic principles 3.1 section, adaptation in nature, including plants, can perceive in three levels; morphological, physiological and behavioural. And two strategies of dynamic or static. Studying plants based on biomimetic principles allows generating concepts to build adaptive envelope design (López, et, al., 2017). Following Table 1 is presenting studies on plants based on adaptation types and strategies. Understanding these two aspects is the first step towards concept generation. After studying adaptation and strategy types, it is possible to propose the level and approach type to translate the natural solution to architectural element. Such study is the first step towards working with the concept generation framework.

Table 1 adaptation types and strategies in plants (López, et, al., 2017)

plant	description	Adaptation type	strategy	picture
Gynandriris setifolia Common name: Thread iris	Hairs on the plant used to reflect sunlight	Morphological	static	
Echeveria Glauca Common name: blue echeveria	Phase Change materials	Physiological	static	
Leaves of Mimosa pudica Common name: humble plant	Folds inward as a reaction to contact	Behavioural	Dynamic	

Understanding plants adaptation towards the environmental condition and their strategies bring us one step closer to concept generation for adaptive building envelopes.

4. Plant-Inspired Proposal Development

Developing proposals from the plant for adaptive building envelopes can be defined as a framework in four phases (Figure7). Phase (1) is the analytical phase that studies the plant adaptation towards environmental conditions. Study in phase (1) is based on two biomimetic design principles, a) adaptation types b) biomimetic strategies. In this phase, a general understanding of the working mechanism of plants will be highlighted. Phase (2) of the proposal development framework focuses on the first transition stage from natural strategy to the architectural solution. Based on biomimetic design principles, the design approach and level of biomimetic design will be defined. Throughout phase (1) and phase (2), the initial proposal from plants translated to architecture will be introduced. Phase (3) of the framework, specify the purpose and target of the new proposal and which building component it will apply. In phase (4), the last variable of the framework, 'climate,' will be added. Each climate region has its characteristics that require specific solutions. Thus, considering the climatic factors is critical for developing a proposal.

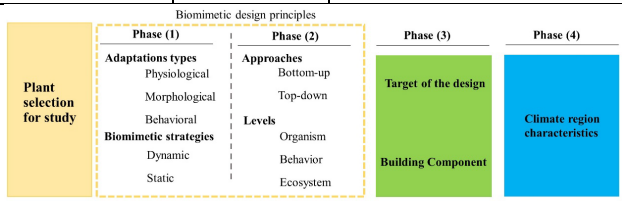


Figure 7 plant-inspired proposal development framework

The following section introduces two plant-inspired proposal development based on the explained framework. It investigates the application of the proposals on an existing building in the Mediterranean climate region to improve energy efficiency.

5. Case Study: Findings and Discussions

The case study of this research aims to propose biomimetic techniques for an existing building in the Mediterranean climate zone to improve the building's energy efficiency. Eastern Mediterranean University's new faculty of Education & Central Lecture Hall (Figure 8) in Cyprus has been selected for this study. The building designed by TASAR Design and Research Centre, Faculty of Architecture, EMU. For this project, Eastern Mediterranean University (EMU) and Erke Sustainable Building Design and Consultancy Ltd. signed a cooperation protocol regarding the LEED Green Building Certification (Platin).

The main aims of the projects were achieving sustainability for building by passive and active strategies, designing an environmentally friendly building, achieving the best interior and exterior spaces relationship, protecting the existing natural

environment, increasing the quality of exterior spaces and easy accessibility both by vehicle and pedestrian.

Figure 8 New Central Lecture Halls and Education Faculty buildings (TASAR, 2018)

From the initial steps of the design, the maximum usage of the south direction was considered. In this case, the building got maximum benefits of solar energy and reduced the energy demand of the building for heating and daylighting. Usage of the PV panels by getting benefits of the south sun direction provides the hot water and is used for the building's floor heating system. Trombe wall as a passive solar technique designed for the west façade. This façade with an external layer of glass and the internal layer of high heat capacity was designed as a passive design decision. For the sunlight control on all the building facades except the eastern façade, shading elements were applied.

Although the architects' decisions helped the building achieve some level of sustainability, there is still a possibility to enhance the energy efficiency of this building to a higher level. In this manner, it has been tried to find plant-inspired solutions in the Mediterranean climate region and developing a proposal for higher energy efficiency of this building.

Perennial plants for this study epecifically Oxalis, belong to groups of plants that adapt themselves throughout the day and night due to exposure to sunlight. These groups of plants can close and open their leaves and flowers during night and day. This plant adaptation ability can translate to building envelope design and improve the building's energy efficiency by controlling the lighting exposure amount. Studying this plant in phase (1) shows the behavioural adaptation with dynamic strategy. Throughout phase (2), with a bottom-up approach, the plant adaptation ability can translate to architectural behaviour level and function sub-level. Learning from plant adaptation can be translated to folding shading intelligent systems for building envelopes with energy efficiency. This technique can be beneficial for the Mediterranean climate region, where buildings are exposed to sunlight for a long time. Following Figure 9 illustrate the proposal development from this plant.

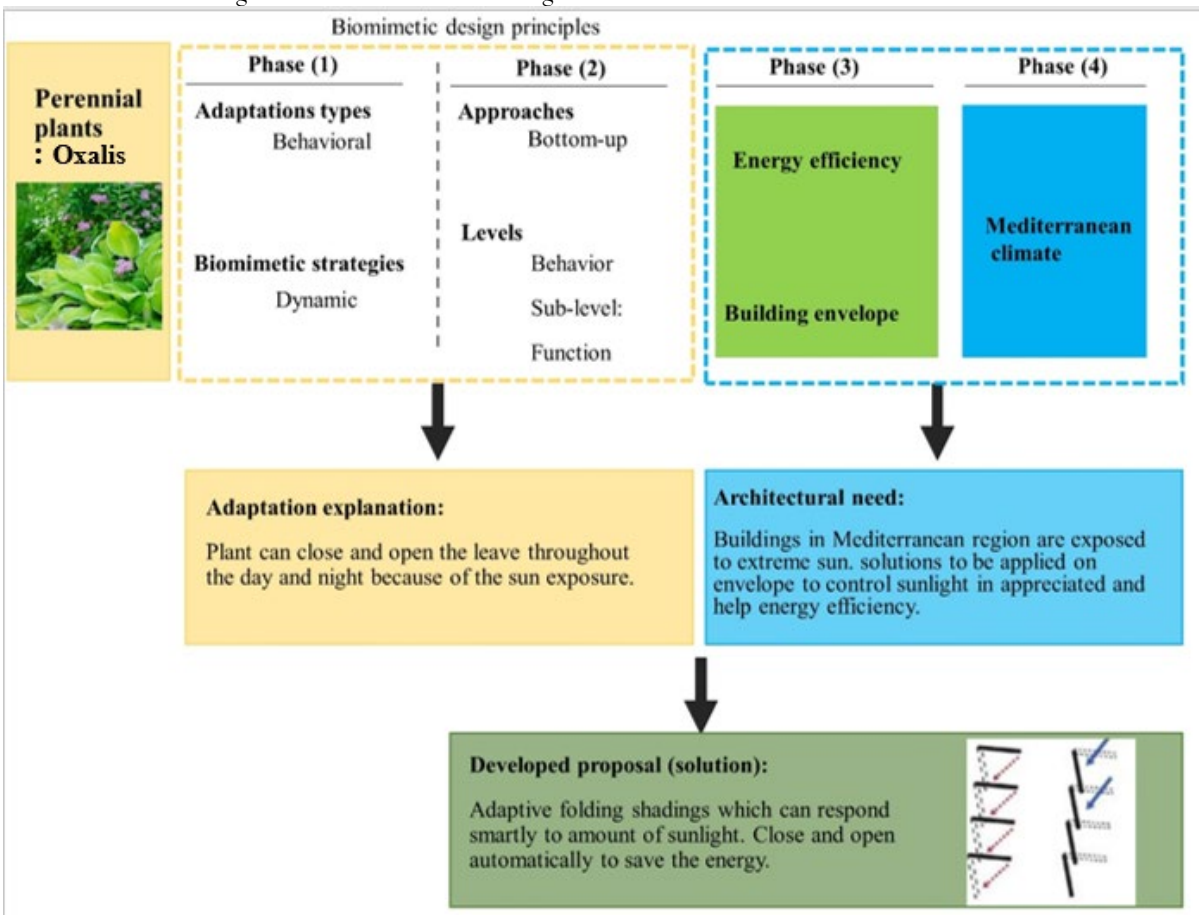


Figure 9 plant-inspired proposal for building enveloped based on Perennial plants adaptation.

The second proposal can be developed from Kalanchoe pumila leaves. This plant, with greyish-green leaves, developed a reflective surface on the leaves that allow them to survive under the sun for long hours. The same static approach can translate to architectural design, improving the energy saving for heating and cooling. By learning from the adaptation type of Kalanchoe Pumila leaves, it is possible to develop a proposal based on phase change material technique and apply a three-dimensional covering surface in material with unique properties to reflect the light. This proposal protects the building from excessive sunlight and temperature. Following Figure 10 illustrate the proposal development from this plant (López, et, al., 2017).

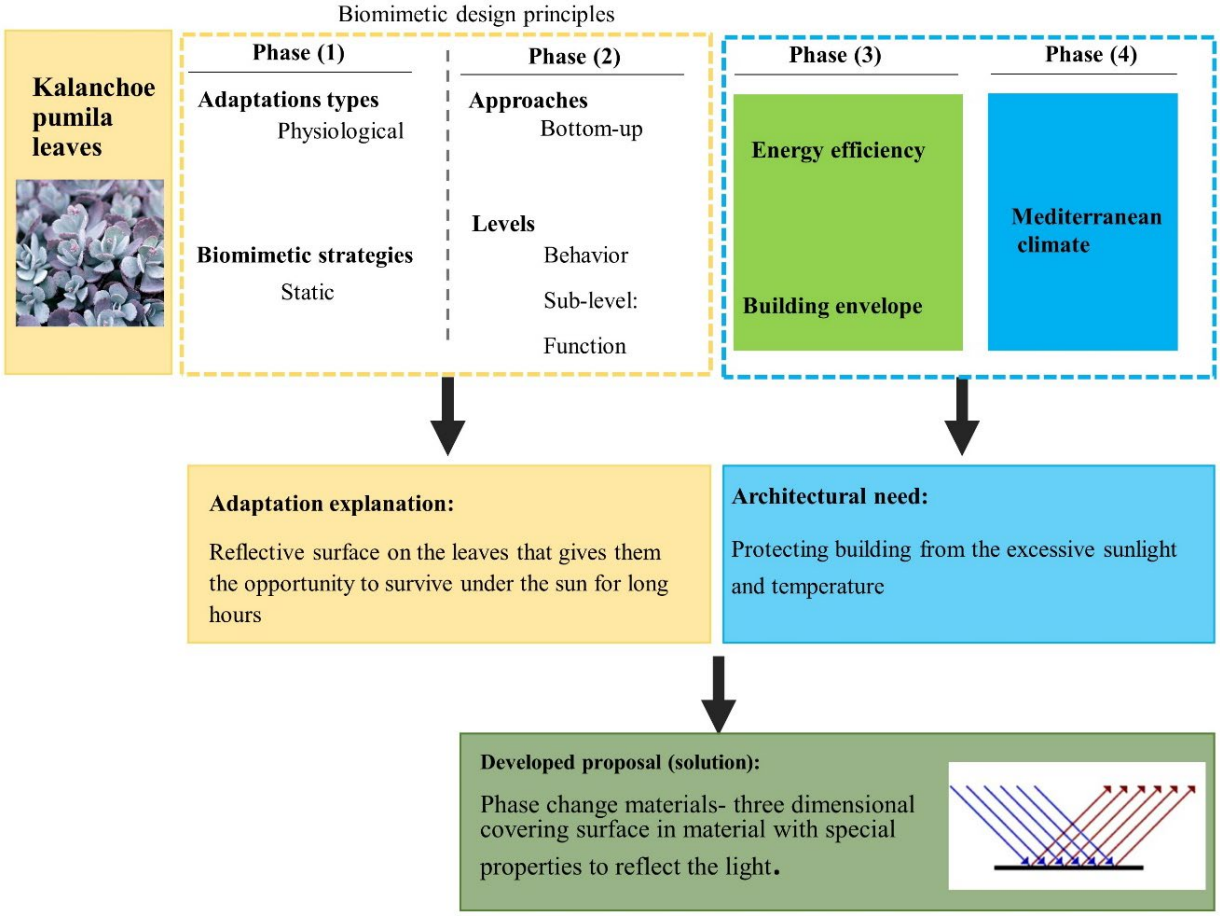


Figure 10 plant-inspired proposal for building enveloped based on Kalanchoe Pumila

Two developed proposals by the plant-inspired method can apply to New Central Lecture Halls and Education Faculty buildings envelope to enhance the building's energy efficiency (Figure 11). The intelligent folding shading devices inspired from adaptation in Perennial plants can be applied on the east oriented building envelope. In this case, the adaptive bio-inspired envelope will react to sunlight. This dynamic strategy will allow controlling the amount of sunlight entering the building. Thus, decrease the lighting load of the building. The second proposal can be applied to the southern envelope. The three-dimensional films acting as phase change materials can change the property of the southern envelope due to extreme sunlight exposure. This proposal decreases the cooling/heating load, and at the same time, the view outside to some level will be kept for lecture rooms and offices.

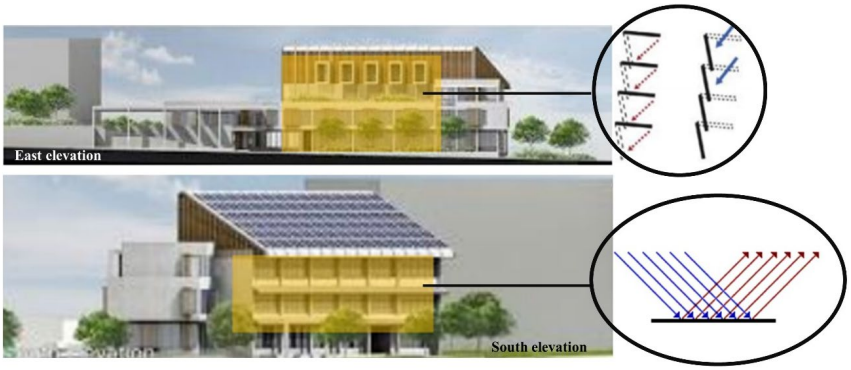


Figure 11 application of proposals on building envelope

Many more lessons can be learned from nature and, with the help of the proposal development framework, transfer them to architectural elements. However, it should be mention, variety of such proposals are still conceptual models, and the ones in practical use can be expensive alternatives. Thus, applying such ideas and approaches should be in proper context to achieve sustainability at all levels and not only from an energy efficiency point of view.

Moreover, in recent years there has been many invaluable studies on biomimetic appraoch for architectural design, but this study by proposing a conceptual framework tried to touch the practical point of this theory more. This study, firstly by giving a wide prespective towards the topic, increases genera ubdrestanding of researches and practitionares about the topic, and later by applying the theory and framewrok on the existing building presents the practicalty of this theory.

Application of the theory of plant-inspired adaptive envelope, not on a new designs, but on an existing building can highligh the opportunity of increasing the sustainability and energy effiiency of already existing building in environment.

Although, this study had a focus on mediterranean climate region, but same approach can be applied to find plant-inspired solutions for adaptive envelopes in variety of climate zones and by proposing the application of such solutions increase the energy efficiency of the existing building at same time as new constructions.

5. Conclusion

Achieving sustainability as an everyday goal is the main issue for architects and designers in recent decades. Building envelopes, as one of the most critical building components, plays an essential role in building sustainability, thus finding solutions and alternatives for envelope designs is one of the trends in architectural research. Adaptive envelopes seem promising alternative for improving the building's energy efficiency while providing high indoor environment quality. One of the approaches towards adaptive envelopes is biomimetic or bio-inspired envelopes.

This study has tried to review the 'biomimetic design' as a vital terminology in architecture. By understanding the principles of biomimetic, the concept of bio-inspired design has been investigated. After surviving millions of years, the natural world, due to the adaptability aspect, is the best source of inspiration. Learning from nature can apply the adaptation to the buildings, which can improve their sustainability drastically. Plants, due to their immobility, are the best source of inspiration for building envelope design. Plants, same as buildings, are static elements in nature which facing various environmental and climatic conditions. Here the contrast between plants and buildings in the adaptability. Over time plants learn to respond and adapt themselves towards critical climatic changes and survive; thus, the same approach can improve the buildings sustainability and survival without causing damage to the environment.

Furthermore, this study reviewed the plant-inspired design approach, and with the help of the literature review, introduced a framework for proposal development that works in four phases. The framework focuses on four aspects 1) lessons from nature- adaptations types and strategies 2) possible translation method- approaches and level 3) building physics and sustainability target 4)climate characteristics.

Two proposals have been developed throughout the study to be applied to an existing building in the Mediterranean climate region. Both proposal but upgrading the conventional building envelope to adaptive envelope improves the building energy efficiency. Two proposals with different adaptation types and strategies can decrease the building's lighting and heating/cooling load.

In today's world, with technological advancement development of ideas from the natural world is very appreciated. Although various studies are ongoing in concept developments or laboratories, some practical concepts are still available to be integrated into adaptive envelope design. However, the majority of the alternative is expensive applications and might not be suitable for all contexts. Further studies on biomimetic design and concept generation for the building envelope is still needed to reach the ultimate sustainability goal. As William Mc Donough said;

'A building should be like a tree; it should thrive on the Sun's energy while enhancing its surroundings.'

Acknowledgements

this article has been written for the course Inar 569- Sustainability in Interior Design under the guidance of

Assoc.Prof. Dr. Ozlem Olgac Turker, who we would like to express our appreciation. In advance, we would like to thank and appreciate to Assoc.Prof.Dr.Turkan Uraz, Assist.Prof.Dr. Polat Hancer which provide us with the documents related to the selected project.

References

Aldersey-Williams, H., (2003), Zoomorphic – New Animal Architecture, London, Laurence King Publishing

Annon, (2005), 'Natural innovation: the growing discipline of biomimetics', *Strategic Direction* 21(10): 35–37.

Aziz, M. S. (2016). Biomimicry as an approach for bio-inspired structure with the aid of computation. *Alexandria Engineering Journal*, 55(1): 707-714.

Bakker LG, Hoes-Van Oeffelen ECM, Loonen RCGM, Hensen JLM (2014) User satisfaction and interaction with automated dynamic facades: a pilot study. *Building and Environment*. 78:44–52.

Ferguson S, Siddiqi A, Lewis K, De Weck O (2007) Flexible and reconfigurable systems: nomenclature and review. In: *Proceedings of ASME 2007—international design engineering technical conferences and computers and information in engineering conference*, Las Vegas

Feuerstein, G., (2002), Biomorphic Architecture – Human and Animal Forms in Architecture, Stuttgart, Edition Axel Menges

H. Herring, R. Roy (2007). Technological innovation, energy efficient design and the rebound effect. *Technovation*, 27 (4): 194-203

Jin Q, Overend M (2014) A prototype whole-life value optimization tool for façade design. *Journal of Building Performance Simulation*. 7(3): 217–232.

kou A. Future buildings: tough and smart on energy efficiency. Research results magazine, Issue 23, June (2013). CORDIS Unit, Publications Office of the European Union

Kuru, A., Fiorito, F., Oldfield, P., & Bonser, S. P. (2018). Multi-functional biomimetic adaptive façades: A case study. In Proceedings of the FACADE 2018 Final Conference of COST TU1403 Adaptive Facades Network, Lucerne, Switzerland. 26-27

Loonen RCGM, Singaravel S, Trcka M, Cóstola D, Hensen JLM (2014) Simulation-based support for product development of innovative building envelope components. *Automation in Construction*. 45: 86–95

Loonen RCGM, Trčka M, Hensen JLM (2011) Exploring the potential of climate adaptive building shells. In: *Proceedings of building simulation 2011*: 2148–2155.

Loonen, R. C., Trčka, M., Cóstola, D., & Hensen, J. L. (2013). Climate adaptive building shells: State-of-the-art and future challenges. *Renewable And Sustainable Energy Reviews*, 25: 483-493.

López, M., Rubio, R., Martín, S., & Croxford, B. (2017). How plants inspire façades. From plants to architecture: Biomimetic principles for the development of adaptive architectural envelopes. *Renewable and Sustainable Energy Reviews*, 67: 692-703.

Mazzoleni I (2010) Biomimetic envelopes. Disegnarecon 3(5): 99–112.

Mlecnik E, Schütze T, Jansen SJT, de Vries G, Visscher HJ, van Hal A (2012) End-user experiences in nearly zero-energy houses. *Energy and Buildings*. 49:471–478.

OECD. Design of sustainable building policies. Paris: OECD; http://www.uea.ac.uk/env/; 2002.

Pedersen Zari M (2010) Biomimetic design for climate change adaptation and mitigation. *Architectural Sci Rev* 53(2):172–183.

Pedersen Zari, M., (2007), 'Biomimetic approaches to architectural design for increased sustainability', Paper presented at the Sustainable Building Conference, Auckland

Reed, B. (2009). The integrative design guide to green building: Redefining the practice of sustainability. 43. John Wiley & Sons.

Schittich C (2001) In Detail: Building Skins-Concepts, Layers, Materials (Basel: Birkhauser

Tabadkani, A., Roetzel, A., Li, H. X., & Tsangrassoulis, A. (2021). Design approaches and typologies of adaptive facades: A review. *Automation in Construction*, 121: 103450.

Tasar. (2018). Retrieved from Tasar Design-Research Center: http://tasar.emu.edu.tr/index.php/design-project/completed-projects

Vincent, J.F.V., Bogatyreva, O.A., Bogatyrev, N.R., Bowyer, A. and Pahl, A.-K., (2006), 'Biomimetics – its practice and theory', *Journal of the Royal Society Interface,* 3(9): 471-482.

Wigginton M, Harris J (2002) Intelligent skins. Butterworth-Heinemann, Oxford

Williamson, T. J., Williamson, T., Radford, A., & Bennetts, H. (2003). *Understanding Sustainable Architecture*. Taylor & Francis.

IJBES

International Journal of Built Environment and Sustainability
Published by Penerbit UTM Press, Universiti Teknologi Malaysia
IJBES 9(1)/2022, 11-21

Public Perception on Attributes of Walking Avenues in Urban Areas of Sri Lanka

N.C. Wickramaarachchi
Department of Estate Management and Valuation, University of Sri Jayewardenepura, Sri Lanka.

M. T. U Perera and J.L.I Dilhan
University of Sri Jayewardenepura, Sri Lanka.

ABSTRACT

Currently, the urban areas become more congested; numerous health concerns such as obesity are becoming more prevalent among urban dwellers followed by lack of exercise. With this situation, provision of adequate areas for exercising to the satisfaction of all is critical with limited space in urban areas. Hence, an ideal solution emerges as 'walking ways' where a strip of land is only needed. The interest of walking ways is also developed in Sri Lanka very recently. However, there is no evidence on a research to identify the attributes, should developed along with the walkway to increase the attraction of the users. The main aim of this study is to examine the public perception on attributes of walking avenues in urban areas of Sri Lanka. Data was acquired by a personal-administered questionnaire from a convenience sample of 150 walking trail users on three settings. The descriptive statistics, univariate analysis, hoc multiple comparisons and homogeneous subsets technique were used as methodological analysis. The findings disclose 'safety' as the preferred attribute while shading and natural settings significant. An income variation presents that user with above the income level of LKR 65,000 preferred cafeterias providing herbal drinks while the users with below that income level are less interest with the attributes of changing rooms and street vendors. This article fills the gap of identifying user perceptions particular to a novel design concept of walking trail in Sri Lanka with interesting attributes getting more benefits.

Article History

Received : *13 June 2021*
Received in revised form : *15 December 2021*
Accepted : *17 December 2021*
Published Online : *31 December 2021*

Keywords:

Public Perception, Public Open Spaces, Walking Avenues, Sri Lanka

Corresponding Author Contact:

nishani@sjp.ac.lk

DOI: 10.11113/ijbes. v9.n1.833

1. Introduction

In recent decades, urban areas have faced difficulties related to increased population concentration. Creating a pleasant urban environment that improves people's quality of life has become problematic. As cities get denser, public open spaces such as parks, playgrounds, beaches, natural vistas, observation points, and so on, are attracting more attention from academic and policy circles. The public open spaces become locations for people to meet, relax, and exchange ideas and engage physical exercises that improve the social wellbeing of residents. Accordingly, public open spaces play multiple roles in making the cities more livable such as facilitate residents' recreation activities, provide a healthy living environment, preserve the biodiversity encourage the social interactions and promote attractive tourism development (Adiba & Roshida, 2019). However, it is hard to develop larger locations in the city to construct public open spaces to accommodate recreational demand. In this scenario, a new design concept was introduced to overcome this problematic situation. Accordingly, the "walking path" is characterized as the most novel

and original idea, which arose from the conversion of narrow strips, primarily of stream bank reserve or areas accessible between two different land uses, with the purpose of fostering urban residents to engage in physical activity. Henceforth, the government's attempt to improve the walkways in line with the elements of current land use planning and typically acknowledged in different themes such as jogging track, walking avenue, walking track and walking trail, etc., (Ranasingha & Ashika, 2016). Walkaways promote the preservation of bio-diversity, adding a more esthetic view to the urban milieu as well as enhancing social values with improvement of quality of life of urban dwellers.

The quality of life of the urban dwellers is usually based on the quality features of open spaces including walking avenues that meet their desires and requirements. Although the projects of public open spaces development including walking avenues have flourished only with physical development but ignored the public desires and requirements in planning and designing of public open spaces in different urban setting. These inconsistencies have led new development initiatives to lose their value and become a societal expense. Lately people's use and contentment with public open spaces as well as influencing variables has been the subject of much scientific research. Consequently the physical features of open spaces (including walkways) such as accessibility, size, facilities, and natural view as well as quality have been proven to influence people's experiences and perceptions (Bedimo-Rung, et al., 2005; Ezennia, et al., 2017; Farahani & Maller, 2018). Thus, without adequate upkeep, simply having facilities is insufficient (Koppen, et al., 2014). Accordingly, physical characteristics, services, maintenance, and management of open spaces, on the other hand, are internal variables that have a direct impact on people's intention and preference (Bedimo-Rung, et al., 2005; Loukaitou-Sideris, et al., 2016; Ramlee, et al., 2016). Meanwhile, several external elements are indirectly related to people's perceptions and contentment with open spaces. One of the most important aspects in this regard is user behavior. Other users' misbehavior leads to widespread unfavorable perceptions. In contrast, socioeconomic characteristics such as age, gender, education, occupation, and income of users (park, walkway, and playground etc.) are equally related to people's feelings within the open recreational space. These aspects are crucial in the provision of public open spaces to increase their quality and design them in accordance with user intentions and preferences. However, prior study has found significant links between public open spaces mainly park and playground features and user preference, as well as between neighborhood preferences and open spaces feature well-being. It conveniently ignores recreational walking, particularly the novel concept of walking trails and its attributes. Therefore more research is needed to examine individual walking track characteristics in depth and assess their relationships with contextually relevant social and economic characteristics of users to close these gaps and establish a better evidence basis to guide walking track design. The main aim of the present study is to examine the public perception on attributes of walking avenue in urban areas of Sri Lanka while assessing comparative influence of individuals' social and economic dynamics with walking trail attributes. The findings of the study will facilitate the policymakers and planners to enhance the use of walking trails effectively than the current use.

2. Theoretical Background

The concept of public open space is prestigious urban design element in planning field (Rogers, 1999; Ezennia, et al., 2017). Public open space is often acknowledged by urban planners and landscape architects as per the acronym of 'POS' (Manta, et al., 2018). Although, within the wider built environment literature, there is a lack of unanimity on how to define public open space. Accordingly, Gold, (1980) defined the term of public open spaces as different meanings which were "Public" denoted as national or local government ownership; "open" publicized as to access for all or not a space for buildings and place for a green; and "space" called as a continual area or expanse which is free, vacant, or unoccupied. Afterward Madanipour, (2003) defined public space as areas beyond the control of an individual or small group, bridging the gap between private and public areas and serving a range of overlapping functional and symbolic functions which have multipurpose accessibility. Accordingly, public open space allies to those entire elements inbuilt and natural environment where the public has free access within the framework of their function (Koppen, et al., 2014) either for collective or personal activities (Wang, et al., 2015). In the current urban milieu, public open spaces are providing tremendous benefits to the economy, society and natural environment viz., protection of natural resources, conservation of historic and archeological sites, resource management, encourage the local economy through job creation and investment, social interaction and social cohesion and expressively providing physical and mental fitness (health) via offering recreation and leisure (Yassin, et al., 2012; Wan & Shen, 2015; Ranasingha & Ashika, 2016; Rahana & Nizar, 2020).

Recreation, in its wider sense, is identical with leisure for most people or else, recreation and leisure are synonymous terms for things which are done during free time (Koppen, et al., 2014). Conversely, the concept of leisure and recreation has a long-lasting history. As per the historical records, the concepts of Garden City, City Beautiful Movement and Neighborhood Unit can be considered as basic theories relating to the notion of recreation since the utopian philosophic era, while recreation was considered to restore mental energy/mental balance by discharging (surplus) energy which can be physical and/or psychological (Jazilatur, 2008). Accordingly, it was developed as far back as the late 19th century since seems applicable today too. Present day recreation still functions as a tool to restore and conserve men and women's energy for further work, duties, and obligations (Brademas, 2018). Even though, the physical activities are being phased out of daily life, transportation, and the workplace while some people walk and exercise in their spare time to make up for their inactive lifestyles. Accordingly, residents have access to local physical activity possibilities, notably recreational walking, through public open spaces (POSs), which are regarded as an important community resource for facilitating active living in the modern era. In modern built environment literature, studies are confirmed significant positive associations of POS access with recreational walking (Bjerke, et al., 2006; Conedera, et al., 2015; Manta, et al., 2018; Adiba & Roshida, 2019). Conversely, planning and design literature elaborated the importance of planning the suitable spaces for walking in urban environment (Giles-Corti et al., 2005; Jim & Chen, 2006) while requirement of overlong space for such development. The present

high demand and competition for urban land resources, it is extremely difficult to locate land for public open space development, explicitly for recreational walking in metropolitan regions. Consequently, narrow strips of stream bank reserve were identified as prime areas for designing public open spaces to promote recreational walking (Refer Figure 1). The new style of public open space is a renowned idea in urban planning today, and it is often recognized in several themes, such as jogging track, walking avenue, walking track, and walking trail, (Ranasingha & Ashika, 2016) inter alia.

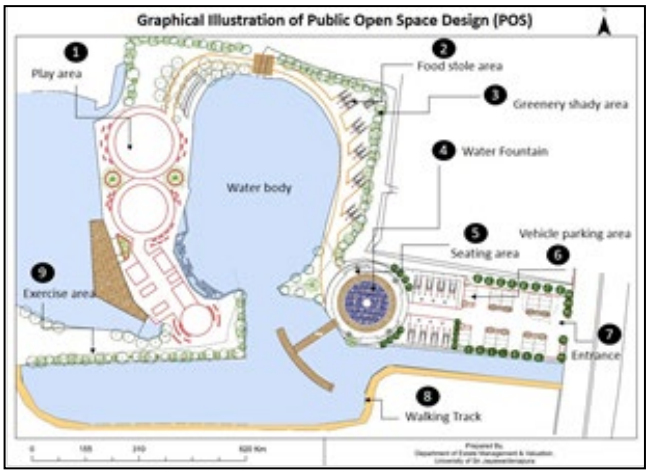


Figure 1 Graphical Illustration of POS with Walking Avenue (Constructed by Author, 2019)

2.1 Attributes of walking Avenues

There is very little information relevant to walking avenue attributes in prevailing literature since the concept has been newly endorsed in urban planning. Therefore, the common characteristics of public open spaces were considered for this study. The studies found that "access" as a major attribute in open spaces (Grahn & Stigsdotter, 2003; Peterson, et al., 1983; Jim & Chen, 2006; Schipperijn, et al., 2010; Koppen, et al., 2014; Loukaitou-Sideris, et al., 2016). According to Bedimo-Rung et al. (2005), access has been defined as "the ability of people to get to and navigate within a public open space" which has been measured using the criterion of park availability to the community, distance from the visitors' place of residence, and ability to navigate within the park. In addition, Fisher et al., (2004) empirically investigated the accessibility measures of older adults towards open spaces in Portland. The results revealed that the overall measure of walking activity within the neighborhood was significantly associated with the number of parking areas, paths, and trails per neighborhood acre, parking condition and traffic to the park. Accordingly, "access" was the main attribute of public open spaces in different studies.

Subsequently, the "Aesthetic appearance" of the natural environment was identified as another attribute of public open spaces in literature. Accordingly, Gobster and Westphal, (2004) confirmed that aesthetic appearance is a critical factor for attracting visitors to Chicago River greenways. Furthermore, Giles-Corti et al., (2005) examined the aesthetic components for contributing to people's enjoyment of open spaces which were tree-lined paths, water features, and the presence of birds, etc. However, aesthetic appearance was measured as per the different dimensions of the natural setting, particularly on perception and preference of user experiences of nature view, landscape, and the environmental features and qualities (Alessa, Bennett, & Kliskey, 2003; Bedimo-Rung, et al., 2005; Brademas, 2018; Madureira, et al., 2018).

The "safety" is one of thr important attribute that has significantly considered when developing public open spaces according to different perspectives of literature (Bedimo-Rung, et al., 2005; Bjerke, et al., 2006; De La Barrera, et al., 2016; Jim & Shan, 2013; Ode Sang, et al., 2016; Schetke, et al., 2016). Bedimo-Rung et al. (2005) empirically investigated the importance of safety factors for attracting visitors to the park environment. The results indicated that the condition and safety of play equipment are significantly impacted by parents' decisions to visit parks with their children. Conversely, Stodolska et al., (2009) showed that how gangs and gang-related drug activities in park environments have discouraged Latino residents' preferences to visit park environments. Accordingly, safety has been confirmed as an essential attribute within the development of open spaces in different countries.

Finally, the studies were identified the importance of "available amenities" in public open spaces in different urban settings. Furthermore, the availability of amenities has been classified as per the different branches in different studies. Accordingly, Aspinall et.al (2008) studied that how "Cafeteria and Sanitary facilities" affected to the older people preferences towards park visitation. The value of having the toilet and cafeteria facilities is significantly greater in this study. In other reference studies indicate that people are more likely to visit the places if it is having the facilities, such as cafes, toilets, changing room, sign system, parking, availability of benches and shadings, etc. which significantly associates with visitors' intention to select particular public open space for a visit (Zhang, et al., 2015; Wan & Shen, 2015; Wang, et al., 2015; Schetke, et al., 2016; Manta, et al., 2018; Madureira, et al., 2018).

2.2 User Perceptions on Walking Avenues

The term "perception" is often defined as "a cognitive meaning which having a set of detection and interpretation of sensory information" (Lemberg, 2010). User perception of public open spaces including walking avenues can be reviewed through the lens of how such open areas being appreciated, and whether or not they are ideal for other spaces. In this sense, perception can be identified as subjective sympathetic feeling, thus, in reality, can be observed across the behavior of individuals through their interactions surrounding the environment (Addis, et al., 2011). Thus, the people's behavioral intentions and perceptions differ depending on their specific qualities. Farahani & Maller, (2018) studied the individual characteristics of green spaces as per the criteria of gender, age, marital status, ability status, immigration status, acculturation status, cultural knowledge, ecological knowledge, place of residence, etc. Accordingly, user perception is an intellectual, complex, and multi-dimensional phenomenon that has been mainly examined based on biological and social, economic, and cultural aspects of users in particular urban areas (Adiba & Roshida, 2019; Ezennia, et al., 2017). Accordingly, the socio-economic and cultural factors mainly investigated on users' age (Schetke, et al., 2016; Schipperijn, et al., 2010; Kienast, et

al., 2012), gender (Ode Sang, et al., 2016; Schipperijn, et al., 2010; Carter & Horwitz, 2014; Conedera, et al., 2015), education, income, and employment (Jim & Shan, 2013; Schipperijn, et al., 2010; Ramlee, et al., 2016), etc. These factors are important to the provision of public open spaces to improve the quality of public open spaces and design them in line with user intensions and preferences.

Prior research has discovered substantial connections between POS features and user preference, as well as substantial connections between neighborhood preference and well-being on POS features. It does not, however, explicitly address recreational walking, including the novel paradigm of walking avenues and its characteristics. To address these gaps and develop stronger evidence foundation to guide walking track construction, further research is needed to evaluate specific walking track elements in depth and analyze their links with contextually relevant social and economic factors of users.

3. Methodology

3.1 Description of Study Area

The study focused on three urban walking avenues that are recently developed from two key neighborhood districts, which are located in western province Sri Lanka (Refer Figure 2). The Table 1 presents the specific characteristics of each selected walking avenues.

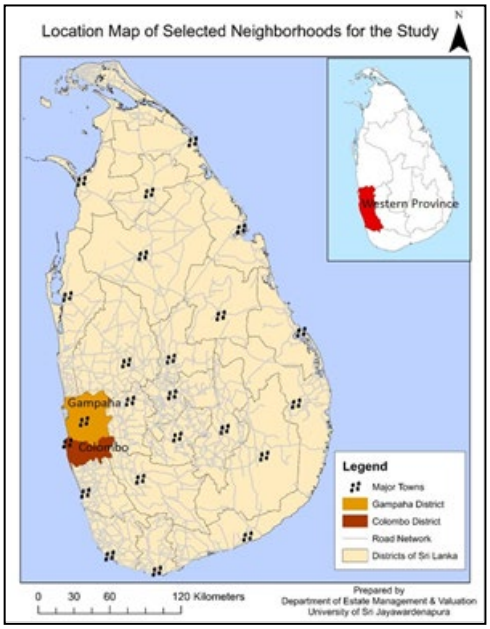


Figure 2 Location Map of Neighborhood Districts (Constructed by Author, 2019)

3.2 Data Collection - A Selection of Respondents

The mixed method approach is primarily adopted for this study. The primary data was collected through a self-administered questionnaire, face-to-face interviews, and observations. The users of the walking ways are the target population of the study. The design of the questionnaires is based on a literature survey and pilot field observation. The questionnaire consists of nominal, ordinal, and Likert scale questions. The sample size is determined as 50 from each location while adopting the convenience sampling method. Conversely, semi-structured interviews were carried out for in-depth understanding of research arena with selected professionals, in particularly urban planners, engineers and technical officers of the Sri Lanka Land Reclamation & Development Corporation, Provincial Road Development Authority and Urban Development Authority. The secondary data was mainly collected from the main planning authority in the relevant areas.

3.2 Data Analysis Procedure

The descriptive statistics is used to identify the socioeconomic characteristics of the respondents from the three case study areas. The Univariate analysis was used to analyze the level of affection of social factors of the mentioned facilities. For the purpose of Compare Dimensions, those factors can group according to the output of univariate analysis. Then, Robust test of equality of mean was applied to check whether mean of all dimensions are same or not. If at least one dimension is different from other, then the technique of Homogeneous Subsets were utilized to analyze the users' perceptions towards walking avenue attributes by classifying them with comparable mean values (to rank the above identify groups of facilities)

Table 1 Characteristic of Selected Walking Avenues

Parliament Walking Track (Case A)	Oruthota Walking Track (Case B)	Mahara Dalupitiya Walking Track (Case C)
Type of Development		
Recreational	Recreational	Recreational
Purpose of Development		
Retention of water	Retention of water	Retention of water
Water Body		
Diyawanna Oya	Ooruwal Oya	Mudun Ela stream
Length and Width of the Track		
1.88km(L) 5m(W)	1.95km(L) 2.4m(W)	1.7km(L) 2.4m (W)
Location		
Western province	Western province	Western province
Colombo District	Gampaha District	Gampaha District
Sri Jayawardenepura Kotte	Oruthota	Kiribathgoda
Significant Elements		
covered with Sandy Loam Soil, Solar power lightning, Shady trees, benches, parking, and cafeteria, etc.	covered with Paving blocks and it contains 120m length and 8 ft. width foot therapy section. Solar power lighting, Shady trees.	covered with Paving blocks and it contains 120m length and 3 feet width ft. therapy section. Solar power lighting, Shady trees
Present Condition		
Entrance		
		
Walking Track		
		
Parking		
		
Bench Arrangement		



Cafeteria/ food outlets



4. Results and Discussion

4.1 Socioeconomic Characteristics of Respondents

The five socioeconomic parameters of gender, age, education level, employment type, and income level were used to identify the characteristics of respondents are summarized in Table 2.

The male respondents outnumbered female respondents by a little margin. The respondents were classified into seven age groups viz., <18 years (Σn = 3);19- 25 years(Σn= 9); 26-35 years(Σn= 36); 36- 45 years(Σn= 63); 46-55 years(Σn=34); 56-65 years(Σn=4) and >66 years (Σn=1). In case A, the majority of respondents (n= 29) had degree-level education, whereas in cases B (n=26) and C (n=22), the majority of respondents had education levels up to A/Ls. Among all 150 respondents, employment types were identified as private sector Employed (Σn=67); Government sector ((Σn=24); Self employers (Σn=34), Unemployed person (Σn=16) and Retired (Σn=9). Majority of respondents in case A earned LKR 65001 – 75,000 income range per month (n=12) and 14% of respondents' monthly income more than LKR 100,000. Conversely, majority of case B (n= 13) and C (n=12) respondents income level were LKR 45,001- 55,000, and anyone not earned more than LKR 100,000 per month.

Table 2 Socio Economic Characteristics of Respondent

Socioeconomic Parameters	Case A		Case B		Case C	
	Frequency	%	Frequency	%	Frequency	%
Gender						
Male	36	72	38	76	40	80
Female	14	28	12	24	10	20
Age						
>18	1	2	2	4	-	-
19 - 25	4	8	3	6	2	4
26 - 35	13	26	14	28	9	18
36 - 45	20	40	21	42	22	44
46 - 55	11	22	9	18	14	28
56 - 65	1	2	1	2	2	4
<66	-	-	-	-	1	2
Education Level						
Up to O/L	2	4	18	36	12	24
up to A/L	19	28	26	52	22	44
Degree Level	29	58	6	12	16	32
Employment Type						
Private Sector	27	54	21	42	19	38

Government Sector	14	28	6	12	4	8
Self-Employment	4	8	12	24	18	36
Unemployment	1	2	7	14	8	16
Retired	4	8	4	8	1	2
Income Level						
<15000	5	10	4	8	10	20
15001 - 25000	2	4	5	10	4	8
25001 - 35000	2	4	11	22	7	14
35001 - 45000	1	2	9	18	9	18
45001 - 55000	3	6	13	26	12	24
55001 - 65000	7	14	2	4	8	16
65001 - 75000	12	24	3	6	-	-
75001 - 85000	10	20	2	4	-	-
85000 - 100000	1	2	1	2	-	-
>100000	7	14	-	-	-	-

Source: Survey data 2019

4.2 Evaluating Walking Avenue Attributes in Relation to Socioeconomic Characteristics of Users

In the questionnaire survey, it has been collected data from respondents about different type of facilities such as Toilets, Changing Rooms, Cafeteria, and Street Vendors, parking facility, Availability of Benches, Shading, Land Escape, Natural View, and Safety. To analyze the level of affection of above social factors for the mentioned facilities the Univariate analysis were used. Accordingly, Table 3 represents the significant values of each socio-economic factors and different facilities of walking avenues in three case areas

Table 3 Walking Avenue Attributes in Relation to Social & Economic Characteristics of User

Test of Between – Subjects Effects										
Types of facilities	C	SV	P	B	T	CR	Sh	LE	NV	Sa
Social and economic factors	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
Corrected Model	.053	.273	.156	.156	.070	.053	.047	.315	.643	.508
Intercept	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
Gender	.112	.206	.500	.500	.066	.063	.530	.329	.312	.042
Age	.415	.814	.183	.183	.382	.537	.116	.274	.996	.523
Education	.967	.783	.239	.239	.248	.652	.220	.339	.900	.721
Employment	.141	.704	.481	.481	.671	.052	.143	.419	.317	.140
Income	.010	.380	.135	.135	.083	.055	.775	.975	.649	.294
Gender * Age	.268	.666	.121	.121	1.000	.105	1.000	.304	.210	.172
Gender * Education	1.000	.	.432	.432	1.000	.681	.319	.304	1.000	.818
Gender * Employment	.780	1.000	.432	.432	1.000	.681	.319	1.000	1.000	.490
Gender * Income	.962	.720	.680	.680	.973	.261	.504	.369	.945	.332
Age * Education	.076	.483	.178	.178	.490	.304	.469	.756	.416	.269
Age * Employment	.600	.497	.440	.440	.639	.930	.056	.941	.701	.096
Age * Income	.758	.347	.635	.635	.710	.105	.676	.067	.382	.977
Education * Employment	.	.	.	.	.	.	.	.	.	.
Education * Income	.477	.122	.638	.638	.743	.685	.660	.235	.335	.487
Employment * Income	.620	.989	.592	.592	.158	.247	.600	.537	.611	.908
Gender * Age * Education	.	.	.	.	.	.	.	.	.	.
Gender * Age * Employment	.	.	.	.	.	.	.	.	.	.
Gender * Age * Income	.	.	.	.	.	.	.	.	.	.
Gender * Education * Employment	.	.	.	.	.	.	.	.	.	.
Gender * Education * Income	.	.	.	.	.	.	.	.	.	.

Gender * Employment * Income	.	.	.	.	.	.	.	.	.	.
Age * Education * Employment	.	.	.	.	.	.	.	.	.	.
Age * Education * Income	.617	.809	1.000	1.000	.785	.909	.103	.320	.485	.726
Age * Employment * Income	.160	.866	.537	.537	1.000	.747	.122	.228	1.000	.856
Education * Employment * Income	.	.	.	.	.	.	.	.	.	.
Gender * Age * Education * Employment	.	.	.	.	.	.	.	.	.	.
Gender * Age * Education * Income	.	.	.	.	.	.	.	.	.	.
Gender * Age * Employment * Income	.	.	.	.	.	.	.	.	.	.
Gender * Education * Employment * Income	.	.	.	.	.	.	.	.	.	.
Age * Education * Employment * Income	.	.	.	.	.	.	.	.	.	.
Gender * Age * Education * Employment * Income	.	.	.	.	.	.	.	.	.	.
Error	120.33	55.66	15.08	15.083	9.583	55.250	9.333	8.750	5.833	7.047
Total	1625	1253	2371	2371	3394	1437	2870	3203	3545	23360
Corrected Total	677.47	223.3	73.87	73.873	52.240	310.86	53.333	38.193	21.473	27.762
R Squared	.822	.751	.796	.796	0.817	0.822	.825	.771	.728	.746

*Note: (Cafeteria= C, Street Vendors=SV, parking facility=P, Availability of Benches= B, Toilets = T, Changing Rooms= CR, Shading=Sh, Land Escape= LE, Natural View= NV, and Safety=Sa.)

Source: Survey data 2019

As per the findings of table 3, all the significant values are greater than 0.05 (5% level significant) that are insignificant apart from the income level with facility of cafeteria and gender with safety facilities. Hence, it is indicating that the Income affected to the Facility of Cafeteria. In such a situation, it is appropriate to check the relation of various income categories. For this purpose, the study was use the method of post Hoc Multiple Comparisons for Observed mean. The results reveled that mean value of all income groups were not different expect few groups. Therefore, for the purpose of Compare Dimensions it can group as follows according to the output of post hoc output.

- Group 3.1: Cafeteria facilities for person who's income level below Rs. 65 000
- Group 3.2: Cafeteria facilities for person who's income level above Rs. 65 001
- Perception on safety different among gender groups.

Therefore, safety can group as below for the purpose of Compare Dimensions.

- Group 10.1: Safety of male
- Group 10.2: Safety of Female

To Compare 12 groups, researcher can use One-way ANOVA or Robust test after test homogeneity of variance.

Table 4 represents each group of variables for compare dimension.

Table 4 Comparative Dimension of each Variable

Group No	Dimensions
Group 1	Facility of Toilet
Group 2	Facility of Changing Room
Group 3: 1	Cafeteria facilities for person who's income level bellow Rs. 65 000
Group 3.2	Cafeteria facilities for person who's income level above Rs. 65 001
Group 4	Availability of Street vendor
Group 5	Facility of Car parking
Group 6	Availability of Bench
Group 7	Availability of Shading
Group 8	Availability of land Scape
Group 9	Availability of Natural View
Group 10.1	Safety of male
Group 10.2	Safety of Female

The Levene's Test for Equality of Variances is used to determine variance homogeneity.

Table 5 Test of Homogeneity of Variance

Test of Homogeneity of Variances			
Dimension			
Levene Statistic	df1	df2	Sig.
142.777	11	1488	.000

P value is less than 0.05 (P value < 0.05); therefore reject the null hypothesis. Hence, at least one variance is differing from others. Therefore, Robust test of equality of Means were apply to check whether means of all dimensions are same or not (refer Table 5).

Table 6 presents the results of the Robust Tests of Equality Means of this study.

Table 6 Robust Test of Equality Means

Robust Tests of Equality of Means				
Dimension	Statistic	df1	df2	Sig.
Welch	4.213E3	11	425.109	.000
Brown-Forsythe	951.874	11	385.445	.000
a. Asymptotically F distributed.				

P value is less than 0.05 (P value < 0.05); therefore reject the null hypothesis. At least one Mean Value is differing from others.Therefore, homogenous subsets technique was applied to identify each homogenous group of dimensions. Table 7 presents the homogeneous subsets of the Study.

Table 7 Homogeneous Subsets of the Study

Dimension Hochberg							
Group	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
Group3.1	114	2.04					
Group4	150		2.62				
Group2	150		2.74				
Group5	150			3.91			
Group6	150			3.91			
Group3.2	36			4.03			
Group7	150			4.33	4.33		
Group8	150				4.59	4.59	
Group1	150				4.72	4.72	
Group9	150					4.85	
Group10.1	114						4.95
Group10.2	36						4.98
Sig.		1.000	1.000	.198	.365	.994	1.000
Means for groups in homogeneous subsets are displayed.							

Source: Survey data 2019

As per the results of Table 7, five homogenous groups of dimensions were identified viz., Group 10.2 and Group10.1; Group 1, Group 7, Group 8 and Group 9; Group 3.2, Group 5 and Group 6; Group 2 and Group 4 and Group 3.1. According to the identified groups of the study, the above ranks can expansion as follows.

- 1st Rank: Safety of male, Safety of Female
- 2nd Rank: Facility of Toilet, Availability of Shading, Availability of land Escape, Availability of Natural View
- 3rd Rank: Cafeteria facilities for person who's income level above Rs. 65 001, Facility of Car parking, Availability of Bench
- 4th Rank: Facility of Changing Room, Availability of Street vendor
- 5th Rank: Cafeteria facilities for person who's income level bellow Rs. 65 000

The above ranks indicating that, Safety (Safety of male, Safety of Female) is the most prioritized character, which influence for attract public for walking areas. Subsequently characters such as Facility of Toilet, Availability of Shading, Availability of land Escape and Availability of Natural View are affecting for attract public for walking areas up to some extent. Furthermore, it emphasize that, the factor of Cafeteria facilities for person who is income level bellow Rs. 65000 is the lowest prioritized character, which influence for attract public for walking areas according to the above sample.

Accordingly, safety (safety of male, safety of female) was a major concern for respondents in all three surveys, as safety was not a problem for users in terms of fear of other people, fear of harm, fear of unsecured animals, and anxiety about traffic flow (especially for those who walking on the jogging trails). Other studies, such as one in Los Angeles (Gearin and Kahle, 2006) have discovered a significant preference for safety in parks. City dwellers in Los Angeles (Gearin and Kahle, 2006) and Hong Kong (Lo and Jim, 2012) have expressed concerns about safety. Increased maintenance seems to boost a person's liking for and sense of security in order to increase public usage of parks visitors. Subsequently, facilities of toilet, availability of shading, availability of landscape and availability of natural view have affected to attract public for walking areas in this study. All three studies had considerable sanitation in terms of cleanliness toilet facilities, and it can be inferred that because all the walking avenues were recently established, they have a proper management system in place with a fresh backdrop. The landscape, shade, and natural view are all considered vital components of POS, and they are also important factors in this study due to the presence of walking pathways with suitable paving blocks, a therapeutic area, solar power illumination, shaded trees, and well-maintained water streams. Thus, many of the respondents stated that natural environment variables had a direct impact on their desire to engage in physical exercise. Various natural environmental influences motivate individuals to jog, stroll, or engage in various forms of physical exercise. The visual aesthetic quality and natural view are vital for users' physical and psychological well-being, as well as for POS's tourist potential. In line with prior research, the study found that high landscape visual quality and natural view have a significant impact on users' enjoyment with urban parks (Chen

et al., 2009). Hence, the variable of Cafeteria facilities for person who is income level above LKR 65,001, facility of car parking and availability of benches are the third significant variables that important to attract public for walking areas. Finally, facility of changing room and availability of street vendors are identified as forth group of factors that influence on user preferences towards walking avenues. The cafeteria facilities for person whose income level below LKR 65, 000 are the lowest prioritized and less influenced factor to attract public for walking areas. Accordingly, people do not expect changing rooms and street food, while high-income groups (income level above LKR 65, 000) enjoy herbal drinks in cafeterias along walking avenues.

5. Conclusion and Research Implications

This paper enlightened the knowledge from survey-based respondent to examine public perceptual preference towards attributes of urban walking avenues in Sri Lanka. For this purpose, it was selected three different cases in Colombo and Gampaha urban areas depicted as (Case A), (Case B) and (Case C). The most common geographical feature of these three places is designed related with water streams. Findings specify that safety is most prominent and preferred attribute of walking avenues. Subsequently, well designed landscaping with natural view, availability of shading and facility of toilet has significant contribution on better perceptions of the walking avenues in the study area. The respective significant factors affecting to the user's attractiveness to the walking avenues are facility of car parking and availability of benches as per the findings of the study. However, people do not show a considerable preference to facilities of changing rooms and street foods, while high-income groups favorably wish to promote ~~to~~ the herbal drinks in cafeterias of walking avenues. The outcome of this study is immensely important to design and management of outdoor environment to prioritize interventions that are likely to maximize preference for different segments of the population. Analysis of participant's responses produced useful information about the relative importance of attributes. Accordingly, analysis procedure of this study may be applied to other environmental settings in which attribute priorities are required to be understood. The safety of the walking path is most preferred attribute in this study. It provides a clue towards responsible bodies for constructing new walking paths with safer environment. In addition offering health and recreational facilities for the public which can also be identified specific benefits, such as protecting water resource (resurgence of streams with clean water, restore of pollute streams, reduction of erosion of stream banks), income generation (By designing community based riverine gardening projects which can generate income for local residence through plant nurseries, cultivating riverine fruit, herbal, vegetables and other useful trees such as bamboos in the stream banks, cultivating high value rice varieties in paddy lands adjacent to the foot paths and promoting inland fishery), Ecology & Recreation (this project can be creatively expanded to transform from improved streams into bio corridors by connecting forest with upgrading ecological balance of biodiversity of the watershed) and promoting eco-tourism (It can be creatively linked with activities of botanical gardens which will generate the opportunities for local investors who involved in eco-tourism).

Acknowledgements

The authors sincerely acknowledge the Center for Real Estate Studies (CRES), Department of Estate Management and Valuation, University of Sri Jayewardenepura, Sri Lanka.

References

Addis, D. R., Roberts, R. P. & Schacter, D. L. (2011). Age-related neural changes in autobiographical remembering and imagining. *Neuropsychology*, 49(13): 3656-3669.

Adiba, S. & Roshida, A. M. (2019). User perception in Public Open Space; A Case of New Delhi, India. *Malaysia, GBES*.

Alessa, L., Bennett, S., & Kliskey ,A. (2003). Effects of knowledge, personal attribution and perception of ecosystem health on depreciative behaviors in the intertidal zone of Pacific Rim National Park and Reserve. *Journal of Environmental Management*, 68: 207–218

Bedimo-Rung, A. L., Mowen, A. J. & Cohen, D. A. (2005). The significance of parks to physical activity and public health: a conceptual model.. *American Journal Of Preventive Medicine*, 28(2): 159-168.

Bjerke, T., Østdahl, T., Thrane, C. & Strumse, E. (2006). Vegetation density of urban parks and perceived appropriateness for recreation. *Urban Forestry & Urban Grennings* , 5(1): 35-44.

Brademas, J. (2018). Basic Concepts: Philosophical Analysis of Play,Recreation, and Leisure. *Journal of Lesuire Research*, 12(3): 289-291.

Carter, M. & Horwitz, P. (2014). Beyond proximity: the importance of green space usability to self-reported health. *Ecohealth*, 11(3): 322-332.

Chen, B., Adimo, O.A. & Bao, Z. (2009). Assessment of aesthetic quality and multiple functions of urban green space from the users' perspective: The case of Hangzhou Flower Garden, China. *Landsc. Urban Plan*. 93: 76–82.

Conedera, M., Biaggio, A.D., Moretti, M. & Home, R. (2015). Residents' preferences and use of urban and peri-urban green spaces in a Swiss mountainous region of the Southern Alps. *Urban Forestry & Urban Greening*, 14: 139-147.

De La Barrera, F., Paecke, S.R., Harris, J., Bascunan, D. & Farias, J.M.(2016). People's perception influences on the use of green spaces in socio economically differentiated neighborhoods. *Urban Forestry & Urban Greening*, 20: 254-264.

Ezennia, I. S., Uwajeh, P. C. & Irouke, V. M. (2017). User Perception Of Neighbourhood Parks And Open Spaces: A Case Of Karakol, North Cyprus. *International Journal of Scientific and Technological Research,* 6(8): 263-268.

Farahani, L. M. & Maller, C. (2018). Perceptions and Preferences of Urban Greenspaces: A Literature Review and Framework for Policy and Practice. *Official Journal of the International Association for Landscape Ecology*, 61(1865-1542): 1-22.

Fisher,K.J.,Li,F.Z.,Michael,Y., &Cleveland,M.(2004). Neighborhood-level influences on physical activity among older adults: A multilevel analysis. *Journal of Aging and Physical Activity*, 12: 45–63.

Gearin, E. & Kahle, C. (2006). Teen and adult perceptions of urban green space Los Angeles. *Child. Youth Environ*. 16: 25–48. 102.

Giles-Corti, B., Broomhall, M. H., Knuiman, M., Collins, C., Douglas, K., Ng, K., Lange, A. & Donovan, R. J. (2005). Increasing walking how important is distance to, attractiveness, and size of public open space? *American Journal of Preventive Medicine*, 28: 169–176.

Gobster, P. & Westphal, L. M. (2004). The human dimensions of urban greenways: Planning for recreation and related experiences. *Landscape and Urban Planning*, 68: 147–165.

Gold, S. M. (1980). Recreation Planning and Design. McGraw-Hill.Gold.

Grahn, P. & Stigsdotter, U. A. (2003). Landscape planning and stress. *Urban Forestry & Urban*, Volume 2(1): 1-18.

Jazilatur, R. (2008). Garden City and City Beautiful Movement Theory. on May 15, 2008.

Jim, C. Y. & Chen, W. Y. (2006). Perception and attitude of residents toward urban green spaces in Guangzhou (China). *Environmental Management*, 38(3): 338-349.

Jim, C. Y. & Shan, X. (2013). Socioeconomic effect on perception of urban green spaces in Guangzhou, China. *Cities*, 123-131.

Kienast, F., Degenhardt, B., Weilenmann, B., Wager, Y. & Buchecker, M. (2012). GIS-assisted mapping of landscape suitability for nearby recreation. *Landscape and Urban Planning*, 105: 385-399.

Koppen, G., Sang, A. O. & Tveit, M. S. (2014). Managing the potential for outdoor recreation: Adequate mapping and measuring of accessibility to urban recreational landscapes. *Urban Forestry & Urban Greening,* Volume 13(1): 71-83.

Lemberg, D. (2010). Environmental Perception, s.l.: Thousand Oaks, CA: Sage.

Lo, A.Y. & Jim, C.Y.(2012). Citizen attitude and expectation towards green space provision in compact urban milieu. *Land Use Policy*, 29: 577–586.

Loukaitou-Sideris, A., Levy-Storms, L., Chen, L. & Brozen, M. (2016). Parks for an Aging Population: Needs and Preferences of Low-Income Seniors in Los Angeles.. Journal of the American Planning Association, 82(3): 236-251.

Madanipour, A. (2003) Public and private spaces of the city, London: Routledge.

Madureira, H., Nunes, F., Oliveira, J. V. & Madureira, T. (2018). Preferences for Urban Green Space Characteristics:A Comparative Study in Three Portuguese Cities. *Environments*, 5: 1-13.

Manta, S. W., Lopes, A., Hino, A.A.F., Benedetti, T. & Rech, C.R. (2018). Open public spaces and physical activity facilities: study of systematic observation of the environment. *oPEN PUBLIC SPACES AND PHYSICAL ACTIVITY FACILITIES,* 20(1980-0037).

Ode Sang, A., Knez, I., Gunnarsson, B. & Hedblom, M. (2016). The effects of naturalness, gender, and age on how urban green space is perceived and used. *Urban Forestry & Urban Greening,* 18: 268-276.
Peterson, G. L., Dwyer, J. F. & Darragh, A. J. (1983). A behavioral urban recreation site choice model.. *Leisure Sciences,* 6(1): 61-81.

Rahana, H. & Nizar, S. A. (2020). Waterfront Development - A Tool to Restore the Neighbourhood. *International Journal of Science and Research (IJSR),* 9(4): 1027-1033

Ramlee, M., Omar, D., Yunus, Z. M. & Samad, Z. (2016). Successful Attractions of Public Space through Users Perception. *Environment-Behaviour Proceedings Journal,* 2: 188-196.

Ranasingha, R. A. D. S. & Ashika, B. A. D. W. (2016). Factors Affecting on Jogging Trail Users' Behavior: The Relative Influence of Individual, Social and Physical Environmental Factors. *North Asian International Research Journal of Social Science & Humanities*, 2(1): 1-13.

Rogers, R., (1999). Towards an urban renaissance: final report of the urban task force, London: Chaired by Lord Rogers of Riverside, Department of the Environment, Transport and the Regions.

Schetke, S., Qureshi, S., Lautenbach, S. & Kabisch, N. (2016). What determines the use of urban green spaces in highly urbanized areas? – Examples from two fast growing Asian cities. *Urban Forestry & Urban Greening,* 16: 150-159.

Schipperijn, J., Stigsdotter, U. K., Randrup, T. B. & Troelsen, J. (2010). Influences on the use of urban green space – A case study in Odense, Denmark. *Urban Forestry & Urban Greening,* 9: 25-32.

Stodolska, M. & Shinew, K. J. (2009). La calidad de vida dentro de La Villita: An investigation of factors affecting quality of life of Latino residents of an urban immigrant residential enclave. *Journal of Immigrant and Refugee Studies*, 7: 267–289.

Wan, C. & Shen, G. Q. (2015). Encouraging the use of urban green space: The mediating role of attitude, perceived usefulness and perceived behavioural control. *Habitat International*, Volume 50: 190-139.

Wang, D., Brown, G. & Liu, Y. (2015). The physical and non-physical factors that influence perceived access to urban parks. *Landscape and Urban Planning,* Volume 133: 53-66.

Yassin, A. B. M., Bond, S. & McDonagh, J. (2012). Principles For Sustainable Riverfront Development For Malaysia. *Journal of Techno-Social,* 4(1): 21-36.

Zhang, W., Yang, J., Ma, L. & Huang, C.(2015). Factors affecting the use of urban green spaces for physical activities: Views of young urban residents in Beijing. *Urban Forestry & Urban Greening*, 14: 851-857.

UTM UNIVERSITI TEKNOLOGI MALAYSIA

IJBES

International Journal of Built Environment and Sustainability
Published by Penerbit UTM Press, Universiti Teknologi Malaysia
IJBES 9(1)/2022, 23-37

BIM Education in Higher Learning Institutions: A Scientometric Review and the Malaysia Perspective

Bruno lot Tanko
School of the Built Environment, University of Reading Malaysia, Johor, Malaysia

Lawrence Mbugua
School of Construction Management and Engineering, Whiteknights Campus, University of Reading, United Kingdom

ABSTRACT

Over the last decade, digital applications and Building Information Modelling (BIM) have been introduced in the construction industry to realize a smart construction ecosystem. However, the construction industry has not completely accepted BIM as a standard, and the concept of using BIM applications in universities has not been thoroughly researched. This paper addresses the first scientometric study of BIM education in universities, identifying the state of BIM education practices, skillsets, and the level of BIM education in universities. The paper used scientometric analysis and the VOSviewer mapping technique to assess the most impactful publication sources with the most important impact on BIM education by searching "BIM Education" and using 250 bibliographic data extracted from the Scopus database from 2011-2020 to identify the existing research gaps and research direction. Second, a structured questionnaire was distributed to 343 Year 2 and Year 3 students from two public and two private Malaysian universities that use BIM in their learning. Descriptive data analysis using cross-tabulation in SPSS and relative importance index (RII) were used to analyze the data. The paper revealed two stages of BIM education research; and identified research gaps in the fields of BIM education, architectural education, e-learning, curriculum and information management. The paper also revealed Revit, Cost X and the Glodon Cubicost software as the most used applications, while the common skillsets are design authoring, modelling, and cost estimation. However, both public and private university students mainly design 3D models at BIM Stage 1. The study recommends that institutions and other stakeholders provide continuous BIM training, purchase BIM software, and integrate BIM into the curriculum of Built Environment higher learning institutions for the next generation to be the generation that uses virtual collaborative platforms.

Received : *17 August 2021*
Received in revised form : *15 December 2021*
Accepted : *17 December 2021*
Published Online : *31 December 2021*

Keywords:

Building Information Modelling, Education, Scientometric Analysis, Skillsets, Built Environment Students, Universities

Corresponding Author Contact:

b.tanko@reading.edu.my

DOI: 10.11113/ijbes. v9.n1.864

1. Introduction

Scientometrics is a large science and technology discipline that includes quantitative analyses of scientific literature. According to Zakka et al. (2021), scientometrics entails using co-citation networks and science mapping to visualise key research areas. A comprehensive literature review is an essential component of any research endeavor, and it plays a key role in scientific research, given the ongoing growth of science. Viergutz & Schulze-Ehlers (2018) state that literature reviews "give a framework for

improving knowledge, supporting theoretical advancement, and suggesting opportunities for additional research. "Science literature is a type of big data analytics and mining (Chen et al., 2014), as well as a set of applications and tools that provide more information on the data's reliability and usefulness in strategic planning (Galetsi & Katsaliaki, 2019). As a result, information science and technology-based scientific mapping is becoming a more common transdisciplinary domain. It is the development and use of computer techniques for visualizing, comprehending, and modeling a wide range of scientific and technical procedures. formal characteristics.

Advanced technology and applications have been deployed in the construction industry, resulting in a smart construction world. Smart construction is the process of planning, organising, constructing, and running a structure using advanced digital computerised technologies and industrialised manufacturing techniques (Reddy and Kone, 2019). Smart technology in construction will improve project viability, sustainability, and quality, reduce building lifetime costs, and benefit a wider range of stakeholders.

In the Architecture, Engineering, and Construction (AEC) industry, BIM is a well-known new technology (Lim et al., 2021) that is used to improve project efficiency by finishing projects on time and on budget. BIM is a database that stores all of the information on the components of a building. Data processing can be improved, lowering the danger of losing project building specifics (Chiu and Lai, 2020; Hong et al., 2019). The usage of BIM will eliminate the cumbersome and time-consuming documentation. The BIM database facilitates the incorporation of information into the project and improves document management coordination. Students can save and keep all project files in the machine instead of utilizing manual storage or filing. As the building sector undergoes a revolution, the demand for BIM qualified professionals is surging (Arroteia et al., 2019). As a result, building businesses' use of BIM qualified workers has an indirect impact on potential BIM labor demand (Wu and Issa, 2014). On a global basis, more construction companies, particularly those in charge of large projects, are incorporating BIM into their project delivery systems. However, the supply of BIM workers is insufficient to meet demand, resulting in a BIM professional shortage.

The shortage of competent personnel in the construction business will have an impact on the economy, project efficiency, and project performance. According to numerous academics, there is a shortage of BIM competent experts (Liu et al., 2015; Ahmed and Hoque, 2018; Farooq et al., 2020), is one of the main factors preventing BIM implementation in the construction industryUpskilling can be accomplished through education, internships, and training. As a result, BIM education is being integrated into tertiary educational institutions in order to educate students with BIM knowledge and abilities, hence expanding the number of future BIM graduates. According to Enhassi et al. (2018), BIM education with credentials is an external method for adopting BIM into the construction sector and will accelerate BIM growth. Current BIM education, on the other hand, emphasizes on BIM software skills rather than open-BIM concepts, BIM management, and learning in a collaborative BIM working environment, according to Smith (2014). Industry technical organisations and bodies must maintain tight relationships with higher learning institutions to examine the BIM curriculum and guarantee that education is equipped with the new BIM expertise and abilities (Chan, 2014).

The Public Works Department (PWD) in Malaysia was the first to deploy BIM with government support in order to promote the use of BIM in construction projects (Latiffi et al.,2015). Similarly, most higher education institutions are emphasizing the integration of BIM into education due to the significant benefits that BIM can provide to students in their possible employment occupations as well as to satisfy industry needs. According to (Agirbas, 2020), the benefits of BIM implementation in education include students being able to understand the complex geometry of any building through 3D visualization using BIM software, understanding basic knowledge and information on sustainability, learning about the properties of the BIM climate, and preparing students for their future working environment. The Malaysian government should provide clear advice and standardization to lead the BIM adoption in education. Various parties are developing plans to integrate a robust BIM curriculum into higher education that takes into account a variety of factors. Students who have completed BIM training at a higher learning institution would be well-versed in BIM knowledge and abilities, equipping them for future employment opportunities.

Despite extensive use in the building industry in the United Kingdom and the United States, BIM adoption in Malaysia is still modest (Mamter and Aziz, 2016). This is owing to a scarcity of BIM-qualified personnel with practical experience with BIM technology and applications in the construction industry (Sun et al., 2017). The paucity is due to the minimal number of recent graduates with BIM expertise and knowledge. As a result, higher education institutions must prioritize BIM education in order to meet the growing need for BIM expertise. BIM integration into higher education syllabuses is still at a low practice level, according to Khiyon (2015), with no standardization.

Several factors aggravate this scenario, including a lack of understanding in the subject of BIM education research in higher education institutions. The present educational barriers to BIM adoption would steadily reduce the number of trained BIM specialists and the rate of BIM adoption. Furthermore, BIM higher education achievements do not fulfill industrial requirements (Liu et al., 2015). As a result, it's critical to recognize all potential roadblocks so that solutions can be found to solve the problem. In Malaysia's higher education system, the study focuses on BIM education methods, BIM implementation hurdles, and BIM implementation solutions. As a result, this research looks at the first global scientometric study on BIM education and the potential of BIM education in Malaysian universities. This study aims to answer the following five primary research questions based on the motivation of the study:

i. What are the phases of BIM education research according to the year of publication?
ii. What are the current research gaps and future direction in BIM education research?

iii. Which countries have the most influence in BIM education research?
iv. What are the most commonly used BIM applications among built environment students?
v. What are the most common BIM skillsets among built environment students?
vi. What is the level of BIM among built environment students?

2. Literature review

2.1 BIM and the Industry

Because of the digital revolution, which connects modern technology with the people who use it, the construction industry is witnessing the Industrial Revolution (IR) 4.0 (Alaloul et al., 2020). The Architecture, Engineering, and Construction (AEC) industry has largely adopted BIM technology, and its emergence into the worldwide market has boosted its application in the construction industry. According to Rostam (2019), 75 percent of construction projects cannot be completed on schedule due to the complexities of the processes. All construction operations, on the other hand, can be completed in a short amount of time and produce a cost-effective end product (Georgiadou, 2019).

A project is visualized using a 3D virtual model that incorporates all architectural element features and metadata. Design errors can be eliminated and design quality can be improved through visualisation when BIM is used. In addition, data about the building's lifecycle can be handled (Doan et al., 2020; Chiu and Lai, 2020; Enhassi, et al., 2018) and can predict the building's lifecycle to ensure that it is operated in a sustainable manner. Designing a sustainable design will be more effective if the design is reviewed using a BIM application.

The construction industry contributes significantly to Malaysia's Gross Domestic Product (GDP), accounting for 3% to 5% of the country's total GDP (Othman et al., 2020). As a result, BIM technology has been incorporated into the Malaysian construction industry, enabling for national-level construction efficiency. BIM has been used primarily in the private sector in Malaysia since the year 2000. However, the government sector, notably the Public Works Department (PWD), embraced BIM technology in the early year of 2007. Most construction parties are aware of this. (Latiffi, 2015). PWD has formed a BIM committee to evaluate BIM adoption in the construction industry by conducting research and determining the most acceptable media for usage in government public works projects. According to Yadav and Kanade (2018), a government commission chose and recommended Autodesk as the BIM platform for construction. The Public Works Departments (PWD) began using BIM software tools at the end of the year 2010, and the use of BIM technology in other construction-related occupations has grown since then. Furthermore, Malaysia's Construction Industry Development Board (CIDB) is a government entity that promotes BIM adoption in the construction industry. CIDB Malaysia supports BIM technology through seminars and is now working on a roadmap that will include BIM implementation guidance. The building concept is initially represented in two-dimensional (2D) text and sketches. Following that, the 2D system evolved into a computer-aided design (CAD) system Lattifi et al. (2015). A CAD framework, according to Kong et al. (2020), provides for the modeling of the building design process in three-dimensional (3D) space and the storage of architectural knowledge in the form of models and images. The CAD foundation will not be fully refined if non-graphic building details are generated using current graphics and models. As a result, Malaysia is using BIM, an advanced software and processing framework, to address all technological difficulties associated with the production of building information.

Malaysia's BIM adoption rate is growing at a slower rate than that of other countries. BIM deployment in Malaysia's construction industry is poor. A lack of expertise, legal backing, interoperability constraints, and other factors are all hindering BIM deployment in Malaysia's building industry Othman et al. (2020). According to Wong and Gray (2019), the most common hurdle to BIM adoption is a lack of BIM education, which accounts for 40.5 percent of the barriers. As a result, BIM training is critical for increasing BIM adoption in the Malaysian construction industry.

BIM is being increasingly widely used in the construction sector, which is increasing demand for BIM experts (Zhang et al., 2016). Building projects and implementation employing advanced BIM technologies are in need of BIM graduates. As a result, BIM should be included in BIM education so that students who work primarily in the Built Environment domain can gain BIM core knowledge and abilities that will prepare them for the actual world.

2.2 BIM and the Academia

The demand for BIM specialists is growing as information technology advances. Many construction companies want BIM graduates to be able to cover a wide range of positions. A shortage of BIM-trained professionals is the current global driving force for BIM deployment in institutions. BIM education in Malaysia is still in its early stages, according to a report by Belayutham and Ibrahim (2018). BIM education is defined as a "process of learning that covers BIM knowledge that an individual must be capable of as well as having an understanding of BIM processes" (Ana Karina et al., 2020). As a result, higher education institutions must incorporate BIM into their curricula so that all graduates are equipped with the necessary skills and knowledge.

Integration of BIM into higher education will aid in the advancement of AEC education and alleviate the shortage of competent BIM practitioners. The industry expects all possible graduates to obtain BIM skills and competence in order to meet the demand for BIM specialists (Zhao et al., 2015). BIM engineers, BIM planners, BIM project managers, BIM technicians, BIM coordinators, IT executives, and other jobs are available in the industry for BIM experts (Kolaric et al., 2019).

Incorporating BIM into higher educational curricula can help to improve AEC education and address the scarcity of competent

BIM experts. To meet the demand for BIM specialists, the industry expects all future graduates to have BIM skills and expertise (Zhao et al., 2015). The industry offers BIM specialists a variety of work options, including BIM engineer, BIM designer, BIM project manager, BIM technician, BIM coordinator, IT directors, and other jobs (Kolaric et al., 2019). Because of BIM education, BIM-oriented graduates will emerge. Technical competency in BIM is a core competence that all graduates must learn, not an optional skill that adds value to a career.

Through BIM education, students can improve their learning experiences by visualizing BIM models. The dynamic 3D BIM model generates a visualization that correctly depicts the reality of the complete building and environment, providing for a better understanding of the project's architectural design (Witt and Kahkonen, 2019). The fundamentals of BIM will be covered, as well as the ideas that underpin it. Because BIM simplifies difficult design procedures, students will be able to boost their productivity by finishing all assignments on time (Doan et al., 2020; Haron et al., 2017).

Incorporating BIM projects into the curriculum would also help students communicate and cooperate better (Jin et al., 2017). To develop a thorough BIM model, students will need to collaborate to accomplish all design tasks.

2.3 BIM Software and Skillsets

The Higher education is incorporating BIM education in order for a large number of students to develop BIM skills and competence in order to fulfill industry demands. Most universities, according to Aziz et al. (2019), employ BIM software such as Autodesk Revit, Naviswork, Cubit software, Glodan Cubicost, and Cost – X. The most often used BIM software at Malaysian higher education institutions are Autodesk Revit (Architecture, Structural, MEP-Mechanical, Electrical, and Plumbing), Autodesk Navisworks, Graphisoft ArchiCAD, and TEKLA Structures (Hedayati et al., 2015).

Autodesk Revit, Graphisoft ArchiCAD, and TEKLA Structures are some of the design authoring software utilized to produce the 3D model. Autodesk Navisworks is a 3D coordination application for 4D scheduling and conflict detection. Cubit software, Glodan Cubicost, and Cost X are used to estimate costs. Students in higher education institutions must have the necessary BIM abilities for a variety of BIM applications at various phases of the project. Table 1 displays various uses of BIM and their definitions at different BIM stages.

A BIM project execution planning guide has been created, which comprises a list of main BIM applications during the lifecycle of the facility or building. BIM is used at numerous stages, including preparation, design, construction, and operation. BIM uses in the planning stage include condition modeling, cost calculation, phase planning, site analysis, and design reviews. The design stage includes plan authoring, design / engineering analysis, and 3D coordination. For site use preparation, 3D monitoring and planning, and record modeling, BIM is used during the construction stage. During the building's operating stage, BIM software is utilized for maintenance and scheduling, as well as building system analysis Kjartansdottir et al. (2017). Kjartansdottir et al. (2017) discovered that existing conditions modeling, cost estimates, phase planning, site utilization planning, 3D coordination, construction system design, digital fabrication, record modelling and 3D control and planning are among the most common BIM applications. Similarly, Existing conditions modelling, cost estimation, site analysis, cost analysis, phase planning/scheduling, design authoring, constructability reviews, design/engineering analysis, programming/space validation program, 3D coordination, digital fabrication, construction system design, record modelling, and a host of other BIM applications for oil and gas projects were identified by Lee et al. (2018).

Table 1 Definition of BIM Uses at Different Stages of the BIM Process

BIM Uses	Definition	Authors
Cost Estimation	Establishing an accurate cost estimation and trace the cost effects on design changes. Quantity take-off is extracted.	Kjartansdottir et al., 2017; Lee et al., 2018; PSU, 2011
Existing conditions modelling	3D models are developed based on the existing site conditions or a specific area within a building or facility. The efficiency and accuracy of the existing site conditions is enhanced.	PSU, 2011; Kjartansdottir et al., 2017; Lee et al., 2018
Cost Analysis (5D modelling)	4D BIM model is linked with the cost data, forming the 5D BIM model that is used to carry out cost analysis.	Lee et al., 2018
Phase planning /Scheduling (4D modelling)	3D model is linked with a programme consisting of project timeframe and schedule for the phased occupancy planning to show the construction process sequences and the space requirements on site.	PSU, 2011; Kjartansdottir et al., 2017; Lee et al., 2018
Programming (Space validation program)	The area and the information of the program is obtained from BIM to access and review the space design which allows the tracking of gross area, rentable area and usable area.	PSU, 2011; Lee et al., 2018
Site Analysis	The use of BIM tools or GIS tools to carry out site location evaluation to decide a location that is appropriate for the future project use and to carry out analysis on the volumes, orientation and position of the facility.	Lee et al., 2018

Design Review	3D model is being reviewed by the project stakeholders to obtain different feedback on validation of design aspects to ensure the design constructability. Besides, it involves the selection of design from various options prepared by BIM, design communication though the process of visualization and virtual digital mock-ups.	PSU, 2011; Lee et al., 2018
Design Authoring	The use of design authoring BIM software to develop BIM model consisting of building properties, quantities, costs, schedule, mean and methods.	Lee et al., 2018
Design /engineering analysis	BIM models are simulated to carry out analysis on the energy, structural, mechanical, electrical, lighting, sustainability and code validation aspects.	PSU, 2011; Lee et al., 2018
3D coordination (Clash detection)	Clash detection is undertaken to examine the physical interferences between the building components within the building system.	PSU, 2011; Kjartansdottir et al., 2017; Lee et al., 2018
Site utilization planning	A process whereby the detailed information of the logistics objects are inserted into the BIM model and link with the 4D scheduling of the project for both temporary and permanent on-site facilities	PSU, 2011; Kjartansdottir et al., 2017; Lee et al., 2018
Digital fabrication	The geometry of the building element is obtained from the BIM model to generate the shop drawings which is then sent to the computerised numerical control equipment for building element prefabrication and assembled on site efficiently.	Kjartansdottir et al., 2017; Lee et al., 2018
Construction System Design	Complex construction system can be modelled for improvement in construction productivity, planning process and safety.	Kjartansdottir et al., 2017; Lee et al., 2018
3D control and planning	Detailed layout points that are taken from BIM will be loaded into the total stations for the assembly of facilities layout to automatically control the movement of construction equipment and location.	PSU, 2011; Kjartansdottir et al., 2017; Lee et al., 2018
Record modelling	Depicting accurate physical representation of the facility's conditions, environment, and assets. Linking of data of operation, maintenance and asset to an As-built model in order to deliver the record model to the employer.	PSU, 2011; Kjartansdottir et al., 2017; Lee et al., 2018
Maintenance and scheduling	Planning and managing the maintenance of the project, building equipment and fabric throughout the facility operational life.	PSU, 2011; Lee et al., 2018
Building System Analysis	Comparing the performance of the building with the specified design.	PSU, 2011

3. Methodology

3.1 Scientometric-Based Review

A scientometric analysis method was used to assess the current domain of BIM education. This allows for a statistical analysis and graphical display of the synthesised network based on scientific articles to depict the conceptual, analytical, and social context of the scientific field (Zheng et al., 2020). The analysis includes selecting tools, gathering, transforming, analyzing, visualizing, reading, displaying, and discussing data. Using keyword co-occurrence analysis, document co-citation analysis and cluster identification analysis with the first step being the creation of networks (Xiao et al., 2019), and utilising quality indexes and extensive bibliographic data, this method offers a quantitative approach that visualizes, plots, and connects research progress in order to analyze the evolution of a study field (Mansuri et al., 2019). With so many scientific papers, it is imperative to know which databases are the most dependable for generating materials. Therefore, this paper made use of the Scopus Analyzer and VOSviewer software. While the Scopus was used to search the literature databases because it is a more broad-based site of more existing journals (Darko et al. 2020, Shukra et al. 2020, Saka and Chan 2019) the VOSviewer was used to create and analyse bibliometric maps (Babalola et al. 2021, Adegoriola et al. 2021, Darko et al. 2020). Unlike other bibliometric mapping applications, VOSviewer pays special attention to the graphic representation of bibliometric maps. The data mining features of VOSviewer are particularly beneficial for swiftly presenting large bibliometric maps (Zakka et al., 2021). Clusters and relationships between keywords, researchers, journals, and institutions were investigated using science mapping. Researchers' data and keywords provide a timeline of the most recent academic developments in the field of BIM education around the world. The research procedure of the study is illustrated in Figure 1. A case study was added to provide a more concrete image of how far BIM education has spread in Malaysia.

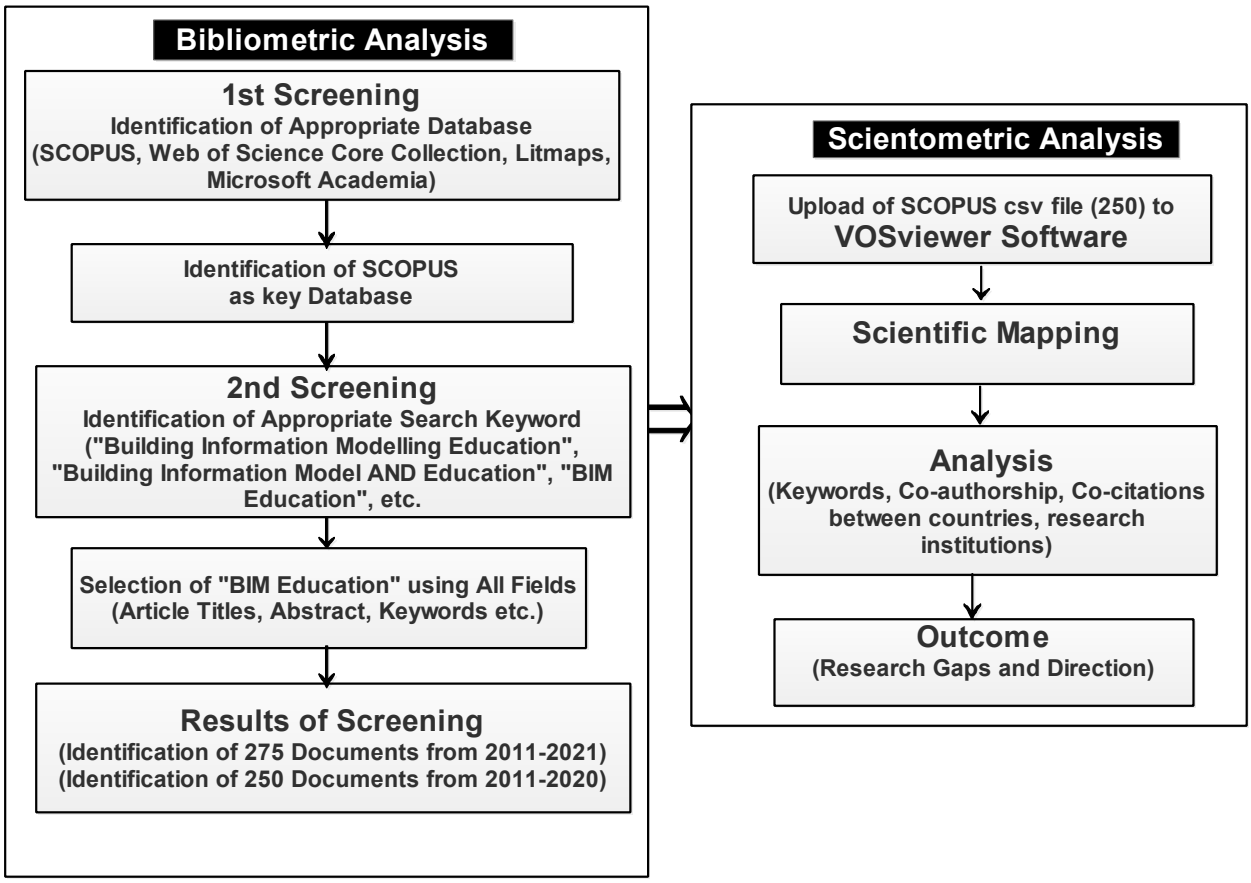


Figure 1 Research procedure of the study

3.2 Quantitative Research Design

Since the research involves the exploration of BIM education in Malaysia, descriptive research was used to specifically respond to the research question and examine the results. Descriptive analysis usually employs questionnaires to explain the difference in various phenomena, whereas the 'observed phenomena' in this study is BIM education in Malaysian higher learning institutions.

343 questionnaires were distributed to a targeted sample size of Year 2 and Year 3 built environment students from two public institutions (University of Malaya and University of Technology Malaysia) and two private institutions (University of Reading Malaysia and INTI International University) in Malaysia using the "simple stratified sampling" process. Students majoring in architecture, quantity surveying, building surveying, construction management, urban and regional planning, and landscape architecture made up the majority of the built environment students. Opinion-based questions on a 5-Likert scale were examined using cross-tabulation in SPSS software, which documented the frequencies of respondents with unique characteristics and analyzed the relationship between different disciplines (Tanko, 2018). The relative importance index (RII) was used to rank the variables and classify the most significant factors.

4. Results and Discussions

4.1 Scientometric Analysis

A total of 250 papers were found in the Scopus database during the literature review. Over a decade of research into BIM education, the initiative has stepped up a notch, according to the literature samples from 2011 to 2020. However, in contrast to other nations, Malaysian BIM education studies are still in their infancy, and many policy decisions have been taken in anticipation of its full adoption. The total sample of literature, source of publication, research keywords, most cited publications, partnering countries, and institutions that are actively engaged in BIM education studies were all examined using the Scientometric method. The types of documents contained in the Scopus database; journal articles and conference papers account for 50.8% and 38.4 %, respectively on global BIM education studies. Since journal articles and conference papers account for nearly 90% of the results, the review focuses on them as the primary source of information. The number of documents provided by authors in relation to BIM education is analysed. The most documents belong to Wu, W (15 documents), Jin, R. (9 documents), and Issa, R.R.A., Li, H. and Zhang, J. having 7 documents respectively (Figure 2).

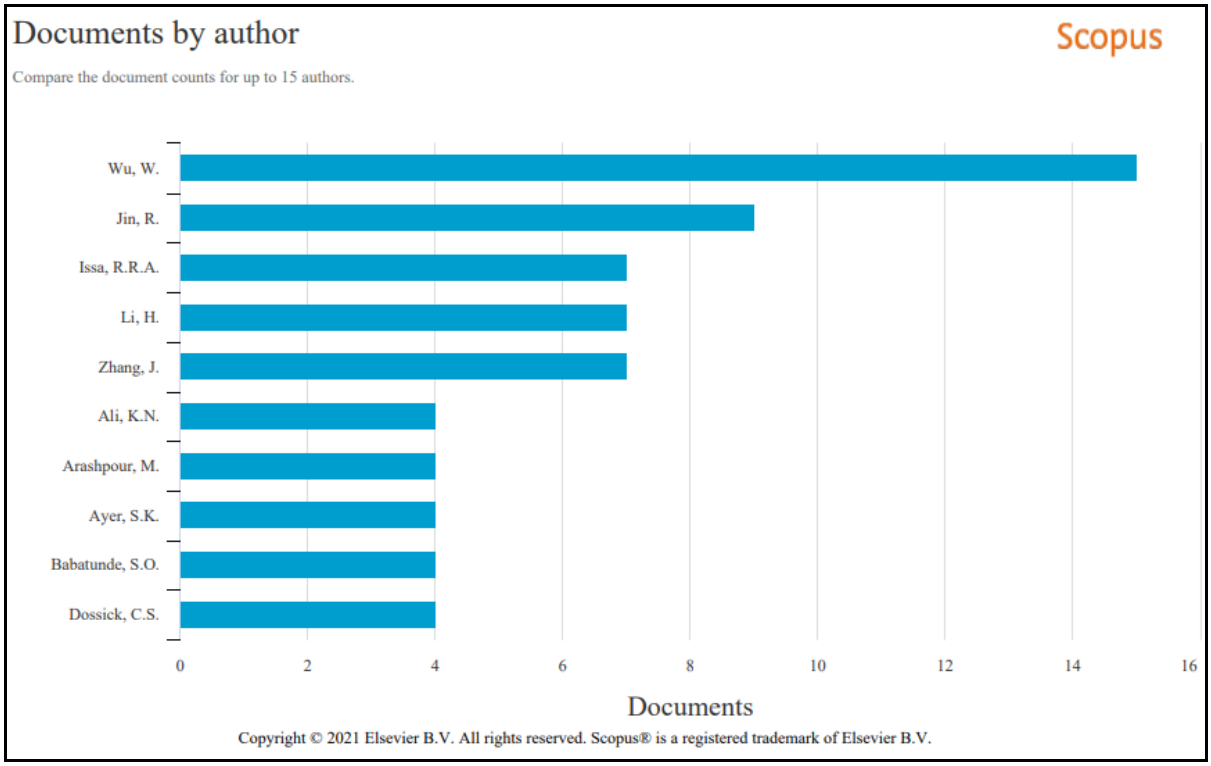


Figure 2 Number of Document by Top Authors

4.1.1 Literature sample and keywords

Figure 3 depicts a compilation of BIM education literature from 2011 to 2020. According to the trend, research into BIM education prior to 2011 was largely unknown. However, since 2011, the number of publications in the field of BIM education has increased. The evolution of BIM education research may be separated into two phases based on the annual publication volume: initiation and development. The annual publication volume during the initial period (2011–2012) was only four articles, which is quite low. During the development phase (2011–2020), the annual publication amount of QS research increased, ranging from 10-45 papers per year. Since 2011, scholarly interest in BIM education has grown, and the annual publication volume has increased in a quasilinear fashion.

BIM education has centred on different aspects of learning from 2011-2020. Ghosh (2012) advocated the setting up of a virtual lab for BIM education. In 2013, Miller et al. developed a BIM framework for the tertiary educational sector in New Zealand and Rosli et al. (2016) explored the preference of BIM software among University of Malaya's architectural students. Boton et al. (2018) developed a framework BIM implementation in engineering education, while Barison et al. (2019) documented an overview of BIM teaching strategies. In 2020, Olowa et al. conceptualized BIM for construction education. As the world moves towards digitalization and smart construction, it is predicted that BIM adoption in higher learning institutions will reach a highpoint in the coming years because of the increasing global interest in BIM education.

Keywords play an important role in scientometric science. Keywords provide an overview of the current research domain in a subject area and serve as a foundation for locating studies in that field. The VOSviewer program is used to visualize keywords in Figure 4. The visualization portrays a timeline of when these keywords were most widely used in BIM education studies. The circles show the degree of keyword co-occurrence, with the larger cycles reflecting the most prevalent topics of research. The closeness of the link between the various keywords is also indicated by the thickness of the lines linking them. The closer two points are to each other, the closer they are connected (Van Eck and Waltman, 2010). The analysis revealed several keywords, along with their frequency and link strength. Based on the keyword analysis, the research gaps are in the areas of BIM Education (Figure 5) with only 5 occurrences and 13 total link strength, followed by architectural education (5 occurrences, 17 total link strength), e-learning (5 occurrences, 34 total link strength), curriculum (7 occurrences, 35 total link strength), and information management (9 occurrences, 66 total link strength).

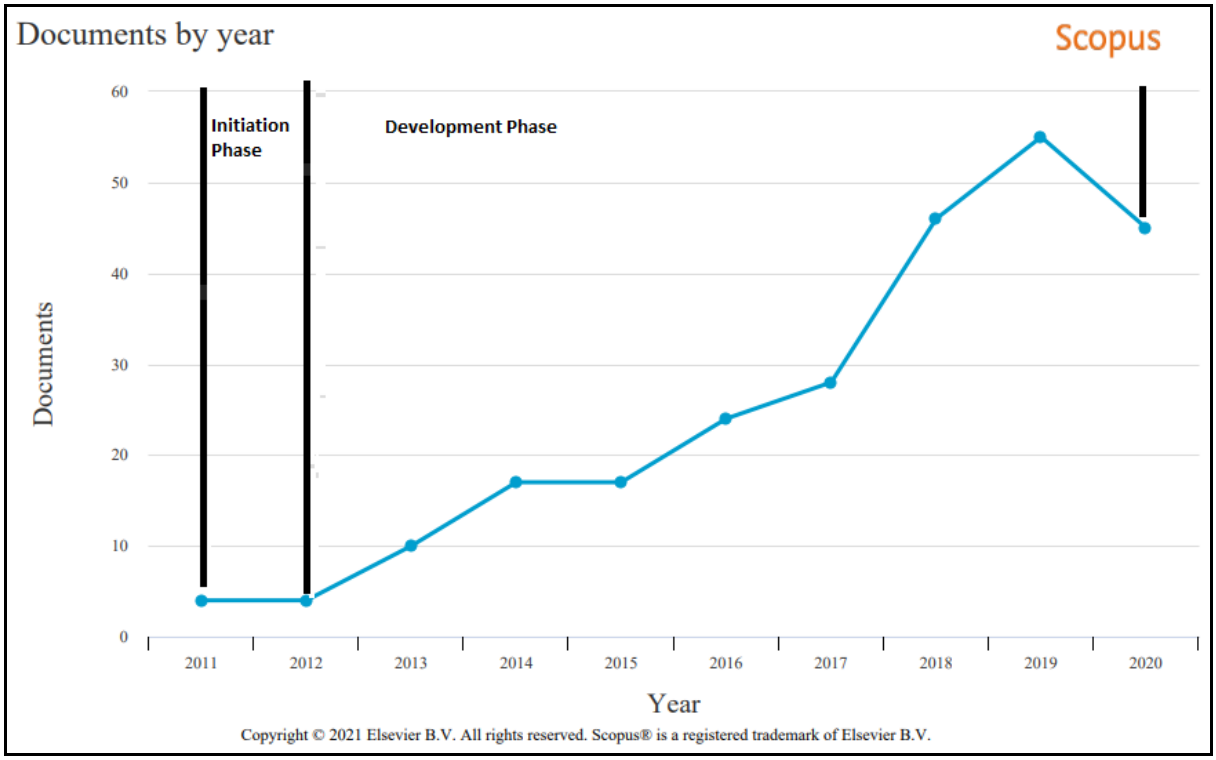


Figure 3 Literature sample and year of Publication

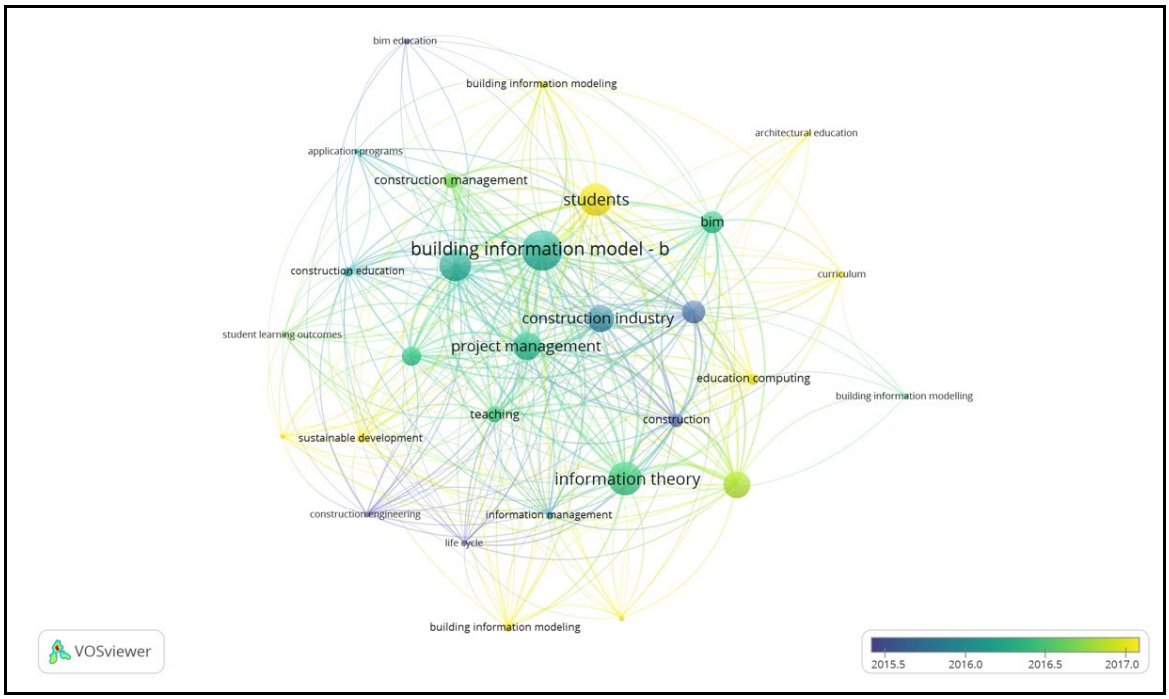


Figure 4 Visualization of Keywords

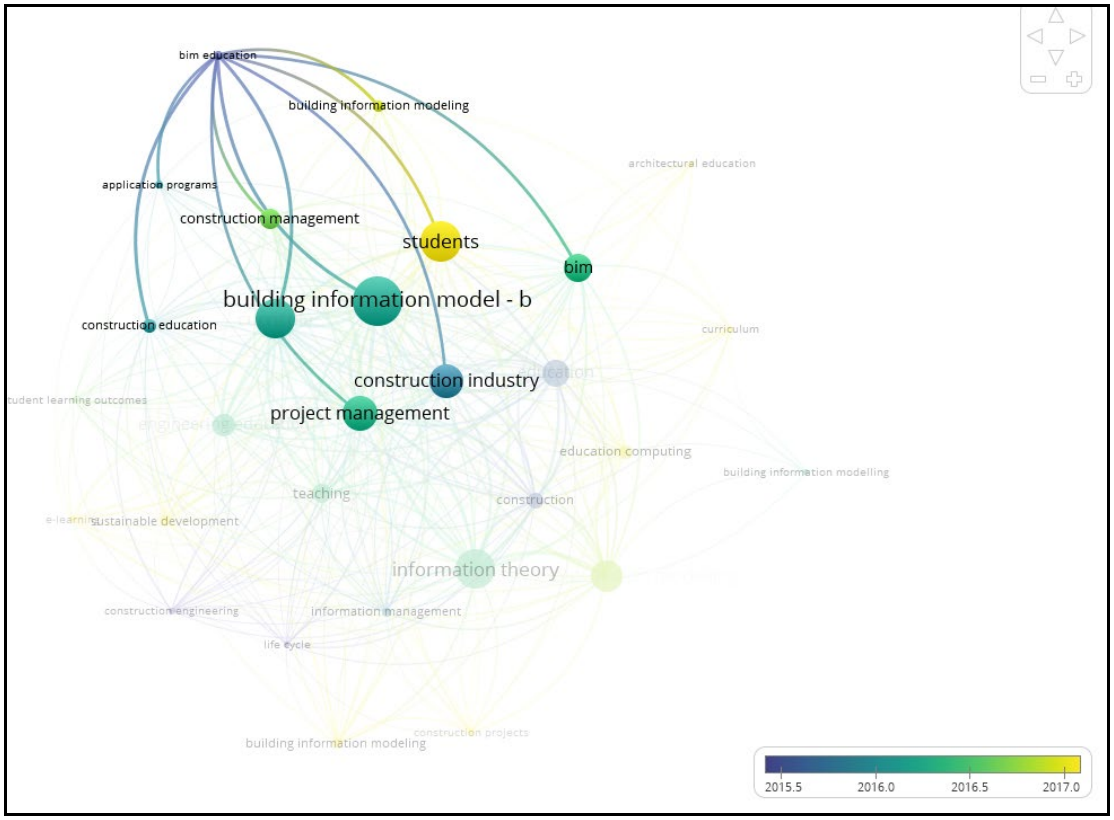


Figure 5 Visualization of BIM Education

4.1.2 Sources of Documents and Impact of Countries

The top 10 institutions involved in the study of BIM education are analyze. The California State University, Fresno has the most studies on BIM education (14), followed by Arizona State University (9) and University of Florida (8). The University of Salford, Deakin University, Universiti Teknologi Malaysia, and Chang'an University have 7 documents respectively. Although there is widespread interest in BIM education, adoption remains poor, as evidenced by the number of documents produced.

The bibliometric analysis and visualization of co-citation between studies in different countries are shown in Figure 6 and Figure 7 respectively. The analysis reveals that the country with the most total link strength, documents, and co-citations is the United States, which has 12 total link strength, 50 documents with a total of 571 citations. Australia in second place, with 10 link strength, 29 documents and 703 citations, and United Kingdom in third place, with 7 link strength, 13 documents and 256 citations. China is fourth with 6 link strength, 8 documents and 37 citations, while Malaysia is fifth with 4 total link strength, 15 documents and 48 citations. The volume of documents indicates that that there is still a global outlook that is deficient in BIM education studies around the world.

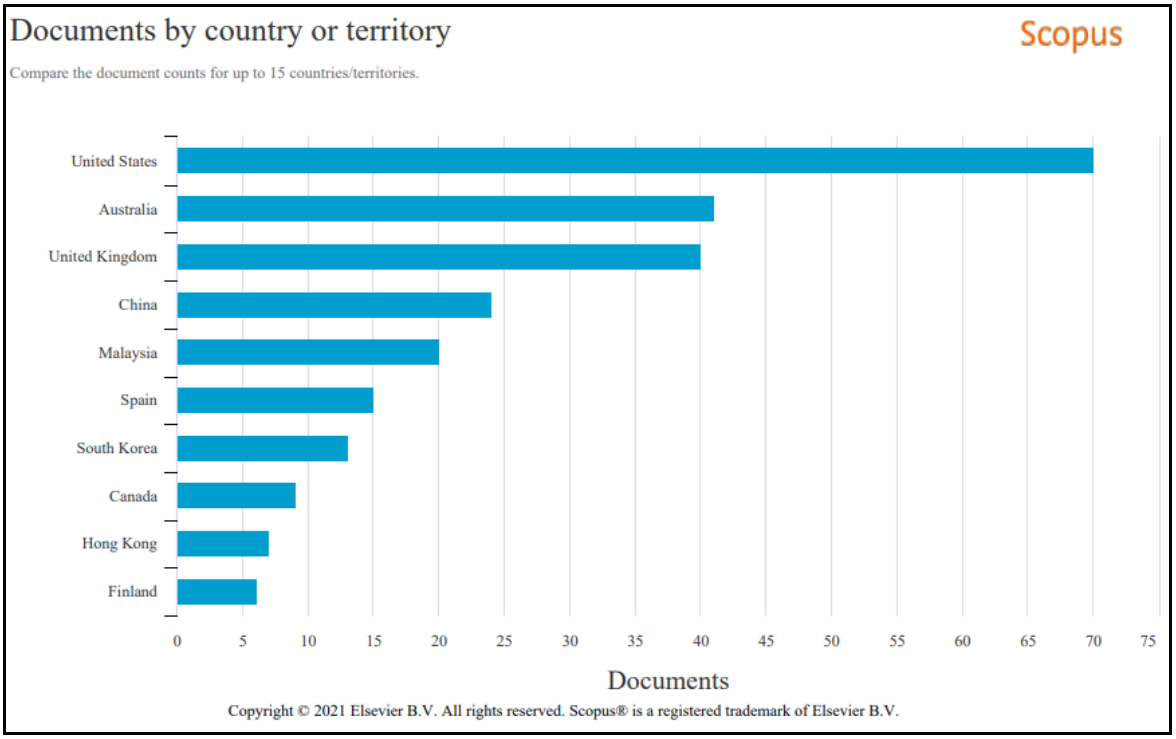


Figure 6 Number of Document by Top Countries

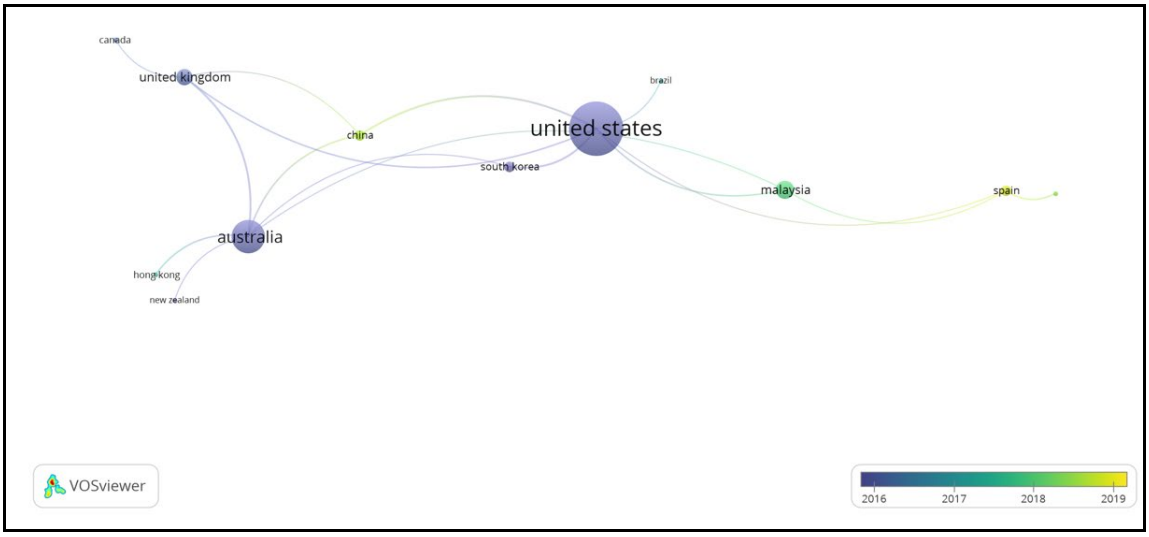


Figure 7 Visualization of Documents by Top Countries

4.2 Quantitative Analysis

This case study focuses on Built Environment students at two private universities in Malaysia (University of Reading Malaysia - UoRM and INTI International University) as well as two public universities (University of Technology Malaysia - UTM and University of Malaya - UM) who use BIM in their learning. From a total sample size of 343, 106 people responded to the survey questionnaire. The overall number of respondents from private institutions is 59 (56 percent), while the number of respondents from public institutions is 47 (46 percent). The UoRM has 32 (30%) students, UTM has 29 (27%) students, INTI International University has 27 (26%) students, and UM has 18 (17%) students. In addition, 78 (73%) students are from quantity surveying discipline, 18 (17%) from architecture, 6 (6%) from landscape architecture and construction management, and 4 (4%) from urban and regional planning and building surveying. The targeted respondents were mainly year 2 (45%) and year 3 (51%) students. Year 1 entry students were not considered in this study while Year 4 students were undertaking internships. However,

the study had 4 (4%) students from Year 4. The findings of the case study are highlighted in Sections 4.2.1 and 4.2.2.

4.2.1 BIM Education Practices and Skillsets among Built Environment Students

BIM applications used by built environment students at public and private universities are depicted in Figure 8. Most of the students utilise more than one BIM software in their learning. Except for AutoCAD and Sketchup, the BIM tools in Figure 8 are used to create building information models. Revit software (51 students), Cost X (49 students), and Glodon Cubicost (45 students) were found to be the most widely used BIM tools in the study. Since quantity surveying students make up 73 percent of the respondents, Cost X and Glodon Cubicost tend to be mostly used. Navisworks comes in fourth place with 10 students, followed by Solibri Model Checker (8 students), Recap Pro for laser scanning (7 students), GIS (Geographic Information System) (5 students), and Rhino 3D (1 student).

The skillsets of built environment students are shown in Figure 9. It can be deduced from the figure that design authoring (62 students), existing condition modelling (61 respondents), and cost estimation (46 respondents) are ranked 1st, 2nd and 3rd skillsets among higher education students. Design review had 35 students, while 3D coordination, phase planning (4D scheduling), site analysis, and programming (site validation program) had 13, 9, 6 and 5 students, respectively. Lee et al. (2018) and Kjartansdottir et al. (2017) support these findings. However, no student had skills in building system analysis, maintenance, and scheduling, record modeling, construction system design, design fabrication, site utilization, logistic planning, 3D control and planning (Digital layout) and cost analysis (5D), as shown in the figure.

4.2.2 BIM Level among Built Environment Students

Figure 10 depicts the BIM education levels available in both public and private universities. It is crucial to briefly describe the various levels of BIM education in this paper. Level 0 refers to 2D design software such as manual sketching and AutoCAD. Stage 1 refers to 3D modelling using 3D parametric modelling or software (Kjartansdottir et al., 2015). Stage 2 refers to 3D modelling and information sharing among disciplines using a cloud-based platform (Hasni et al., 2019) while Stage 3 refers to the development of a single integrated model where designs and information can be updated in a cloud-based system. Based on the results, no public or private university student is in BIM stage 0. Private higher learning institutions have a higher mean score of 0.97 for BIM stage 1 than their public counterparts (0.85). Public institutions, on the other hand, outperformed private universities in BIM Stage 2 (0.15). Unfortunately, no higher education institutions have reached BIM Stage 3. At BIM Stage 1, both public and private higher education students mainly build 3D models using parametric 3D software, according to the overall findings.

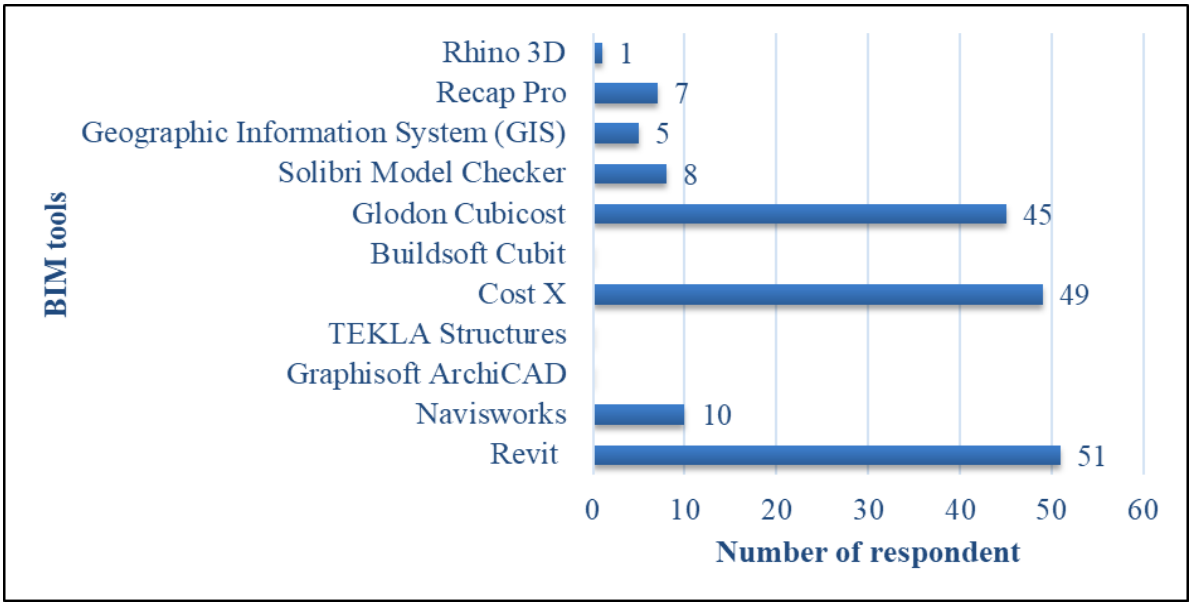


Figure 8 BIM Applications Used by Built Environment Students

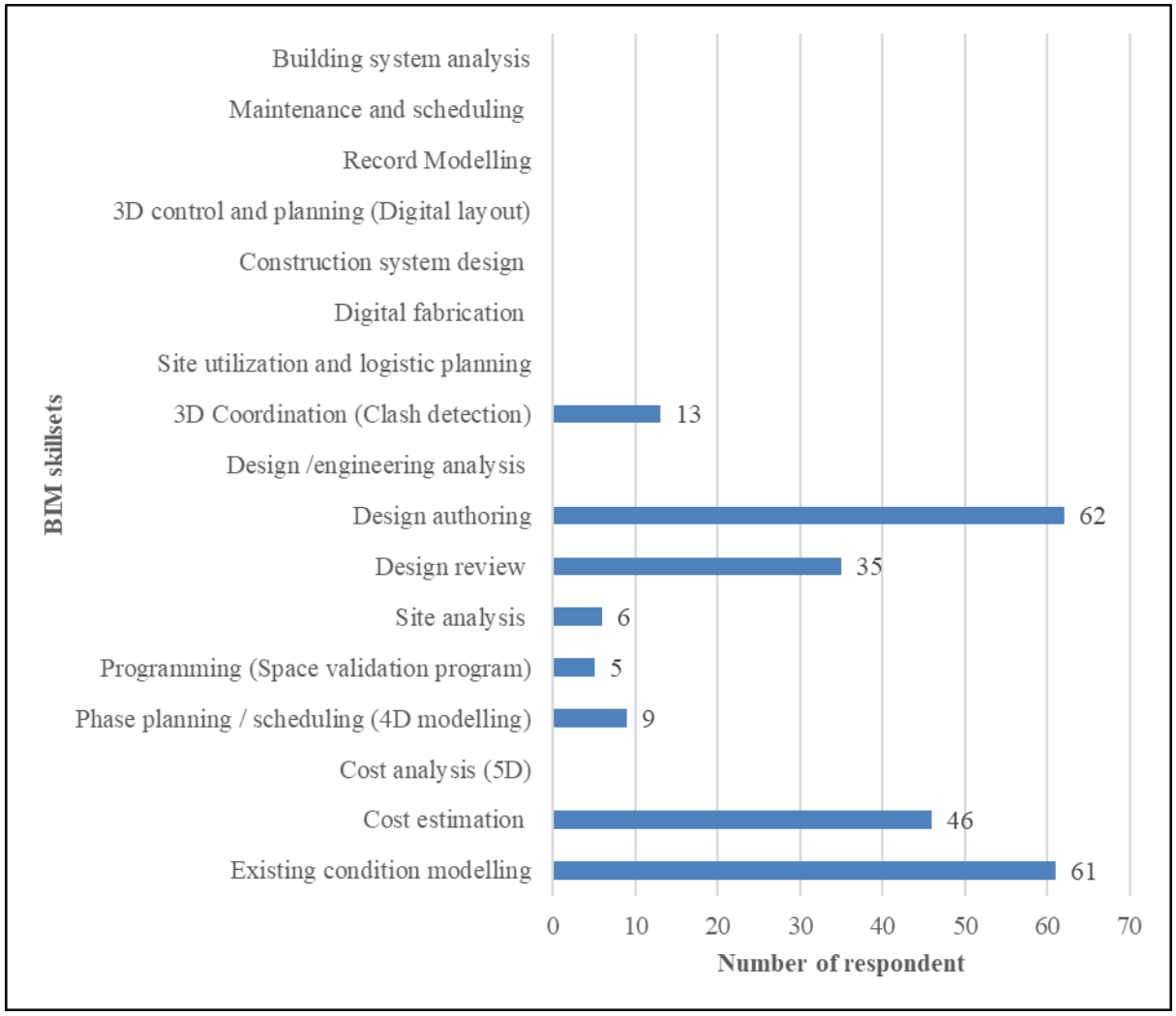


Figure 9 BIM Education Practices among Built Environment Students

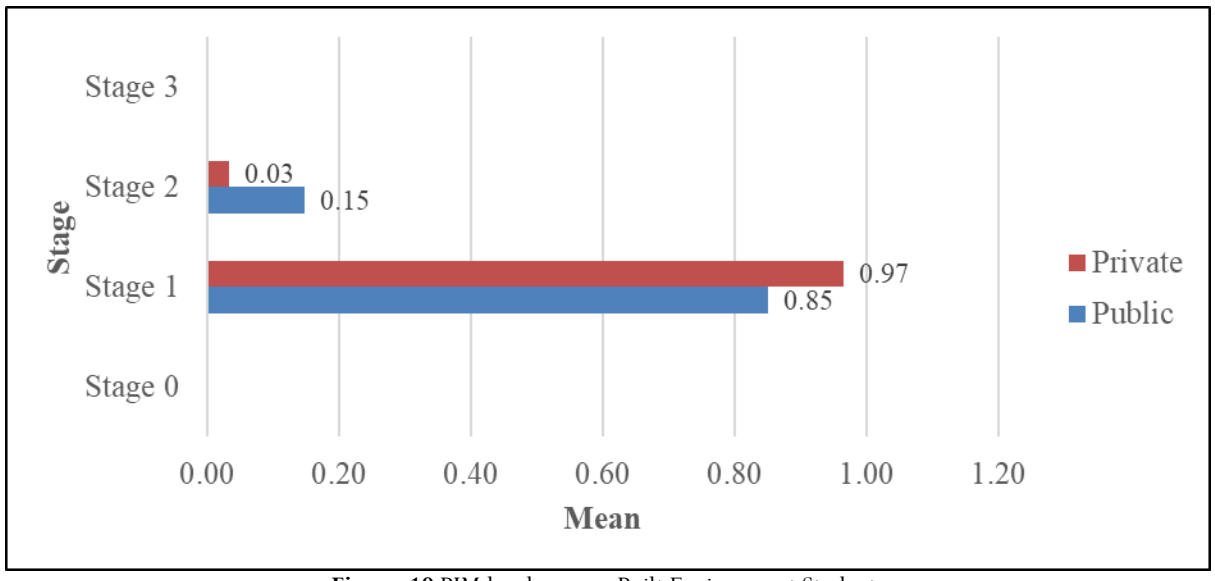


Figure 10 BIM levels among Built Environment Students

5. Conclusion and Recommendations

The status of global BIM education practices was determined using science mapping and scientometric analysis in this study. The study identified the research trend from 2011 to 2020, as well as the publications in various countries, and revealed two stages of BIM education research: initiation and development phases. The scientometric analysis found five (5) research gaps in BIM education, architectural education, e-learning, curriculum and information management. On a national basis, the United States, Australia, United Kingdom, China, and Malaysia are the most influential countries in BIM education research. Therefore, the practical implication is concerned with the possibility of establishing existing research directions to provide avenues for developing new research questions and, thus making, theoretical contributions. This could be used by policymakers and construction stakeholders as a starting point for identifying major issues in BIM education for further research in policymaking dialogue. The study goes on to investigate BIM education further by identifying BIM practices, skillsets, and BIM level. The most used BIM applications among built environment students are Revit, Cost X, and the Glodon Cubicost software, with design authoring, modeling, and cost estimation as major skillsets. The study also revealed that at BIM level 1, both public and private university students are primarily engaged in designing 3D models. The study advises institutions and education stakeholders to provide continuous BIM training, acquire BIM software, and integrate BIM implementation framework into the higher learning institutions' curricula.

Acknowledgements

References

Adegoriola, M.I., Lai, J.H.K., Chan, E.H. and Amos, D. 2021. Heritage Building Maintenance Management (HBMM): A Bibliometric-Qualitative Analysis of Literature. *Journal of Building Engineering*. 42, doi.org/10.1016/j.jobe.2021.102416

Agirbas, A. (2020). Teaching Construction Sciences with the Integration of BIM to Undergraduate Architecture Students. *Frontiers of Architectural Research*. 9(4): 940-950. doi: 10.1016/j.foar.2020.03.007

Ahmed, S., and Hoque, M. (2018). Barriers to Implement Building Information Modelling (BIM) to Construction Industry: A Review. *Journal of System and Management Sciences*. 8(1): 45-60.

Alaloul, W.S., Liew, M.S., Zawawi, N.A.W.A., and Kennedy, I.B. (2020). Industrial Revolution 4.0 in the Construction Industry: Challenges and Opportunities for Stakeholders. *Ain Shams Engineering Journal*. 11(1): 225-230. doi: 10.1016/j.asej.2019.08.010

Ana Karina, S. R. (2020). Implementation of Building Information Modelling in the Dominican Republic Construction Industry. Ph.D Thesis, University of Wolverhampton.

Arroteia, V.A., Amarul, G.G.D., Kikuti, S.Z., and Melhado, S.B. (2019). BIM Knowledge Assessment: An Overview among Professionals, in Architecture in the Age of the 4th Industrial Revolution, Porto, Portugal, 2: 315-324.

Aziz, N.M., Yap, P.X., and Zainon, N. (2019). Assessing BIM Education Level in Quantity Surveying Programme: A Survey in Malaysian Higher Institution. *International Journal of Innovation, Creativity and Change*. 9(7): 37-50.

Babalola, A., Musa, S., Akinlolu, M.T., Haupt, T.C. 2021. A Bibliometric Review of Advances in Building Information Modelling (BIM) Research. *Journal of Engineering, Design and Technology*. DOI: 10.1108/JEDT-01-2021-0013

Barison, M.B. and Santos E.T. (2019). BIM Teaching Strategies: An Overview of the Current Approaches. *EG-ICE 2010 - 17th International Workshop on Intelligent Computing in Engineering*, 2019.

Belayutham, S., Zabidin, N.S., and Ibrahim, C.K.I.C. (2018). Dynamic Representation of Barriers for Adopting Building Information Modelling in Malaysian Tertiary Education. *Construction Economics and Building*. 18(4): 24-44. doi: 10.5130/AJCEB.v18i4.6228

Boton, C., Forgues, D. and Halin, G. (2018). A framework for Building Information Modeling Implementation in Engineering Education. *Canadian Journal of Civil Engineering*. 866-877, 10.1139/cjce-2018-0047

Chan, S.T.W. (2014). Barriers of Implementing BIM in Construction Industry from the Designers' Perspective: A Hong Kong Experience. *Journal of System and Management Sciences*. 4 (2): 24-40.

Chen, C., Dubin, R., & Schultz, T. (2014). Science Mapping. Encyclopedia of Information Science and Technology, Third Edition, August, 4171–4184. https://doi.org/10.4018/978-1-4666-5888-2.ch410

Chiu, W.Y.B., Lai, J.H.K. (2020). Building information modelling for Building Services Engineering: Benefits, Barriers and Conducive Measures. *Engineering, Construction and Architectural Management*. 27(9): 2221-2252. doi: 10.1108/ECAM-10-2018-0460

Darko, A., Chan, A.P.C., Adabre, M.A., Edwards, D.J., Hosseini, M.R. and Ameyaw, E.E. 2020. Artificial Intelligence in the AEC Industry: Scientometric Analysis and Visualization of Research Activities. *Automation in Construction*. 112. doi.org/10.1016/j.autcon.2020.103081

Doan, D.T., GhaffarianHoseini, A., Naismith, N., Ghaffarianhoseini, A., Zhang, T. and Tookey, J. (2020). Examining Critical Perspectives on Building Information Modelling (BIM) Adoption in New Zealand. *Smart and Sustainable Built Environment*, 10(4): 594-615. doi: 10.1108/SASBE-04-2020-0043

Enhassi, A., AbuHamra, L.A., and Alkilani, S. (2018). Studying the Benefits of Building Information Modeling (BIM) in Architecture, Engineering and Construction (AEC) Industry in the Gaza Strip, Jordan. *Journal of Civil Engineering*. 12(1): 87-98.

Farooq, U., Rehman, S.K.U., Javed, M.F., Jameel, M., Aslam, F., and Alyousef, R. (2020). Investigating BIM Implementation Barriers and Issues in Pakistan Using ISM Approach. *Applied Sciences*. 1-18, doi: 10.3390/app10207250

Galetsi, P., & Katsaliaki, K. (2019). Review Article Big Data Analytics in Health: An Overview and Bibliometric Study of Research Activity. *Health Information & Libraries Journal*. 37: 5–25. https://doi.org/10.1111/hir.12286

Georgiadou, M.C. (2019). An Overview of Benefits and Challenges of Building Information Modelling (BIM) Adoption in UK Residential Projects. *Construction Innovation* 19(3): 298-320. doi: 10.1108/CI-04-2017-0030.

Ghosh A. (2012). Virtual Construction + Collaboration Lab: Setting a new paradigm for BIM Education. *ASEE Annual Conference and Exposition, Conference Proceedings*, 2012.

Haron, N.A.,Raja Soh, R.P.Z.A., and Harun, A. (2017). Implementation of Building Information Modelling (BIM) in Malaysia: A Review. *Science and Technology*. 23(3): 661-674.

Hasni, M.I.A.K., Ismail, Z. and Hashim, N. (2019). Contractual Aspects in the Utilisation of Level Two Building Information Modelling (BIM) within Malaysian Public Construction Projects in *MATEC Web of Conferences*, 266, 05002, pp.1-7. doi: 10.1051/matecconf/201926605002

Hedayati, A., Mohandes, S.R. and Preece, C. (2015). Studying the Obstacles to Implementing BIM in Educational System and Making Some Recommendations. *Journal of Basic and Applied Scientific Research*. 5(3): 29-35.

Hong, Y., Hammad, A.W.A., Sepasgozar, S. and Akbarnezhad, A. (2019). BIM adoption Model for small and Medium Construction Organisations in Australia. *Engineering, Construction and Architectural Management*. 26(2): 154-183. doi: 10.1108/ECAM-04-2017-0064

Jin, R., Yang, T., Piroozfar, P., Kang, B., Hancock, C.M., and Tang, L. (2017). Project-based Pedagogy in Interdisciplinary Building Design adopting BIM. *Engineering, Construction and Architectural Management*. 25 (10): 1376-1397. doi: 10.1108/ECAM-07-2017-0119

Khiyon, N.A. (2016). Incorporating of Building Information Modelling into Quantity Surveying Programmes Syllabus in Malaysia, Pacific Association of Quantity Surveyors (PAQS) Congress Papers Library, pp.1-8.

Kjartansdottir, I.B., Mordeu, S., Nowak, P., Philp, D., and Snaebjornsson, J.T. (2017). *Building Information Modelling BIM*. Great Britain: POLCEN Sp. z o.o.

Kolaric, T., Mandicak, T., Vukomanovic, M., and Mesaros, P. (2019). The Influence of BIM Education Improvement on Raising BIM Awareness in Croatia and Slovakia. *Periodica Polytechnica Architecture*, 50(1): 21-29. doi: 10.3311/PPar.13868

Kong, S.W.R., Lau, L.T., and Phan, D.T. (2020). A study on effectiveness of Building Information Modelling (BIM) on the Malaysian construction industry, in *IOP Conference Series: Materials Science and Engineering*, 713, The 2nd Global Congress on Construction, Material and Structural Engineering 26–27 August 2019, Melaka, Malaysia, pp.1-9.

Latiffi, A.A., Mohd, S., and Brahim, J. (2015). Application of Building Information Modeling (BIM) in the Malaysian Construction Industry: A Story of the First Government Project. *Applied Mechanics and Materials*. 773-774: 943-948.

Lee, CY., Chong, HY. & Wang, X. (2018). Streamlining Digital Modeling and Building Information Modelling (BIM) Uses for the Oil and Gas Projects. *Archives of Computational Methods Engineering*. 25:349–396. doi: 10.1007/s11831-016-9201-4

Lim, Y.W., Chong, H, Y., Ling, P.C.H. and Tan, C.S. (2021). Greening Existing Buildings through Building Information Modelling: A review of the recent development, 200, https://doi.org/10.1016/j.buildenv.2021.107924

Liu, S., Xie, B., Tivendale, L., and Liu, C. (2015). Critical Barriers to BIM Implementation in the AEC Industry. *International Journal of Marketing Studies*. 7(6): 162-171. doi: 10.5539/ijms.v7n6p162

Mamter, S., and Aziz, A.R. (2016). Holistic BIM Adoption and Diffusion in Malaysia, in *MATEC Web of Conference 66*, 00094, pp.1-8. doi: 10.1051/matecconf/20166600094

Mansuri, L., Udeaja, C., Trillo, C., Kwasi, G., Dilip Patel, Kumar Jha, C. B. M. and, & Gupta, S. (2019). Scientometric Analysis and Mapping of Digital Technologies Used in Cultural Heritage Field. In: Gorse, C and Neilson, C J (Eds) *Proceedings of the 35th Annual ARCOM Conference*, 2-4 September 2019, Leeds, UK, Association of Researchers in Construction Management, 255-264, September.

Miller, G., Sharma, S., Donald, C. and Amor, R. (2013). Developing a Building Information Modelling Educational Framework for the Tertiary Sector in New Zealand. *IFIP Advances in Information and Communication Technology*. 606-618, 10.1007/978-3-642-41501-2_60

Olowa, T., Witt, E. and Lill, I. (2020). Conceptualising Building Information Modelling for Construction Education. *Journal of Civil Engineering and Management*. 551-563, 10.3846/jcem.2020.12918

Othman, I., Al-Ashmori, Y.Y., Rahmawati, Y., Amran, Y.H.M., Al-Bared, M.A.M. (2020). The level of Building Information Modelling (BIM) Implementation in Malaysia. *Ain Shams Engineering Journal*. 12(10): 455-463. doi: 10.1016/j.asej.2020.04.007

PSU (2011). *BIM Project Execution Planning Guide Version 2.1*. Pennsylvania: Penn State University.

Reddy, H.G., and Kone, V. (2019). Study on Implementing Smart Construction with Various Applications Using Internet of Things Techniques. *International Journal of Recent Technology and Engineering (IJRTE)*. 7(6C2): 188 -192.

Rosli, M.F., Razak, A.S. and Amer Younus M. (2016). To BIM or not to BIM: A pilot study on University of Malaya's Architectural Students' Software Preference. *Journal of Design and Built Environment*. 13-26, 10.22452/jdbe.vol16no1.2

Rostam, D. (2019). Education Needs to Support Architecture, Engineering, and Construction Collaboration Using Building Information Modeling. Ministry of Higher education and Scientific Research (MHE), pp.54-62. doi: 10.14500/aro.10604

Smith, P. (2014). BIM Implementation – Global Strategies. *Procedia Engineering*. 85: 482-492.

Sun, C., Jiang, S., J.Skibniewski, M., Man, Q., and Shen, L. (2017). A Literature Review of the Factors Limiting the Application of BIM in the Construction Industry. *Technological and Economic Development of Economy*. 23(5): 764-779. doi: 10.3846/20294913.2015.1087071

Saka, A.B and Chan, D.W.M. 2019. A Scientometric Review and Metasynthesis of Building Information Modelling (BIM) Research in Africa. *Buildings*: 9(85): doi:10.3390/buildings9040085

Shukra, Z.A. and Zhou, Y. 2020. Holistic Green BIM: A Scientometrics and Mixed Review. *Engineering, Construction and Architectural Management*, DOI: 10.1108/ECAM-05-2020-0377

Tanko, B.L. (2018). Roadmap for Implementing Value Management in the Nigerian Construction Industry. PhD Thesis, Universiti Teknologi Malaysia.

Viergutz, T. and Schulze-Ehlers, B. (2018). The use of Hybrid Scientometric Clustering for Systematic Literature Reviews in Business and Economics. DARE Discussion Papers 1804, Georg-August University of Göttingen, Department of Agricultural Economics and Rural Development (DARE).

Witt, E. and Kähkönen, K. (2019). BIM-Enabled Education: a Systematic Literature Review, Lill, I. and Witt, E. (Ed.), in *10th Nordic Conference on Construction Economics and Organization* (Emerald Reach Proceedings Series, Vol. 2), pp. 261-269. doi:10.1108/S2516-285320190000002042

Wong, S.Y., and Gray, J. (2019). Barriers to implementing Building Information Modelling (BIM) in the Malaysian Construction Industry, in IOP Conf. Series: *Materials Science and Engineering*. 495, 012002, pp.1-9. doi: 10.1088/1757-899X/495/1/012002

Wu, W., and Issa, R.R.A. (2014). Key Issues in Workforce Planning and Adaptation Strategies for BIM Implementation in Construction Industry, in 2014 *ASCE Construction Research Congress*, Atlanta, GA, pp 1-10. doi: 10.1061/9780784413517.087

Xiao, X., Skitmore, M., Li, H., & Xia, B. (2019). Mapping Knowledge in the Economic Areas of Green Building using Scientometric Analysis. *Energies*, 14(15). doi.org/10.3390/en12153011

Yadav, S. and Kanade, G. (2018). Application of Revit as Building Information Modeling (BIM) for Integrated Project Delivery (IPD) to Building Construction Project- A Review. *International Research Journal of Engineering and Technology*. 5(10): 11-14.

Zakka, W. P., Abdul Shukor Lim, N. H., & Chau Khun, M. (2021). A Scientometric Review of Geopolymer Concrete. *Journal of Cleaner Production*. 280, 124353. https://doi.org/10.1016/j.jclepro.2020.124353

Zhang, J., Schmidt, K. and Li, H. (2016). BIM and Sustainability Education: Incorporating Instructional Needs into Curriculum Planning in CEM Programs Accredited by ACCE. *Sustainability*. 8(525): 1-32 doi:10.3390/su8060525

Zhao, D., Mccoy, A.P. and Bulbul, T. (2015). Building Collaborative Construction Skills through BIM-integrated Learning Environment. *International Journal of Construction Education and Research*. 11(2): 97-120. doi: 10.1080/15578771.2014.986251

Zheng, C., Yuan, J., Zhu, L., Zhang, Y., & Shao, Q. (2020). From Digital to Sustainable: A Scientometric Review of Smart City Literature between 1990 and 2019. *Journal of Cleaner Production*. 258, 120689. https://doi.org/10.1016/j.jclepro.2020.12068

UTM UNIVERSITI TEKNOLOGI MALAYSIA

IJBES

International Journal of Built Environment and Sustainability
Published by Penerbit UTM Press, Universiti Teknologi Malaysia
IJBES 9(1)/2022, 39-53

Building Energy Codes: Reviewing the Status of Implementation Strategies in the Global South

Tariene Gaum
Department of Architecture and Industrial Design, Tshwane University of Technology, South Africa

Jacques Laubscher
Department of Architecture and Industrial Design, Tshwane University of Technology, South Africa

ABSTRACT

The public understanding of climate change, methods, mitigation, adaptation and the reason behind it have been investigated in developed countries. The current knowledge levels in the Global South remains limited, this while countries forming part of the Global South are more vulnerable to resultant effects of global warming. This requires the urgent attention by both citizens, who lack relevant information as well as decision makers lacking environmental literacy to establish long-term sustainable strategies. With just 9 years left, the probability of achieving the Sustainable Development Goals (SDGs), is unlikely and will require the complete redevelopment of the building sector. Focusing on the built environment, this paper uses contemporary definitions of the Global South to establish the contribution, significance and lack of energy efficiency mechanisms in the face of climate change. A combination of literature, desk research and data gathering from various sources are employed to establish the contribution of the Global South built environment to climate change. Using Carbon Dioxide (CO_2) emissions, 2050 urban population figures and distinctive climatic regions as basis, this study selected the largest role players to establish the status, extent and efficacy of building energy codes. The review point towards a built environment lacking the necessary building energy codes, with approximately 47% of selected Global South countries not implementing any form of building energy efficiency regulations or related policies. As part of the recommendations, Global South countries lacking the necessary regulations are encouraged to revise, update or adopt possible best practice standards from relevant countries that implement mandatory building energy codes. This study aims to address the gap in knowledge, establish a way forward and facilitate a larger implementation of building energy codes and strategies in the Global South.

Article History

Received : *24 August 2021*
Received in revised form : *12 October 2021*
Accepted : *17 December 2021*
Published Online : *31 December 2021*

Keywords:

Climate change, Global South, CO_2 emissions, building energy codes and built environment.

Corresponding Author Contact:

GaumT@tut.ac.za

DOI: 10.11113/ ijbes. v9.n1.871

1. Introduction

On a worldwide scale, communities are increasingly becoming more vulnerable to the effects of climate change. The European Union and 179 other countries spent two weeks in Paris setting out an agreement that could possibly keep global temperatures below 2°C. The twenty-first session of the Conference of the Parties (COP 21) was one of the largest gatherings of world leaders and stated that the reduction in temperatures would only be possible by significantly reducing greenhouse gas (GHG) emissions (United Nations Framework Convention on Climate Change [UNFCCC], 2016).

The Intergovernmental Panel on Climate Change (IPCC) claims, the main impacts of climate change in Global South countries will likely increase in urban areas within the next few decades (IPCC, 2014).The term Global South broadly refers to regions of Asia, Africa, Latin America and Oceania as a concept to describe third world countries, low income countries or developing countries (Dados & Connell, 2012). Evidence of the vulnerability of urban populations are demonstrated by the growing number of people that are seriously affected or killed due to extreme weather conditions caused by the effects of climate change (Hoeppe & Gurenko, 2007; Moser & Satterthwaite, 2008; Satterthwaite *et al.*, 2009). According to the 2018 Population Division Report from the United Nation (UN), more than 55% of the global population are living in urban areas (UN, 2018). Further studies from 2016 indicate that an estimated 793 million people are exposed to conditions below the UN defined breadline of US$1.90 a day (UN, 2018) and although communities worldwide are affected by extreme weather events, the urban poor often living in informal settlements, are most vulnerable.

The Sustainable Cities Report states, *"[t]here is a direct link between buildings and climate change due to the high rate of carbon emissions from the construction and ongoing use of buildings. Building resources take up to 40 per cent of energy use and 17 per cent of fresh water use. Twenty-five per cent of wood harvested and 40 per cent of material produced are attributed to the built environment"* (De Lilly, 2009). Energy consumption in the built environment has increased significantly over the past years with buildings consuming more than one-third of the global energy (United Nations Environment Programme [UNEP], 2016). This is due to population growth, increase in floor area, time spent indoors and global climate change particularly referring to Global South countries (Pelling, 2003; Tanner *et al.*, 2009). Climate change is projected to worsen by the year 2050 if no drastic energy strategies are implemented (Georgieva, 2018).

In order to fulfil the SDGs for the built environment, the UN suggests implementation of energy efficiency policies and regulations addressing the design, construction and operation of buildings should be supported by developed countries both technically and financially. The Organisation for Economic Co-operation and Development (OECD) together with the International Energy Agency (IEA) state more than 60 countries worldwide implement both mandatory and voluntary building energy codes (IEA, 2017). Although the number of countries with energy codes are steadily growing, two-thirds (66.6%) of countries worldwide are still without mandatory energy codes and not addressing the effects of climate change (IEA, 2017). The Director of the Energy Research Centre at the University of Cape Town, Winkler (2006) is of the opinion that the implementation of codes or regulations are not meaningful without appropriate enforcement mechanisms and that a combination of policies are required to achieve greater results. However, according to the IEA (2017), enforcement of codes is still a major issue in many countries, and many of the existing energy codes need to be updated to address new building targets along with existing building practices.

It is therefore important to investigate the building energy codes across Global South countries, determining the percentage of countries with or without building energy codes and thereby establishing their current implementation status. The overall aim of this article is to magnify the lack of building energy codes in the Global South, contribute towards the knowledge gap using existing data and make recommendations towards future studies focusing on possible best practice guidelines and implementation strategies for Global South countries.

2. Methodology

Scholars in today's information age collect and archive vast amounts of data for use by researchers globally. Resultantly, the use of existing data is becoming common practice in research (Andrews, Higgins, Andrews & Lalor, 2012; Smith, 2008; Smith *et al.*, 2011). Desk research usually refers to secondary data collected from the original source for another primary purpose. Commonly derived from international institutions who collect and store published report studies (Salkind, 2010). This study uses a desk research approach, to investigate existing information on building energy codes used by different implementing agencies in the Global South. The majority of data sources identified in this paper originate form official regulatory organisations that exists in each country.

The first subsection of this article serves as an introduction to the impacts of climate change and the importance of building energy code implementation, specifically within the Global South. Thereafter a comprehensive definition of the Global South is provided to eliminate any uncertainty. The desk study establishes the importance of the Global South, highlighting the current climate impacts and lack of building energy codes in developing countries. Further discussions include the effect of CO_2 emissions in relation to the built environment and the vulnerability of future urban expansion to the expected impacts of climate change in the Global South.

The literature survey establishes the criteria for selecting Global South countries with significant built environment attributes. This is followed by the data-gathering phase, focusing on collecting available building energy codes and reviewing the implementation and status of Global South countries. The relevant building energy codes, energy efficiency policies and related documents of the selected countries were sourced from various governmental departments, industry professionals,

official regulatory bodies and personal communication via email, phone and interviews.

Building energy codes and implementation practices vary significantly amongst countries. Due to the diversity in energy codes within the Global South, challenges arise in evaluating the full impact of the energy efficiency regulations. However, this article aims to highlight the need for energy efficient building regulations in developing countries together with discussions and recommendations on how Global South countries could address the challenges of climate change by implementing energy efficient building strategies or mechanisms.

3. Literature Review

3.1 Definition of the Global South

The Global South is a term occasionally used by scholars and politicians to describe 'economically disadvantaged countries', 'developing countries' or 'third world' countries. These countries include Asia, Africa and Latin America (Hossain, 2006). In 1980, German Chancellor, Willy Brandt published a report identifying a North/South line, also known as the Brandt Line (Vanolo, 2010. The Brandt Report (1980) gave rise to the terms, Global North and Global South, often referring to the richer and more developed nations in contrast to the poorer and more underdeveloped world.

The Global South is also used by academics as a convenient geographical border to identify the world's poor countries lying South of Latitude 30 North, excluding Australia and New Zealand (Rigg, 2015). The geographical delineation is more complicated than the term suggests and it is anticipated to change in the future.

Figure 1 is adapted by the author to illustrate the division between the Global North and Global South using the Brandt Line. The study identified 141 countries that fall within the geographical delineation.

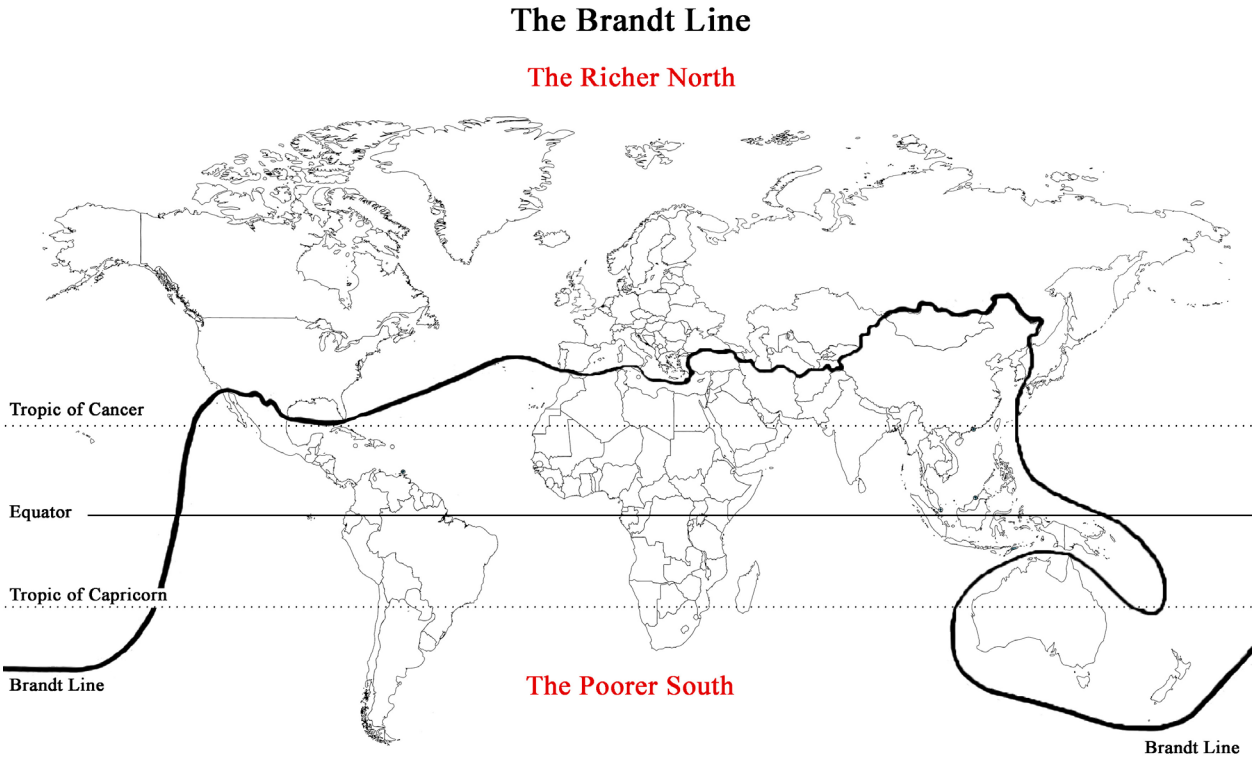


Figure 1 The Brant Line: The Rich North and the Poor South (Author, adapted from Grovers, 2016)

In 2015, the Global South Studies Center (GSSC) in Germany approached academics, journals and academic institutions to reflect on the term the Global South. Ming'ate (2015), researcher at the Department of Environmental Studies and Community Development in Kenya states that: "[t]he nations of Africa, Central and Latin America, and most of Asia are collectively known as the Global South. These nations are also referred to collectively as the poor world, the less-developed world, the non-Western world, and the developing countries".

Magallanes (2015), Director of the Institute of Political Studies in Venezuela is of the opinion that: "As underdeveloped countries become more visible, they are frequently referred to under the collective label the *"Global South*". Despite the advantages, this designation offers as a synthesizing term, I consider it ambiguous because it uses a simple geographical criteria to describe a complex social situation which distinguishes poor countries from the wealthiest".

The GSSC research fellow, Schwarz (2015), argues that the Global South is a neutral reference replacing the terms developed and developing countries. Schwarz argues that when using the term, it should be accompanied by an explanation. Dirlik (2015) and Rehbein (2015) state the definition of the Global South may change due to geo-political shifts leading to the re-consideration of which countries are part of the Global South and which are not.

In the context of the article, the Global South is defined as:

> Developing countries with typically poor economic growth that is also referred to as "third world countries", "less developed countries", "underdeveloped countries" and ultimately the "Poor South".

3.2 Climate change in the Global South

The Global South is known for its history of weak institutions, armed conflict, poverty and humanitarian crises. Different countries in the Global South have been trying for decades to overcome and improve their domestic circumstances and now also have to address the effects of global warming (Ortiz, 2016). The complex phenomenon of climate change has both direct and indirect effects on human security and influence the stability of states and communities across the globe. However, the cities and people of the Global South are most vulnerable to the effects of a continuous warming world (Brock, 2012). These are the people who least can afford preparation for future uncertainty.

Vivekananda (2016), an expert in security and climate change states: "Disaster Risk Reduction and climate change adaption in fragile and conflict-affected states in the Global South have long been overlooked, as it is often perceived as too challenging or a lower priority". With the increased impacts resulting from climate change, floods and droughts will gradually become more severe and extreme weather conditions will have an indefinite impact on the Growth Domestic Product (GDP), economy, food, energy and agriculture of each country. Resultantly, existing social hurdles in Global South cities with high population figures of urban poor will be more difficult to overcome (Alam & Rabbani, 2007).

According to the IPCC (2014), Africa has been identified as one of the most vulnerable continents facing climate change. The major contributing factors are the African geography and Africa being one of the hottest continents of the world. It is predicted to warm up to 1.5 times quicker than the global average (IPCC, 2014). Fossil fuel emissions are understood to be the primary source of emission largely being attributed to Africa's growing population (IPCC, 2014).

According to Engelbrecht (2017), chief researcher at the Council for Scientific and Industrial Research (CSIR) states: "Research into how global warming will impact the planet decades into the future; how will this affect South Africa, and will our situation stay the same or get any worse". He argued that the current progression of mitigating climate change is not taking place at a fast enough pace and a 3°C increase in temperature by 2040 could be expected (Engelbrecht, 2017). However, should aggressive implementation action of energy efficiency strategies be implemented as suggested by the Paris Agreement, climate change could still be addressed affectively by the end of the century (Engelbrecht, 2017).

In an attempt to address these challenges, organisations such as the CSIR, National Oceanic and Atmospheric Administration, the UN and the International Institute for Climate and Society are focusing on finding possible solutions for the current and future challenges of climate change. This complex task need to be addressed urgently to achieve global climate change targets.

3.3 Role of energy efficiency regulations

One of the major built environment SDGs highlight the need for sustainable energy services and infrastructure in developing countries, in particular least developed countries. While the use and implementation of building energy codes and standards exist in almost all developed countries, developing countries are slow to introducing such legislation (UNEP, 2009a, 2009b).

Energy efficiency regulations are a set of standards that prescribe the minimum energy performance for buildings or manufactured products. The term energy efficiency should not be confused with sustainability or "green buildings" as the criteria includes renewable materials and embodied energy (Communities, 2010). Typically, energy efficiency only refers to the energy usage and demand of a building.

One of the main objectives for energy codes and standards are to set out minimum requirements for energy efficient design principles and construction processes. Building energy codes specify the construction, performance and consumption of new buildings as well as additions, alterations and renovations. Implementation of these codes can sometimes take place on a voluntary basis however, they are mostly written in mandatory, enforceable language to describe the cost effective energy saving measures and significantly reduce overall built environment energy consumption (Bartlett *et al.*, 2003; Iwaro and Mwasha, 2010).

In context of this article, building energy codes are defined as:

> Guidelines specifying the minimum requirements for design and construction in order to save energy as cost-effectively as possible. These regulations are written regulatory documents that the local government enforce and should be adopted in the design stage of buildings to possibly maximise the potential energy savings (Bartlett *et al.,* 2003).

3.4 The significance Building Energy Codes in the Global South

The incorporation of energy efficient measurers into international standards, national policies, strategies and planning to alleviate climate change impacts are crucial to the development of Global South countries.

According to the UN Environment and IEA's Global Status Report (2017) the global building sector will presumably double in floor area by 2060, adding an additional 230 billion m² worldwide. This increase is equivalent to the current floor area of

Japan being built every single year for the next 40 years, until 2060 (UN Environment and IEA, 2017). Expected growth in building floor area of 63% is predicted for Global South countries (IEA, 2017). Harvey (2014) states: "it is impossible to know what the net effect of increasing building floor area and global extension of the proposed tightening of building codes for new and renovated buildings would have on overall fuel and electricity demand".

The rapid growth in population and purchasing power within developing countries could lead to a 50% increase in energy demand in buildings by 2050 (IEA, 2016). A growth in building floor area is linked to economic growth and the associated increase in energy use of the building sector. The IEA (2016) states 85% of projected growth for global energy demand until 2050 is expected to occur within the Global South. Building energy demand is one of the biggest contributors to the future effects of climate change. The linked building growth is expected to be particularly rapid in Africa and Asia (UN Environment and IEA, 2017). This projected increase is concerning because many countries, especially developing nations are not implementing mandatory building energy efficiency strategies (UN Environment & IEA, 2017).

The 2013 United Nations Development Programme (UNDP) Report indicates rapid economic development could be expected in smaller countries like Bangladesh, Chile, Vietnam, Mauritius, Ghana, Tunisia and Rwanda (UNDP, 2013). This report estimates that by 2030 approximately 80% of the world's middle-class population will be living in the Global South (UNDP, 2013). The rapidly growing Global South cities are housing high concentrations of urban poor being particularly sensitive to climate change and the related vulnerabilities (Alam & Rabbani, 2007).

The UN believes that sustainability, "green buildings" and energy efficient building practices could contribute towards meeting the SDGs of 2030. Therefore, future building and construction processes have to be reviewed. Ideally, the construction of energy-efficient buildings should be promoted, while the energy systems of existing buildings should focus on the reduction of CO_2 and other GHG emissions.

3.5 Lack of Building Energy Codes in the Global South

Building energy codes and regulations of countries in the Global North (developed nations) are widely researched and implemented, whereas similar research in the Global South (developing countries) is almost non-existent.

As mentioned earlier, the IEA (2019) report indicates that in 2019 almost 66,6% of countries worldwide still lacked mandatory building energy codes, as a result it was calculated that approximately 5 billion m² of buildings was built without the necessary energy performance requirements. The enforcement of building energy codes need to include high-performance construction that will increase the current 275 million m² in order to cover the 5 billion m². Further research confirms the implementation of mandatory or voluntary building energy codes are only present in 75 (38,5%) countries globally and of these countries, approximately 45% only have codes that partially cover the building sector (IEA, 2019).

Figure 2 highlights the lack of information and building energy codes in the Global South. It is clear from Figure 2 that most of the developed Nations already have existing mandatory building energy codes with a few countries implementing voluntary standards. It is evident that there is a major lack of information and implementation in Global South countries and this study seeks to address the gap in knowledge.

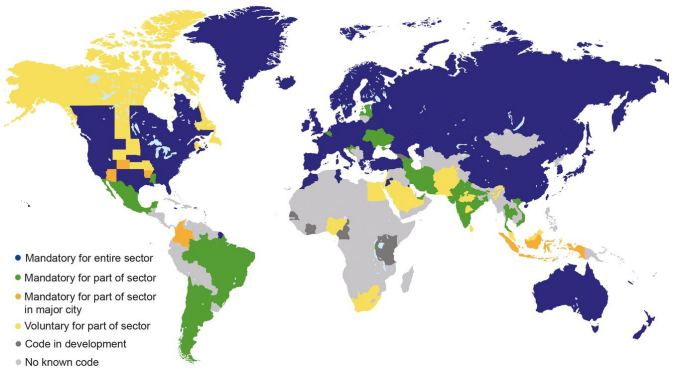


Figure 2 Building energy codes by jurisdiction (Author; adapted from IEA Report, 2019)

The overall performance of buildings, building envelopes, energy efficient designs and construction practices are crucial to the success of the overall sustainable development. A proven method to reduce energy consumption in the built environment is the implementation of building energy codes and standards. However, most countries have not made this a priority and in order to meet SDGs and ambitions within the next decade, all countries need to establish and implement mandatory energy codes (IEA, 2019).

The need to accommodate rapidly growing building sectors, improving thermal comfort and reducing overall energy consumption, specifically in the Global South calls for immediate action and drastic measures to be introduced.

4. Review of pertinent aspects

4.1 Urban population and vulnerability in the Global South

Globally, more than half of the world's population live in urban areas and the continuing growth of the world's population and urbanisation is expected to increase by an additional 2.5 billion people by 2050, with approximately 90% of the increase taking place in Asia and Africa (UN, 2014). Roughly two-thirds of the world's population is projected to live in urban areas by 2050, with the greatest growth expected in China, India, Africa and other developing economies (UN DESA, 2018). India, China and Nigeria are expected to account for 37% of the world's total urban population by 2050 (UN DESA, 2018).

Urban areas currently account for 67 – 76% of the total global energy consumption and 71 – 76% of CO_2 emissions derived from fossil fuels (Seto *et al.,* 2014). A study by the IEA suggest that the largest increase in CO_2 emissions from energy use will be from developing countries (IEA, 2008). It is expected that the expansion of urban areas could increase the total energy use intensity, GHG emissions and economic activity that would contribute towards the effects of climate change (Seto, Güneralp and Hutyra, 2012; UN DESA, 2012). Should the proposed and current energy saving systems been implemented already, it is estimated that the primary energy demand would have reduced from 70% in 2013 to 66% in 2050 (IEA, 2016).

Urbanisation across international borders is seen as an important driver in poverty reduction. This is especially true for immigrants coming from countries with a low GDP and Gini coefficient. In contrast, the unplanned and rapid growth of urban population in the Global South could adversely affect existing development and infrastructure of developing countries (UN, 2014). Therefore, it is important to highlight the need for sustainable urban energy paths and indicate the importance of meeting global low-carbon targets within the built environment (IEA, 2017).

4.2 Impact of CO_2 emissions on the built environment and the Global South

Unfortunately, policy makers see the global issue of climate change as confrontational, with the debate of also becoming one between the Global North and the Global South. In the Global North, the average carbon emission per capita is about five times more than in the Global South (Gosh, 2009). This gap is expected to narrow with developing countries requiring increased access to adequate housing, electricity and wealth. The expected rapid growth of the future urban population of the Global South and associated increased use of energy will increase the CO_2 emissions from related fossil fuels and power generation. Currently, approximately 40% of the total global CO_2 emissions originate from energy use by the building sector (IEA, 2020; IEA & UNEP, 2018; UNEP, 2016).

The future energy requirements of the aforementioned trend will significantly impact on the origin and method of providing energy for urban areas (IPCC, 2014). The effect of the expected rise in floor area and income per capita will lead to an increase of double or perhaps even triple the current energy use and related emissions by 2050 (IEA, 2016)). All of the above taken into consideration, the building sector is becoming less likely to meet future climate change targets in addition to fulfilling potential goals set out by the SDGs and the Paris Agreement.

It should be priority for developing countries to establish and implement new sustainable building strategies, taking urbanisation trends into account. Energy efficient systems and renewable energy technologies should form an integral part of the future building sector, ultimately reducing energy consumption and lowering levels of GHG emissions.

4.3 Distinctive climate zones in the Global South

The Köppen-Geiger Climate Classification system was developed by the German botanist-climatologist Wladimir Köppen, arguing native vegetation bests defines climates. The map was first published in 1884 with subsequent revisions by German climatologist Rudolf Geiger in 1940 (Kottek *et al.,* 2006). A group of scientists from Australia and Germany updated the Köppen-Geiger Climate Classification to the first digital world map (Belda *et al*., 2014).

Using a large global data set of long-term monthly precipitation and temperature measurements, the Köppen-Geiger map is divided into five major climatic zones with each type represented by a capital letter (A – E) and 31 climate types. The major climatic types are then further sub-divided based on precipitation (second capital letter) and temperature (third lower case letter) as seen in Figure 3 (Kottek *et al*., 2006). The detailed Köppen-Geiger map is widely used by researchers across various disciplines as a basis for assessing the output of global climate models (Peel, Finlayson & Mcmahon, 2007).

The worlds various climate zones can be derived from the Figure 3, adapted by the author from the Köppen-Geiger climate classification (Kottek *et al*., 2006) for background into the North/ South delineation, illustrating the various climatic zones above and below the defining line.

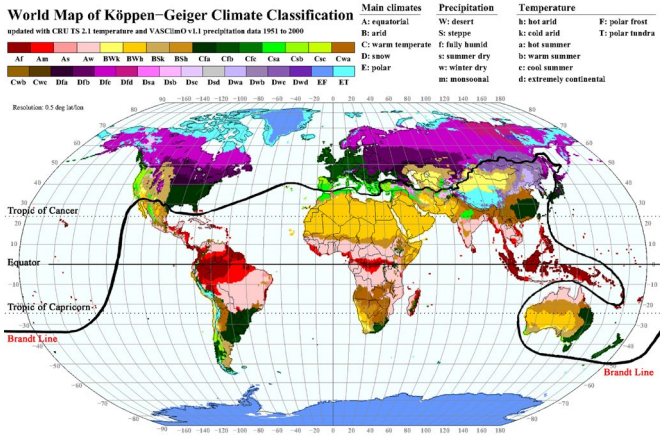


Figure 3 World Map of Köppen-Geiger Climate Classification (Author, adapted from Kottek *et al.,* 2006)

The Köppen-Geiger identifies five distinctive climate zones, namely: Equatorial, Arid, Warm Temperature, Snow and Polar. The map indicates most Global South countries have similar climatic zones, with the exception of China and small parts in South America. Except for the Polar climate zone all other distinctive climate zones are represented within countries present in the Global South.

5. Data and research study area

5.1 Selection criteria for data collection

The selection of countries were determined by the comprehensive literature review on the contribution, significance and role of building energy codes in the Global South to determine their relationship with climate change. The research reveals three major components that contribute to the effects of climate change namely; future urban population, carbon emissions and distinctive climate zones. These components became significant in the selection criteria because the impact of climate change is projected to increase should no drastic energy strategies be implemented.

After identifying the different countries from the selection criteria, a comprehensive investigation was conducted on each of the 61 countries building regulations and regulatory codes based on the issues surrounding climate change. This article illustrates the major gap in knowledge regarding built environment energy efficiency policies and makes recommendations towards future studies focusing on possible best practice guidelines and implementation strategies for Global South countries.

5.2 Sampling size and the level of representation on the population

The sampling size was determined by the aforementioned criteria being the three major components contributing towards climate change namely; 2050 urban population, carbon emissions and distinctive climate zones. Current definitions of the Global South (and the 141 countries included in the Brandt delineation) are largely based on opinion and geopolitical aspects.

5.2.1 Criteria 1: Urban Population in 2050

It is generally accepted that Global South countries with the highest 2050 urban population will be the biggest energy consumers with resultant GHG emissions and impacts on climate change (Seto, Güneralp & Hutyra, 2012). For the purpose of this study, it was important to target these countries specifically.

Countries with an urban population of 19.3 million or greater in 2050 was included in this study as it represents approximately 91% of the Global South's 2050 urban population and 75% of the World's 2050 urban population.

Using this delimitation, 49 of the 141 (34, 8%) Global South countries fall within the selected criterion. Table 1 identify and list the selected countries and the respective urban population projected for 2050.

5.2.2 Criteria 2: Total CO_2 emission contribution

Countries with high CO_2 emission rates contribute significantly to climate change, making this one of the inclusion criteria. Using the information obtained from the COP 21 agreement (UNFCCC, 2016) the 49 countries identified in Table 2 represent 97.3% of the Global South's CO_2 emissions and 51.5% of the world's total CO_2 emissions.

Countries in the Global South with significant CO_2 emission are ranked accordingly. The 49 highest CO_2 emitters are compared against the previous identified 49 countries with highest 2050 urban population, as listed in Table 1.

Table 2 identify and list the 49 countries with the highest CO_2 emission rates while highlighting the countries not appearing in Table 1.

Table 1 Global South countries with an Urban Population ≥19.3 Million (UN, 2018)

Rank	Country	Urban population 2050 (Total Million)
1	China	1 014,5
2	India	834,0
3	Nigeria	275,5
4	Indonesia	227,9
5	Brazil	211,7
6	Pakistan	176,4
7	Mexico	141,9
8	Congo (DRC)	119,3
9	Bangladesh	112,4
10	Egypt	86,8
11	Philippines	85,1
12	Turkey	80,0
13	Iran, Islamic Republic	78,5
14	Tanzania	73,2
15	Ethiopia	71,8
16	Iraq	63,6

Table 2 Countries in the Global South with the highest level of CO_2 emissions (UNFCCC, 2016)

Rank	Country	CO_2 Emissions (Gg CO_2 Equivalent)
1	China	7 465 862
2	India	1 523 767
3	Brazil	923 544
4	Korea,	688 300
5	Mexico	632 880
6	Indonesia	554 334
7	South Africa	544 314
8	Iran, Islamic Republic	483 669
9	Turkey	459 102
10	Sierra Leone	365 107
11	Argentina	332 499
12	Kenya	313 442
13	Saudi Arabia	296 060
14	Cote d'Ivoire	271 198
15	Vietnam	266 049
16	Ecuador	247 990

17	Vietnam	59,2
18	South Africa	57,8
19	Argentina	52,3
20	Angola	48,5
21	Algeria	47,2
22	Thailand	46,9
23	Colombia	46,2
24	Korea (South)	44,2
25	Kenya	41,9
26	Sudan	40,0
27	Saudi Arabia	40,0
28	Venezuela	38,2
29	Cote d'Ivoire	36,4
30	Ghana	36,1
31	Peru	35,9
32	Malaysia	35,8
33	Cameroon	34,9
34	Myanmar	34,2
35	Uganda	33,9
36	Morocco	33,8
37	Mozambique	33,3
38	Madagascar	29,6
39	Afghanistan	28,1
40	Mali	26,5
41	Yemen	26,1
42	Syrian Arab Republic	24,3
43	Niger	24,2
44	Zambia	23,9
45	Burkina Faso	22,5
46	Somalia	20,7
47	Senegal	20,6
48	Uzbekistan	20,2
49	Korea (North)	19,3

17	Thailand	236 974
18	Nigeria	212 444
19	Uzbekistan	199 837
20	United Arab Emirates	195 308
21	Malaysia	193 397
22	Egypt	193 238
23	Venezuela	192 192
24	Cameroon	165 725
25	Pakistan	160 589
26	Colombia	153 885
27	Philippines	126 879
28	Algeria	111 023
29	Bangladesh	99 442
30	Chile	91 576
31	Korea (North)	87 330
32	Peru	80 591
33	Syrian Arab Republic	79 070
34	Turkmenistan	75 409
35	Iraq	72 658
36	Zimbabwe	68 541
37	Sudan	67 840
38	Angola	61 611
39	Qatar	61 593
40	Morocco	59 700
41	Azerbaijan	48 209
42	Ethiopia	47 745
43	Singapore	46 832
44	Bolivia	43 665
45	Tanzania	40 506
46	Tunisia	39 342
47	Myanmar	38 375
48	Cuba	36 340
49	Ghana	33 660

Table 2 identified 12 countries not included in the list of highest Global South 2050 urban populations. However, the identified countries contribute significantly to CO_2 emissions and it becomes necessary to include these in the final list.

The following 12 countries are added to the previously identified 49 countries: Azerbaijan, Bolivia, Chile, Cuba, Ecuador, Qatar, Sierra Leone, Singapore, Tunisia, Turkmenistan, United Arab Emirates and Zimbabwe. This increased the total to 61 of the available 141 (43, 3%) Global South Countries, falling within the selected criteria.

5.2.3 Criteria 3: Distinctive climate zones

The distinctive climate zones in the Global South carries significant value due to specific climate conditions. Research indicates that the distinctive climate conditions of some countries could possibly lead to an increase in drought, heat waves, excessive flooding and storms (IPCC, 2018). Resultantly, communities who are not resilient to this will be destroyed, devastated and even poorer than they currently are.

This article deems it important to also use the Köppen-Geiger Climate Classification as part of the selection criteria in order to ensure that all possible climate zones are included within the study. In this article, the selected countries in the Global South represent all distinctive climate zone set out by the classification, with the exception of the Polar Climate zone.

According to the Fragile Planet Report of the Hong Kong and Shanghai Banking Corporation (HSBC) (2018), the following countries are amongst the list of most vulnerable to the effects of climate change and extreme weather conditions: India, Pakistan, Philippines, Bangladesh, Mexico, Kenya, South Africa, Thailand and Vietnam. All of the identified countries with distinctive climate zones are already included in the current list of 61 countries.

5.3 Data analysis of study area

A graphical summary of the selection criteria mentioned above is presented in Figure 4. This provides a comprehensive view of the 61 countries included in the study using a geographical representation. After finalising the selected countries using the identified criteria, the building energy codes were traced for each country. This was done to establish the current implementation status of building energy codes in each country.

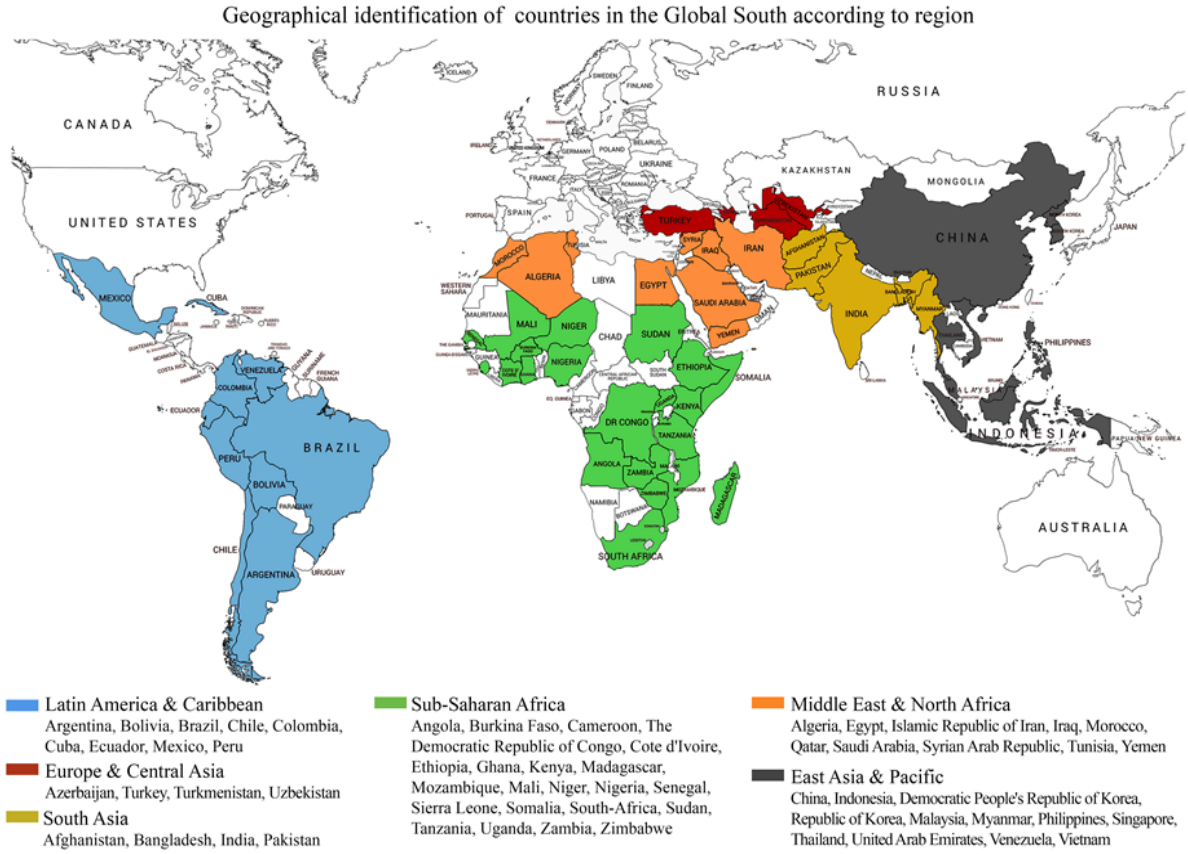


Figure 4 The final nominated countries in the Global South by region (Author, 2021)

The research methodology employed to source relevant information on the energy efficient building regulations of the 61 Global South Countries, included:

- Extensive library searches and various web engines were used find publically available data.
- Architectural associations, organisations and related government institutions from each country were listed and contacted to obtain documents not available to the public.
- Individual Architectural firms were contacted for further assistance on countries where information or documentation was still outstanding.
- The relevant regulations, policies or energy efficient strategies were grouped into the following 4 categories: Mandatory, Voluntary, non-existent and no information available.
- The official language of each country posed significant challenges and required many of the documents to be translated. However, this was made possible with the assistance of google translate, fellow colleagues and foreign students from the institution

After analysing the documentation obtained on building energy codes of the 61 countries, the data was categorised accordingly. This process identified countries without building energy codes, whether voluntary or mandatory. The existing building energy codes were further analysed to arrive at a final number of Global South countries with and without building energy codes. Ultimately defining the current implementation status of building energy codes on the Global South. The information was collated in different charts with graphical illustrations.

The data was processed using Microsoft Excel® (Microsoft Office® Professional Plus 2016) software program to present the statistical graphics. The Geographical Maps were created to add perspective to the countries locations by using the online platform *MapChart* and Adobe Photoshop Pro.

6. Findings and Discussion

This section of the article presents the analysis and discussion of the findings of the study.

6.1 Implementation status of building energy practices in 61 Global South countries

This section of the article focuses on the results obtained from the 61 Global South countries, implementation status of their respective energy efficiency building codes or standards and the contribution to alleviating global climate change impacts.

The primary objective is to identify countries in the Global South with mandatory building energy codes and highlight countries that do not implement energy efficiency building regulations. Table 3 below indicates the status of energy efficiency regulatory building practices in the 61 Global South countries, including the possibility of passive design principles and whether enforcement of building energy codes take place on a mandatory, voluntary or non-existent basis.

Table 3 Status of Energy Efficiency Building Codes for the top 10 African countries (Author, 2021)

No	Country	Energy Efficiency Building Code (EEBC)	EEBC Status		Passive Principles	Voluntary
			Mandatory	None		
1	Afghanistan	None	–	✓	–	–
2	Algeria	Technical Regulations Document (DTR C 3-2)	✓	–	✓	
3	Angola	None	–	✓	–	–
4	Argentina	National Programme for Rational Use of Energy and Energy Efficiency (Decree 140/2007)	–	✓	✓	✓
5	Azerbaijan	Town Planning and Construction Code of the Republic of Azerbaijan 2012	✓	–	✓	–
6	Bangladesh	Bangladesh National Building Code 2015	✓	–	✓	–
7	Bolivia	Bolivian Construction Regulations 2012	–	✓	✓	–
8	Brazil	Quality Technical Regulation for the Energy Efficiency Level of Buildings commercial, Services and Public 2010	✓	–	✓	✓
9	Burkina Faso	Burkina Faso Code of urban planning and construction, Law No. 017-2006	–	✓	–	–
10	Cameroon	None	–	✓	–	–
11	Chile	General Ordinance of Urbanism and Construction 2017	✓	–	✓	–
12	China	GB-50189:2014	✓	–	✓	–
13	Colombia	Colombian Construction Regulations for Earthquake resistance 2010	–	✓	✓	–
14	Congo (DRC)	No Information				
15	Cote d'Ivoire	None	–	✓	–	–
16	Cuba	Caribbean Uniform Building Code 1985(CUBiC)	–	✓	–	–
17	Ecuador	Ecuadorian Standard of Construction energy efficiency in residential buildings 2018	✓	–	✓	–
18	Egypt	Residential Energy Efficiency Building Code 2011 (EEBC)	✓	–	✓	–
19	Ethiopia	Ethiopian Building Code Standard 2013	–	✓	✓	–
20	Ghana	Ghana Building Code (GS1207: 2018)	✓	–	✓	–
21	India	Energy Conservation Building Code 2016 - 2017	✓	–	✓	–
22	Indonesia	Indonesian National Standards *(SNI 03-6389-201; SNI 03-6390-2011; SNI 03-6197-2011;SNI 03-6196-2011)*	✓	–	✓	–
23	Iran, Islamic Rep	Code Number 19 - 2001	✓	–	✓	–
24	Iraq	None	–	✓	–	–
25	Kenya	Building Code of the Republic of Kenya 2009	–	✓	✓	–
26	Korea (North)	No Information				
27	Korea (South)	Building Design Criteria for Energy Saving 2008(BDCES)	✓	–	✓	
28	Madagascar	All Building Works of Madagascar	–	✓	–	–
29	Malaysia	Code of Practice on Energy Efficiency for non-residential Buildings 2014 (MS1525)	✓	–	✓	–
30	Mali	None	–	✓	–	–
31	Mexico	Energy conservation code for Buildings of Mexico 2016	✓	–	✓	–
32	Morocco	General Construction Regulations 2014	✓	–	✓	–
33	Mozambique	General Regulations 1976	–	✓	–	–
34	Myanmar	Myanmar National Building Code 2016	✓	–	✓	–

35	Niger	No Information				
36	Nigeria	National Building Energy Efficiency Code 2017	✓	–	✓	–
37	Pakistan	Building Energy Code of Pakistan 2011	✓	–	✓	–
38	Peru	National Building Regulations 2006	–	✓	–	–
39	Philippines	The Philippine Green Building Code 2015	✓	–	✓	–
40	Qatar	Qatar Construction Specification 2014	✓	–	✓	–
41	Saudi Arabia	Saudi Building Code Energy Conservation Requirements 2007 (SBC 601)	✓	–	✓	–
42	Senegal	No 2009-1450 the Regulatory Part of the Town Planning Act	–	✓	–	–
43	Sierra Leone	The National Building Control Regulations 2015	–	✓	✓	–
44	Singapore	Code for Environmental Sustainability of Buildings 2012	✓	–	✓	–
45	Somalia	No Information				
46	South Africa	South African National Standard (SANS) 10400:2011 & SANS 204:2011 Energy Efficiency	✓	–	✓	–
47	Sudan	General Building Regulations 2008		✓	✓	–
48	Syrian Arab Rep	New Arab Building Energy Code 2010	✓	–	✓	–
49	Tanzania	Urban Planning and Space Standards Regulations 2011; Urban Planning Act 2007	–	✓	–	–
50	Thailand	Building Energy Code 2009 *(Volume 126, Part 12A - Building's area from 2000 m²)*	✓	–	✓	–
51	Tunisia	Tunisia Thermal Building Regulation 2009	✓	–	✓	–
52	Turkey	Thermal Insulation for Building 2008 (TS 825) & Regulation of energy performance of buildings 2010 (Bep-TR)	✓	–	✓	–
53	Turkmenistan	SNT 3.04.03-94 Residential Buildings; SNT 2.03.10-2001 Roofs and Roofing; SNT 2.01.01-98 Building Climatology; SNT 2.01.03-98 Building Thermal Engineering	✓	–	✓	–
54	Uganda	Building Control Regulations 2012	–	✓	✓	–
55	United Arab Emirates	Abu Dhabi International Building Codes 2013	✓	–	✓	–
56	Uzbekistan	No Information				
57	Venezuela	General Specifications for Buildings		✓	–	–
58	Vietnam	National Technical Regulation on Energy Efficiency Buildings 2013	✓		✓	
59	Yemen	None	–	✓	–	–
60	Zambia	No Information				
61	Zimbabwe	Model Building By-Laws 1997	–	✓	–	–
		STATUS OF IMPLEMENTATION STRATEGIES	***31***	***24***	***39***	***2***

The following section explains the preliminary findings on the current status of building energy codes of the 61 countries in the Global South.

After analysing the respective building energy codes, research indicates that 51% (31 out of 61) of the selected countries in the Global South implement mandatory building energy codes and currently only 3% of the countries, namely; Argentina and Brazil have voluntary standards.

However, it is concerning that 39% of the countries do not have any form of building energy codes or policies. This while only 31 out of 61 Global South countries with the implementation of either mandatory (49%) or voluntary codes (3%) are working towards overcoming the effects of climate change by developing strategies to achieve a more resilient sustainable environment. This represents approximately half of the countries that are responsible for climate change, emitting 33% of the GHG emissions originating from the Global South.

After extensive research and various data collection methods employed, the lack of information on 6 out of 61 (10%), countries suggest the absence of building energy codes or related policies. This while it is most likely that voluntary building energy codes will eventually become standard practice as the necessary energy efficiency policies are already proposed is some of the documents. An example of this include the current energy efficiency regulations of Brazil that only partially covers federal public buildings with voluntary codes for the remaining commercial and residential sectors.

From the analysis it is evident that many of the countries do not have building energy codes. Though, it is noted that most of the countries implement standard building regulations and that 39 out

of 61 (63%) countries recommend the use of passive principles. However, the implementation of passive strategies alone are not enough to fulfil 2050 climate change targets, the SDGs or the Paris Agreement objectives for the built environment.

The current global climate change crisis requires policy maker to address the need for extensive energy efficiency measures, supporting long-term sustainable building practises.

6.2 Summarised results

To simplify and summarise the status, extent and implementation of building energy codes the previous 4 categories were combined into 2 simple groups, namely; mandatory and non-existent.

Figure 5 is a graphical representation of the summarised results showing the extent of mandatory versus non-existent building energy codes. This represent the availability, implementation and lack of energy efficiency policies in the built environment and identify possible research gaps. This is followed by analysing and discussing the relevant results.

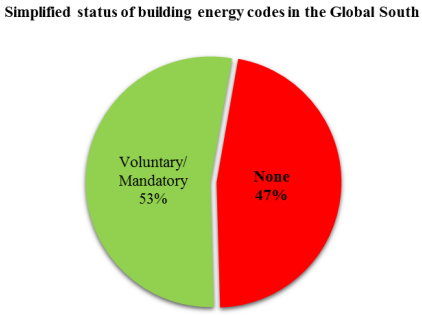


Figure 5 Graphic summary of the combined data from countries in the Global South (Author, 2021)

The combined data revealed 53% of the selected countries are implementing mandatory and/or voluntary building energy codes, while 47% of the selected countries do not implement or address energy efficiency through building energy codes.

Although more than half of the Global South countries implement some form of building energy code, it is clear from the chart that there is still a major gap in the implementation of codes and the overall knowledge regarding the effects of climate change on the built environment, regulations and its associated responsibilities. As a result the 30 developing countries, 47% forming part of the study are without instruments addressing energy consumption in the built environment and risk becoming more exposed to the effects of climate change.

6.3 Geographical results

The presentation of geographic data enables the reader to analyse and interpret data from a spatial perspective. Figure 6 illustrates the geographical implementation status of building energy codes in the selected 61 Global South countries.

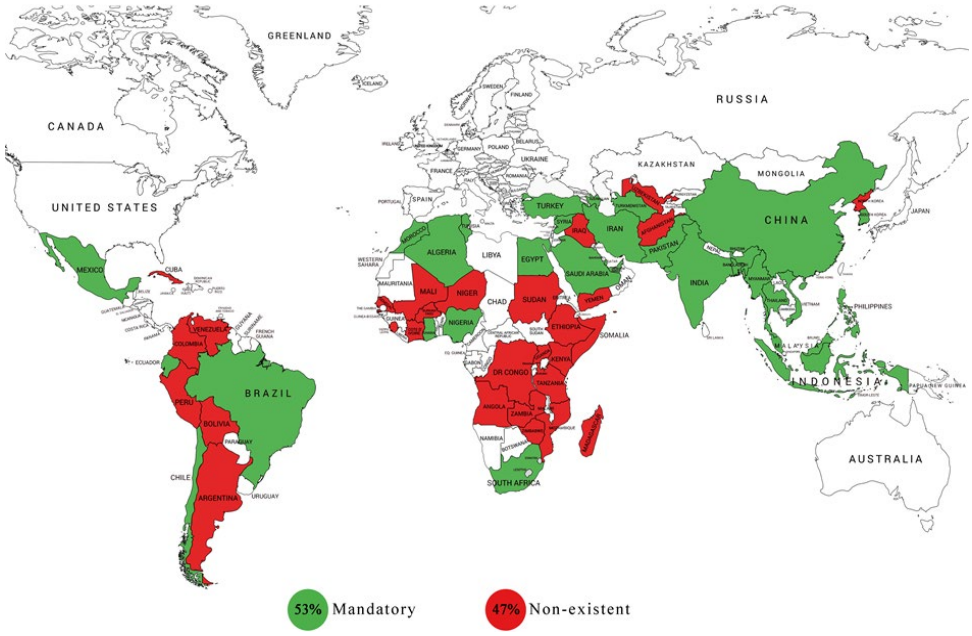


Figure 6 Combined status of building energy codes in the selected Global South countries (Author, 2021)

Further analysis on the geographical result from Figure 6 point towards a major lack of information or implementation of building energy codes on the African continent with the exception of Algeria, Egypt, Ghana, Morocco, Nigeria, South Africa and Tunisia. Currently 73% (19 out of 26) of African countries included in the study do not have any building energy codes or related information available. This could be due to African countries being more underdeveloped than the rest of the Global South. As stated earlier, countries in Africa are most at risk when facing the results of climate change, especially global warming.

In Latin America and the Caribbean, only 4 out of 10 countries (40%) have building energy codes. This indicates the disregard of more than halve of the continents countries to the impacts of climate change and their resultant consequences. The study suggests that Cuba, Peru, Bolivia and Argentina ungently adopt regulations from neighbouring countries as a foundation for draft policy implementation.

The graphical representation from Figure 6 clearly demonstrates the efforts from Asia and the Middle East in supporting sustainable building practices, with 80% of countries on the continent implementing mandatory building energy codes. Furthermore, studying recent trends in Asia suggest the rapid development of energy efficient building strategies for countries without mandatory energy codes are beyond doubt.

Although the majority, 53% of countries in the Global South are implementing some form of building energy code, it is evident that there is a general lack of implementation, enforcement and knowledge of such codes and their related practices. It is still concerning that nearly halve, 47% of the Global South countries have not made any efforts toward implementing energy efficiency strategies in the built environment.

7. Conclusions and recommendations

The effective implementation of building energy codes are essential mechanisms in creating sustainable, low-carbon and energy efficient built environments for the future. In light of the current global climate change crisis, this article set out to establish the implementation status of building energy codes in pertinent Global South countries to magnify the need for built environment mitigation strategies.

The literature review identified the selection criteria by identifying countries contributing significantly to climate change. The desk study included a detailed review of current CO_2 emissions, 2050 urban population figures and distinctive climate zones in the Global South, ultimately identifying 61 countries for inclusion in the study. Research commenced on the 61 Global South countries, identifying those with or without building energy codes in an attempt to magnify the lack of energy efficiency policies and provide a global perspective of the issue. The research established a large percentage, nearly half (47%) of Global South countries are not addressing the issues of climate change through the use and implementation of building energy codes. This situation is exacerbated on the African continent, where 73% of the selected African countries are not addressing energy efficiency through built environment regulatory policies. The resultant impacts causing irreversible climate damage, continuous rise of global average temperatures, increased poverty and the increase in droughts, floods and other extreme weather conditions. These findings are of great concern, seeing that Global South countries, specifically the African continent are most at risk when facing climate change impacts.

The uniqueness of this study lies in the contribution of new knowledge, addressing limited research on the theme and the limited information available on building energy codes in the Global South. This paper presents the first published evidence by identifying existing building energy codes in the Global South. This paper also attempts to create awareness on the lack of climate change policies in the built environment, thereby providing information to government organisations, relevant stakeholders and decision makers on the importance of achieving built environment climate change targets through the adaptation, implementation or development of building energy codes.

It is suggested that Global South countries develop some form of building energy code to reduce the impact of climate change globally. Countries without energy codes are encouraged to implement or adopt available building energy codes with associated climatic regions. On the African continent, the following countries; Mali, Niger and Sudan could consider the application of energy efficiency regulatory practices from Algeria and Egypt displaying similar climatic conditions. The use of draft polices derived from the Brazilian and Nigerian energy efficiency codes are also suggested for the Democratic Republic of the Congo, Uganda and Côte d'Ivoire.

However, further in-depth studies on policy adaptation is required to determine the accuracy of climate specifications, overall contribution to 2050 climate targets, the SDGs and alignment with global climate change initiatives.

8. Future Research Studies

Further research studies are recommended to identify the specific criteria necessary for the development and implementation of sufficient global best practices models by countries not currently implementing any energy efficient building regulations. It is also suggested that future studies investigate pledges made by individual governments and relevant stakeholders on the 2050 climate change targets, Paris agreement objectives and their probability of achieving the SDGs of 2030.

These studies could provide countries with the necessary information to develop, adapt or revise current built environment energy efficiency strategies to mitigate climate change and reach targets by 2050. Subsequently, this will assist with increased implementation of building energy codes globally, reducing CO_2 emissions and ultimately creating more sustainable building practices.

References

Alam, M., & Rabbani, G. (2007). Vulnerabilities and responses to climate change for Dhaka. Environment and Urbanization, 19: 81-97.

Andrews, L., Higgins, A., Andrews, M. W., & Lalor, J. G. (2012). Classic grounded theory to analyse secondary data: Reality and reflections. The Grounded Theory Review, 11(1):12-26.

Bartlett, R., Halverson, M.A., & Shankle, D.L. (2003). Understanding Building Energy Codes and Standards. National Technical Information Service: Washington.

Belda, M., Holtanová, E., Halenka, T., & Kalvová, J. (2014). Climate classification revisited: from Köppen to Trewartha. Clim Res 59(1): 1–13.

Brandt Report. (1980). Independent Commission on International Development Issues. 1980. North–South, a programme for survival: Report of the independent commission on international development issues. Cambridge, Mass: MIT Press.

Brock, H. (2012). Climate change: Drivers of insecurity and the Global South. London: Oxford Research Group.

Communities. (2010). *Building regulation.* [Online]. Available from: http://www.communities.gov.uk/documents/panningandbuilding/pdf/cited2010S. [Accessed 30 April 2021].

Dados, N., & Connell, R. (2012). 'The Global South', *Contexts*, 11(1), pp. 12–13. doi: 10.1177/1536504212436479.

De Lilly, A. (Editor). (2009). Sustainable Cities Report 2009. Braamfontein: South African Cities Network (SACN).

Dirlik, A. (2015). Concepts of the Global South. The Global South, 1(1), pp. 13-14. Global South Studies Center, University of Cologne, Germany.

Engelbrecht, F. 2017. Understanding climate effects. Mail & Guardian. [Online]. Available from: https://mg.co.za/article/2017-02-10-00-understanding-climate-effects. [Accessed: 08 March 2019].

Georgieva, K. (2018). Chief Executive Officer, World Bank. Groundswell: Preparing for Internal Climate Migration. Washington, DC: The World Bank.

Gosh, J. (2009). The global north-south carbon divide, The Guardian, international edition.

Grovers, T. (2016). 'Is the Brandt Line Irrelevant in the 21st Century?' Hubpages, 26 May 2016. [Online]. Available from: https://hubpages.com/education/Is-the-Brandt-Line-Irrelevant-in-the-21st-Century. [Accessed: 22 January 2020].

Harvey, L. D. D. (2014). Global climate-oriented building energy use scenarios. Energy Policy, 67, pp. 473-487.

Hoeppe, P., & Gurenko, N. E. (2007). Scientific and economic rationales for innovative climate insurance solutions, in Gurenko, N.E. (ed.) Climate change and insurance: Disaster risk financing in developing countries, London: Earthscan Publications, 607–620.

Hossain, S. M. (2006). Urban poverty and adaptations of the poor to urban life in Dhaka City, Bangladesh, PhD thesis, Sydney: University of New South Wales.

HSBC. (2018). Fragile Planet Report: Scoring climate risks around the world. London: HSBC Bank plc. [Online]. Available from: https://population.un.org/wup/Publications/Files/WUP2018-Highlights.pdf. [Accessed: 01 October 2019].

IEA. (2008). Worldwide Trends in Energy Use and Efficiency, OECD/IEA, Paris.

IEA. (2016). World Energy Outlook 2016 Biomass database. [Online]. Available from: http://www.worldenergyoutlook.org/resources/energydevelopment/energyaccessdatabase/. [Accessed: 08 March 2018].

IEA. (2017). Energy Technology Perspectives 2017: Catalysing Energy Technology Transformations, IEA, Paris.

IEA (2019), *World Energy Outlook 2019*, IEA, Paris. [Online]. Available from: https://www.iea.org/reports/world-energy-outlook-2019. [Accessed 29September 2021].

IEA (2020), *Global Energy Review* 2020, IEA, Paris. . [Online]. Available from: https://www.iea.org/reports/global-energy-review-2020. [Accessed 29September 2021].

IEA and UNEP (2018): 2018 Global Status Report: *Towards a zero-emission, efficient and resilient buildings and construction sector.*

IPCC. (2014). Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press.

IPCC. (2018). Climate Change 2018: Chapter 3:Changes in Climate Extremes and their Impacts on the Natural Physical Environment. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge, UK: Cambridge University Press.

Iwaro, J., & Mwasha, A. (2010). *A review of building energy regulation and policy for energy conservation in developing countries.* [Online]. Available from: https://www.researchgate.net/publication/227415222_A_review_of_building_energy_regulation_and_policy_for_energy_conservation_in_developing_countries. [Accessed May 14 2021].

Kottek, M., Grieser, J., Beck, C., Rudolf, B., & Rubel, F. (2006). World Map of the Köppen-Geiger Climate Classification Updated. Meteorologische Zeitschrift. 15: 259-263. 10.1127/0941-2948/2006/0130.

Magallanes, R. (2015). Concepts of the Global South. On the Global South, 1(1), pp. 13-14. Global South Studies Center, University of Cologne, Germany.

Ming'ate, F. L. M. (2015). The Global South: What does it mean to Kenya. The Global South, 1(1), 12-23. Global South Studies Center, University of Cologne, Germany.

Moser, C., & Satterthwaite, D. (2008). Towards pro-poor adaptation to climate change in the urban centres of low- and middle- income countries. Climate Change and Cities Discussion Paper 3, London: International Institute for Environment and Development.

Ortiz, D. A. (2016). Climate Change Compounds Humanitarian Crises in Global South, Inter Press Service New Agency 2016, San Jose.

Peel, M. C., Finlayson, B. L., & Mcmahon, T. A. (2007). Updated world map of the Köppen-Geiger climate classification. Hydrology and Earth System Sciences Discussions, European Geosciences Union, 11 (5): 1633-1644.

Pelling, M. (2003). The vulnerability of cities: Natural disasters and social resilience. London: Earthscan.

Rehbein, B. (2015). Concepts of the Global South. The Global South, 1(1), pp. 13-14. Global South Studies Center, University of Cologne, Germany.
Rigg, J. (2015). The Global South. The Global South, 1(1): 6-7. Global South Studies Center, University of Cologne, Germany.

Salkind, N. J. (2010). Encyclopedia of research design Thousand Oaks, CA: SAGE Publications Ltd.

Satterthwaite, D., Huq, S., Reid, H., Pelling, M., & Lankao, P.R. (2009). Adapting to climate change in urban areas: The possibilities and constraints in low- and middle-income nations, in Bicknell, J., Dodman, D. and Satterthwaite, D. (eds.) Adapting cities to climate change: understanding and addressing the development challenges, London: Earthscan, 3-34.

Schwarz, T. (2015). Concepts of the Global South. Voices from around the world. Global South Studies Center Cologne, Cologne, Germany.

Seto, K. C., Guneralp, B., & Hutyra, L. R. (2012). Global Forecasts of Urban Expansion to 2030 and Direct Impacts on Biodiversity and Carbon Pools. Proceedings of the National Academy of Sciences of the United States of America, 109: 16083-16088.

Seto, K. C., S. Dhakal, A. Bigio, H. Blanco, G.C. Delgado, D. Dewar, L. Huang, A. Inaba, A. Kansal, S. Lwasa, J.E. McMahon, D.B. Müller, J. Murakami, H. Nagendra, and A. Ramaswami, (2014). Human Settlements, Infrastructure and Spatial Planning. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Smith, A. K., Ayanian, J. Z., Covinsky, K. E., Landon, B. E., McCarthy, E. P., Wee, C. C., & Steinman, M. A. (2011). Conducting high-value secondary dataset analysis: An introductory guide and resources. Journal of General Internal Medicine, 28(8): 920- 929.

Smith, E. (2008). Using secondary data in educational and social research. New York, NY: McGraw-Hill Education.

Tanner, T., Mitchell, T., Polack, E., & Guenther, B. (2009). Urban governance for adaptation: Assessing climate change resilience in ten Asian cities. IDS Working Paper 315, Brighton: Institute of Development Studies.

UN. (2014). United Nations Department of Economic and Social Affairs, Population Division 2014. World Urbanization Prospects: The 2014 Revision, Highlights (ST/ESA/SER.A/352).

UN. (United Nations). (2018). United Nations: Ending Poverty. [Online]. Available from: https://www.un.org/en/sections/issues-depth/poverty/. [Accessed: 30 July 2019].

UN. (United Nations). (2018). United Nations: Revision of World population Urbanization prospects. [Online]. Available from: https://population.un.org/wup/Download/. [Accessed: 08 September 2019].

UN DESA (United Nations Department of Economic and Social Affairs, Population Division). (2012). World Urbanization Prospects, the 2011 Revision: Highlights (United Nations, New York). [Online]. Available from: www.un.org/en/development/desa/publications/world-urbanization-prospects-the-2011-revision.html. [Accessed: 16 May 2019].

UN DESA (United Nations, Department of Economic and Social Affairs, Population Division). (2018). World Urbanization Prospects 2018: Highlights (ST/ESA/SER.A/421). [Online]. Available from: https://population.un.org/wup/Publications/Files/WUP2018-Highlights.pdf. [Accessed: 22 May 2019].

UN Environment & IEA. (2017). Towards a zero-emission, efficient, and resilient buildings and construction sector. Global Status Report 2017.

UNEP. (2009a). United Nations Environmental Programme: *Assessment of policy instruments for reducing greenhouse gas emissions.* [Online]. Available from:/http://www.unep.org/sbci/pdfs/SBCI_CEU_Policy_Tool_Report./cited2009S. [Accessed 26 January 2021].

UNEP. (2009b). *Assessment of policy instruments for reducing greenhouse gas emissions from buildings.* [Online]. Available from: /http://www.unep.org/themes/consumption/pdf/SBCI_CEU_Policy_Tool_Report/cited2009S. [Accessed 26 January 2021].

UNEP. (2016). Global Status Report 2016: Towards zero-emission efficient and resilient buildings. Global Alliance for Buildings and Construction (GABC).

UNFCCC (United Nations Framework Convention on Climate change). (2016). Report of the Conference of the Parties on its twenty-first session, held in Paris from 30 November to 13 December 2015: FCCC/CP/2015/10. [Bonn], United Nations FCCC.

UNPD. (2013). UN Development Programme (UNDP), Human Development Report 2013 - The Rise of the South: Human Progress in a Diverse World, ISBN 978-92-1-126340-4. New York: UNDP.

Vanolo, A. (2010). The border between core and periphery: Geographical representations of the world system. Tijdschrift voor economische en sociale geografie 101: 26–36.

Vivekananda, J. (2016). Climate Change Compounds Humanitarian Crises in Global South, Inter Press Service New Agency, San Jose.

Winkler, H. (2006). Energy policies for sustainable development in South Africa's residential and electricity sectors: Implications for mitigating climate change. PhD thesis. Cape Town: University of Cape Town

IJBES

International Journal of Built Environment and Sustainability
Published by Penerbit UTM Press, Universiti Teknologi Malaysia
IJBES 9(1)/2022, 55-72

A Study On Inter- Relationship Of Open Space And Social Cohesion For Wellbeing Of Elderly: A Systematic Literature Review

Shanta Pragyan Dash
Kalasalingam School of Architecture, Kalasalingam Academy of Research and Education, Tamil Nadu, India

N. Lakshmi Thilagam
Kalasalingam School of Architecture, Kalasalingam Academy of Research and Education, Tamil Nadu, India

ABSTRACT

Social cohesion in public open spaces has been recommended as one of the key elements for improving the wellbeing of the elderly. Social cohesion includes relational elements and individuals' feeling of association. Over the past few decades, increasing social interaction in the neighbourhood is part of larger urban areas and has been regarded as one of the social sustainability initiatives and plays an important role in megacities sustainability. Comprehending place attachment is necessary to enhance elderly people's interactions to make them self-reliant. The study aims to identify the characteristics of open spaces with their major influential factors for enhancing social cohesion for the well-being of the elderly in an urban residential environment through a systematic literature review. The study focuses on addressing three research questions and analysing its results from primary literature studies in the review process. Ten electronic databases were searched for relevant work from papers written in English between 2011 and 2021. Quantitative, qualitative, and mixed methods studies were included. A narrative synthesis was carried out of published works to address the research questions after identifying the various characteristics. The review, which includes 57 published papers, found that the Open spaces are ideally characterized by accessibility, walkability, reduced fear and security, built environment characteristics, landscape elements, climate, best practices, and New Urbanism principles. On the other hand, social cohesion is influenced by activities, safety and security, public places, accessibility, natural elements, noise levels, vehicular interruptions, dimensions and geometry, climate, and physical amenities. A conceptual framework relating to open space attributes and social cohesion is proposed as the finding of the research. Prioritizing the attributes based on the physical, behavioural, and psychological needs of the elderly to keep them active in their aging process could be the further scope of research in this direction.
]

Article History

Received : *10 September 2021*
Received in revised form : *16 December 2021*
Accepted : *17 December 2021*
Published Online : *31 December 2021*

Keywords:

Social cohesion, open spaces, social interaction, place attachment, aging.

Corresponding Author Contact:

dashshanta5@gmail.com

DOI: 10.11113/ ijbes. v9.n1.880

1. Introduction

The aging of the population has become one of the world's unprecedented phenomena. According to the United Nations survey report, it has been observed that the world population has risen annually and that the proportion of the global population over 60 is expected to exceed 23 percent by 2050. (Guo et al., 2020). Increasing recognition of the challenge of active aging is greatly affected by the role of the elderly in society, as demonstrated in the United Nations report. In the early years of the 21st century, the WHO contribution to the Second United Nations World Assembly on Aging is a model of Active Ageing (Diego et al., 2020). In this regard, the environment plays an important role in preserving the ability of physically active older people to access comprehensive support and health care during their aging.

To determine the quality of the life in the city and urban space for the city inhabitants, Urban Parks play a key role in addressing the social, economic aesthetic, natural, and health-related functions. Open Spaces have a detrimental impact on urban diseases, relieve public stress, and help in developing an ambient atmosphere of welcoming and inclusive neighborhood. Therefore, it is essential to have proximity to these green Open Spaces which increases the frequency of the visit which is directly associated with mental wellbeing and improves the physical health condition of the elderly (Błaszczyk et al., 2020). The various attributes that influence the accessibility to these green areas for the elderly are gender, age, and the number of children in the households. As a result, these attributes reflect the structure of the family and the regional culture of the society from a larger perspective. It has been found through research that there has been an increase in the trend of visiting elderly citizens to such green spaces as compared to the other age profile for a society with an active age population (Uchiyama, 2020). The availability of the park within a residential neighborhood and its accessibility are the two major determinants for the visit to such parks by the elderly. While the term parking availability applies to the existence of a part within an urban space measured by using the walking distance whereas accessibility refers to the presence of different barriers to reach two such Open Spaces (Liang et al., 2021). These barriers can be recognized and measured as an aspect of safety both at a physical and psychological level for the elderly who visit such parks. Many researchers have suggested that the aspect of accessibility to the parks and the proximity within an urban space always increases the willingness of the elderly to visit such spaces more frequently as a daily routine habit. On the other hand, some researches have proven that the factors like accessibility and availability do not necessarily always influence people's preference and frequency of the visit to the parks (Liang et al., 2021). Therefore, physical activity is always associated with the streets' microenvironment and its greenery and is most likely to occur in residential neighborhoods as a reason for safety and security. Researchers have also proved that street greenery has a positive relationship with physical activity which has been demonstrated through empirical studies (He et al., 2020).
As per the PA recommendations, it is advised that walking in the neighborhood community for the elderly may be a safe and comfortable way for the elderly to be healthy and well-being. However, it was found during the study of global services that one-third of 60 years of age and half of 80 years of age do not comply with the PA recommendations, which involve at least 150 minutes of moderate aerobic exercise per week (Hu et al., 2020). The main reason is that there is a lack of facilities and facilities for outdoor thermal recreation in a residential neighborhood that is a significant requirement of the elderly. Therefore, to improve physical activity by walking, it is necessary to create spaces within the residential neighborhood that address the specific needs of the elderly to promote their physical activity, which, in turn, would contribute to good health (Levinger et al., 2020). As per the theory of SPF (social production function theory), elderly people can achieve well-being with the remarkable precision obtained by maximizing their functional goals such as stimulation, comfort, status, behavior, and affection, along with the universal goals of physical and social well-being. (Cramm et al., 2012) found that people who have a good social life and a rather good social cohesion within the residential neighborhood community are optimistic about a joyful relationship and life satisfaction with good health and well-being with their families and their livelihoods. Social cohesion is also a key social challenge that many communities face and that needs to be addressed from an urban as well as an architectural perspective. Urban green spaces are perceived to be a crucial aspect of social integration in an urban setting that is important to the well-being of the elderly and to the attainment of environmental sustainability. These spaces not only offer a range of social interaction within the residential community, but also enhance opportunities for the elderly to strengthen their physical and mental well-being within the city. The measures taken by the Open Spaces in the urban area and the strength of its inhabitants are greatly linked as they reflect the daily lives of the people living in the residential environment (Kondo et al., 2015).

Numerous studies have been conducted on the impact of the Neighborhood and Open Spaces on the health and well-being of the elderly. Along with its many advantages, some of the key research reports have found that these impacts cannot be realized due to various factors for visiting these spaces. The lack of awareness and information on the critical success variables that enable the elderly to visit these places, of which social cohesion is an important factor and has scope for further study. However, there is no comprehensive systemic research that shared the critical factors influencing the visit to the Open Spaces for Social Cohesion. To fill this gap, we believe that it is vital to study the significant factors that affect social cohesion so that studying these factors will allow these elderly visitors to optimize the effects of the Open Space on their well-being. To study and examine this subject in more depth, this paper focus on addressing the following research questions:
RQ1. What are the characteristics of Open Spaces that influence the visit of the elderly to these Spaces which have been addressed in the literature?

RQ2. What are the most influential factors affecting Social Cohesion aspects in these Open Spaces for enhancing visits of the elderly?

RQ3. What are the gaps, limitations, and future work recommendations for Open Space correlation with Social Cohesion on elderly for their well-being?

The researchers carried out a detailed review of 57 articles to address these questions. The study aims to identify the key aspects for integrating Open Space attributes and Social Cohesion for the well-being of the elderly in a residential community. Also, the outcomes of the research shall contribute to ongoing research by establishing an overview of the various social cohesion features extracted from case studies and reports. The rest of this review article is laid out as follows:

Section 2: Introduces the definition of Open Spaces and Social Cohesion based on the existing literature;

Section 3: Explains the review method used in the Systematic Literature Review (SLR) and how this research was carried out;

Section 4: Provides the results of SLR through data extraction and synthesis;

Section 5: Outlines the result of the research questions and establishing the correlations between Open Space and Social Cohesion; and

Section 6: Presents the conclusion to this Systematic Literature Review.

1.1 Definition Of Open Space And Social Cohesion

Regarding current research, there is not a clear consensus on the concept of open space. In the active living research, Open Spaces are essentially community parks and green spaces which are conceptualized concerning the pleasures of natural reserves and greenways (Wang & Kang, 2020). Many scholars have also identified Open Spaces based on diverse viewpoints, such as green spaces, urban Open Spaces, and Open Spaces catering to user needs. No precise description exists for these concepts (Wen et al., 2020). The concept defines the physical environment of public open space and the activity of the open space. There could be specific characteristics for designing an Open Space that can support walking paths, large areas for physical activities, as well as several other practices. As a result, prospective research would take into consideration a wider spectrum of public open space rather than Green Park and Open Spaces.

On the other hand, social cohesion has been researched extensively from a theoretical and methodological perspective. Numerous experimental studies have been conducted in this context. There have been different approaches in the longitudinal studies of social cohesion to observe and measure, influencing social cohesion and its resilience which create positive connectivity, also had led a point to the plurality of the ways to explore social cohesion.

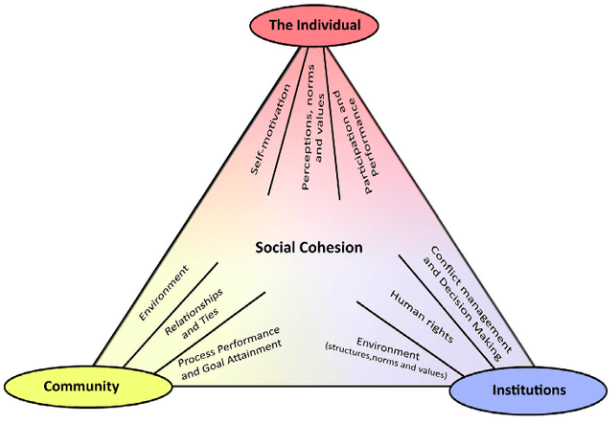


Figure 1: Framework to characterize social cohesion (Source: Fonseca et al.)

The framework for analysing social cohesion was proposed by Fonseca (see Figure 1), which explained the dynamic interactions and interrelationships found at all levels of social cohesion from individual to community, institutional level (Fonseca et al., 2019). The research concluded that all three levels of analysis must be considered when implementing a systematic approach to social cohesion research. There is an urge to construct a sense of belonging to a group for a society for an individual to maintain social cohesion. These cognitive values should be closely linked to the individual's interaction with the world to give them a stronger understanding of their environment. An individual will only be able to be a part of group activity and achieve optimal performance in that group setting if they have a proper environment that is compatible with their values and norms. Since the health and wellbeing of an older population are dependent on their daily activities and quality of life, there is a need to establish a strong co-relationship between their visits to the open spaces and assessing how they are performing during their stay in the spaces, developing the sense of social cohesion in the spaces. There is a need to understand the elderly quality life approach and the benefits of open space, particularly for older adults, to make them more active and healthy during their aging process. (See Table 1) It summarizes the various definitions of Open Space and Social Cohesion according to previous studies in line with the Urban Design research perspective.

Most experiments have not been able to resolve the problem of "self-selection" (Cao et al., 2006). People who enjoy using open spaces for their recreation can tend to reside in communities. These individuals could also have some attributes that complicate any comparisons (Kaczynski & Mowen, 2011). Longitudinal study designs have gained from numerous research on public open spaces and physical activities. The links between open spaces and physical fitness may be obscured (Veitch et al., 2014). Walking and the proximity to the open space, perceived nature, and scale of the larger open spaces are significant (Kaczynski et al., 2014). Empirical research is needed to check and determine if public open spaces have a long-term influence on physical wellbeing to promote social cohesion (Björk et al., 2008). The research suggests that people who gained access to different forms of open space have walked for 18-21 minutes

each time they had accessed open space (Koohsari et al., 2013). It can be inferred that open spaces with varying forms of activities can promote a positive association to social cohesion.

Table 1: Definitions of Open Space and Social Cohesion (Summarised by Author)

No.	References	Definition
Definitions of Open Space		
1	Schmidt et al. (Schmidt, 2008)	Public Open Space (POS) in residential areas are defined as urban open spaces near neighborhoods, such as public spaces around people's homes (e.g. streets, squares), neighborhood parks and community gardens.
2	Cheraghi et al. (Type & History, 2019)	POSs are defined subjectively and objectively different from the seniors' perspective because of mental and physical challenges as well as local socio-cultural differences based on the elders' quality of life approach.
3	Bedimo- Rung et al. (Model, 2005)	POS areas parks and green spaces, appear to be key built environment settings that provide opportunities for a variety of physical activity behaviors, such as recreational walking and playing sports.
4	Carmona M (Int & Carmona, 2018)	Within urban design research, public open space is defined as "managed open space, typically green and available and open to all, even if temporally controlled"
5	Nicole Edwards (Edwards et al., 2013)	Public open space as "spaces reserved for the provision of green space and natural environments, accessible to the general public free of charge".
6	National Heart Foundation of Australia (Badland et al., 2019)	POS are "spaces within the urban environment that are readily and freely accessible to the wider community, regardless of size, design or physical features and are intended primarily for amenity or recreation purposes – whether active or passive"
Definitions of Social Cohesion		
1	Durkheim (Berkman et al., 2013)	It is best defined by the absence of conflict or crime, to be studied through the level of the community/society.
2	Council of Europe (REPORT OF HIGH-LEVEL TASK FORCE ON SOCIAL COHESION, 2008)	It is linked to this level of the community through the shared values of reciprocity, loyalty, and solidarity, and the quality of social relations that includes the value of trust.
3	Canadian Government (Jeannotte, 2003)	The ongoing process of developing a community of shared values, shared challenges and equal opportunity within Canada, based on a sense of trust, hope and reciprocity among all Canadians.
4	OECD,2011 (The Challenges for Social Cohesion in a Shifting World, 2011)	A cohesive society works towards the well-being of all its members, fights exclusion and marginalization, creates a sense of belonging, promotes trust, and offers its members the opportunity of upward mobility.
5	Bernice et al. (Lott & Lott, 1965)	Group cohesion is the desire of individuals to maintain their affiliation with a group, and this drive is measured by influence and initiative, task competence, and especially like-dislike.

2. Review Methods

To answer the research questions posed in this research, the systematic analysis methodology outlined by (Hanafizadeh et al., 2014) was used. A systematic literature review, as suggested by (Marakhimov & Joo, 2017), describes a process to identify, analyze, and interpret the existing studies that are directly relevant to research into a given subject or phenomena.

In section 1, it has been found that many researchers have emphasized the importance of open space and its impact on health and wellbeing. However, the scope for further research for conducting a systematic review has been considered to address:

a. The characteristics of open space for enabling the elderly visit to foster social cohesion to keep them active.
b. Identification of current studies' potential limitations related to open space factors and social interaction attributes and to recommend the further scope of research in this direction.
c. To provide a conceptual framework establishing the relationship between Open space and social cohesion based on in-depth understanding through literature review to address new research dimensions. (Hanafizadeh et al., 2014).

The aspects mentioned above are the key components for conducting a systematic review. Kitchenham and the Charters have been adopted by the researchers for the study. There are three main measures to carry out a systematic review of literature, i.e. planning, conducting, and reporting. Relevant activities and tasks are linked to each phase, such as framing the correct research question, developing the review protocol, identifying the parameters for the exclusion and inclusion of the SLR published studies, a search strategy followed by the collection of the primary study, data extraction, and data synthesis, and finally conclude the main study by writing the SLR. These two measures have, as Niknejad suggested, been thoroughly clarified in the following parts. (Niknejad et al., 2020).

2.1 Review Protocol

Following the description of the study topic for Systematic Literature Review, the next step of the SLR is to identify the review protocol and the research methods for performing the SLR to reduce the bias of the researchers. The portion of the analysis procedure to be carried out as a researcher comprises the following steps, which include the definition of the research question, the development of the search strategy, the step-by-step collection of the main primary studies determining the inclusion-exclusion criteria followed by data extraction and synthesis and, finally, the reporting of results. The review protocol applied for this analysis was adopted by the review protocol suggested by Niknejad (Niknejad et al., 2020). which had been found as the most appropriate research methodology for conducting SLR by the researchers which include the recent strategies summarized from previous studies. (See Figure 2) It explains the phase-wise explanation of the review protocol which have been applied for this systematic literature review.

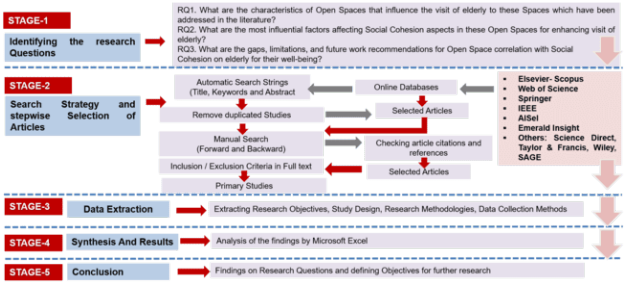


Figure 2: Review Protocol followed for SLR (Source: Author)

2.2 Inclusion and Exclusion Criteria

Researchers also established certain inclusion and exclusion criteria to assess the importance and significance of follow-up to study objectives to support researchers in conducting the SLR. The research focused largely on papers written in English between 2011 and 2021. This article is close to previous work undertaken the same year in 2011 because of the rationale behind the selection of 2011 to shape the first year of the search protocol. Past studies also aimed at an in-depth understanding of social cohesion and its impact on healthy aging for the elderly. The table (See Table 2) summarizes the inclusion and exclusion criteria considered for this study.

Table 2: Inclusion and Exclusion criteria for conducting SLR. (Source: Author)

Criteria	Principle
Inclusion	Papers published between 2011 and 2021
	Full text
	Peer-reviewed studies
	Papers focusing on Open Space and Elderly
	Papers focusing on Methodologies and strategies on impact analysis
	Papers that answer the defined research questions
Exclusion	Papers not in the English language
	Papers less than 3 pages
	Non-peer reviewed studies
	Papers with only Abstracts/ short communications etc.

2.3 Search Strategy

The search strategy proposed by Niknejad has been followed up in two steps both automatic and manual (Niknejad et al., 2020). In the Automatic search strategy, based on the keywords used in the research-based, a search string was defined. The main keywords according to the research questions which have been used as search strings are "OPEN SPACE", "ELDERLY", "COMMUNITY PARKS", "WALKABILITY", "ACCESSIBILITY ". The operators ''OR'' and ''AND'' were used to connect the primary keywords, the synonyms, and some related key terms. It should be noted that the researchers used the keywords by shifting the word positions or deleting some of the words during each search process to obtain the most relevant papers. The subsequent search string used was: ("URBAN OPEN SPACE", "SOCIAL COHESION",) AND (''Public open Space" or "POS") AND (''success factors'' or SF or ''success factors'' or ''significant factors'' or ''influential factors''). To execute these keywords, this study used Elsevier's Scopus database, which is the largest database for peer-reviewed international conferences and journals in the field of Open Space and Geriatric health.

2.4 Study Selection Process

The most important studies have been identified according to the objectives of the current systematic review. The search strategy defined in Section 3.3 was applied, resulting in 1305 articles. The titles, the abstracts, and the conclusion sections of all the collected papers were reviewed (675 papers). After duplicates were excluded, 155 papers were chosen as the secondary selection. Searching for literature is challenging when many scholars rely on the same keywords and buzzwords (Levy & Ellis, 2006). This research used the forward and backward search strategy to address these challenges. The forward and backward search technique was first put forward by Webster and Watson (Webster & Watson, 2002). The forward search technique involves tracing the texts referenced in the selected studies, while the backward search technique involves checking all the sources in each of the selected studies (Levy & Ellis, 2006). The Google Scholar search engine was used to perform the forward search process. A total of 110 papers were chosen after introducing forward and backward approaches. Subsequently, full-text screening was carried out based on inclusion and exclusion requirements, resulting in the deletion of 53 articles. In the end, 57 papers were left which were more relevant towards the objectives and the research questions framed to conduct a systematic literature review. These were the primary studies used for this systematic review about the current research of the last 10 years on Open space and attributes towards well-being (See Table-3).

Table 3 : Primary studies and their findings. (Source: Author)

ID	Title	Author/ Year	Objective	Theory/Model	Research strategy	Methodology	Data collection Method	Subject	Country	Online database Publisher	Theme
S1	A comprehensive review of thermal comfort studies in urban open space	Dayi Lai et al. (2020)	The objective of the research is to provide an understanding of outdoor thermal comfort with its direct and indirect infulence on visit of the users to Urban open spaces	Conceptual Framework	Review and Survey	Quantitative	Observation and interview	Outdoor thermal comfort	China	Science Direct	Identified direct and indirect influencing factors of OTC based on previous studies
S2	Acoustic demands and influencing factors in facilities for the elderly	Luying Wang et al. (2020)	To examine elderly individuals' acoustic demands categorized into the following three types: activity type, objective and demographic factors	Conceptual Framework	Objective measurements	Quantitative and Qualitative	semi-structured interview survey and	Acoustic demands	China	Science Direct	acoustic environment and their demands in open Spaces for elderrly
S3	A Framework for Elder-Friendly Public Open Spaces from the Iranian Older Adults' perspectives: A Mixed-Method Study	Azadeh Lak et al. (2020)	To identify the elders' preferences, especially their use of public open spaces (POSs) in Iranian urban neighbourhoods as well as identifying the association among the factors.	Grounded Theory (GT) & Partial least squares-Structural Equation Modelling (PLS-SEM)	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Semi-structured interviews	Non-physical dimensions of POS	Iran	Science Direct	Non-physical dimensions of POS (social environment, cultural environment and sense of belonging)
S4	Analyzing the effects of Green View Index of neighborhood streets on walking time using Google Street View and deep learning	Donghwan Ki et al. (2020)	The study examined the street Green View Index (GVI) and its associations with walking activities by different income groups	Google Street View (GSV) and deep learning	Review and Survey	Qualitative	Observation and interview	Green View Index and walking behaviour	South Korea	Science Direct	Importance of eye-level street greenery for analyzing the relationship between urban green and walking behavior.
S5	Area-Level Associations between Built Environment Characteristics and Disability Prevalence in Australia: An Ecological Analysis	Nicola Fortune et al. (2020)	To explore associations between area-level disability prevalence for people aged 15–64 years and area-level built environment characteristics in Australian Cities	Conceptual Framework	Review and Survey	Quantitative and Qualitative	Observation and interview	Ecological analysis	Australia	Elsevier	geographically targeted interventions improve access to health-enhancing neighborhood
S6	Assessing the Rationality and Walkability of Campus Layouts	Zhehao Zhang et al. (2020)	To develop a new campus walkability assessment tool, which optimizes the Walk Score method based on the frequency, variety, and distance of students' walking from public facilities.	Walk Score Method	Review and Simulation	Quantitative and Qualitative (Mixed Method study)	Observation and interview	Walkability	Tianjin	Elsevier	evaluate the rationality of facility layout and walkability, and to give suggestions for improvement.
S7	Association of street greenery and physical activity in older adults: A novel study using pedestrian-centered photographs	Hui He et al. (2020)	To study the street greenery association with the odds of achieving 300 mins or more of physical activity per week for the elderly	Machine learning technique along with the pyramid pooling module.	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Observation and interview	Pedestrian-centered street greenery	China	Science Direct	Adding street greenery or improving existing street greenery create an aging-friendly urban environment
S8	Attitudes of Polish Seniors toward the Use of Public Space during the First Wave of the COVID-19 Pandemic	Beata Fabisiak et al. (2020)	The study focus on the recognition of the needs of seniors concerning the use of public spaces in the times of the COVID-19 hazard.	Conceptual Framework	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Observation and interview	Visit to Public Open Spaces during COVID	Poland	Elsevier	Redesign public spaces minimize the feeling of fear when using public spaces after the lockdown were evaluated by seniors.
S9	Awareness of urban climate adaptation strategies –an international overview	Sanda Lenzholzera et al. (2020)	To understand what different actors know about the different types of interventions to improve urban climate conditions and how their awareness level can be raised.	Conceptual Framework	Pilot study using semi-structured interviews	Quantitative and Qualitative (Mixed Method study)	Semi-structured interviews	Urban climate conditions and their awareness level	Ten countries	Science Direct	Awareness raising should involve media campaigns, further education and display of good practice.
S10	Blue space, health and well-being: A narrative overview and synthesis of potential benefits	Mathew P. White et al. (2020)	To provide a model of how exposure to aquatic environments, or blue spaces such as rivers, lakes benefit health and well-being.	Conceptual Framework	Narrative review approach	Qualitative	Review	Aquatic environments and its relation to well being	UK	Elsevier	A narrative overview and synthesis of the potential benefits of aquatic environments for health and well-being

S11	Correlates of frequency of outdoor activities of older adults: Empirical evidence from Dalian, China	Zhengying Liu et al. (2020)	to examine the association between neighborhood characteristics and the frequency of type-specific outdoor activities.	Empirical Investigation	zero-inflated count modeling approach	Quantitative and Qualitative (Mixed Method study)	Semi-structured interviews	leisure walking and skill-based leisure activities.	China	Elsevier	Create physical activity-supportive and inclusive neighborhood environments for older adults
S12	Design Strategy of Friendly and Healthy Environment for Urban Aging Community	Xiaoyi Hu et al. (2020)	To examine how to achieve the local benefits of the elderly in urban aging communities	Empirical Investigation	Review and Survey	Qualitative	Semi-structured interviews	elderly's adaptation to the community's outdoor environment	China	Elsevier	the relationship between the daily activities of the elderly and the community environment,
S13	Effects of the built and social features of urban greenways on the outdoor activity of older adults	Po-Ju Chang (2020)	To examine the effects of the physical and social environment of neighbourhood greenways	multilevel model	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Semi-structured interviews	neighbourhood social capital	Taiwan	Elsevier	natural elements to promote outdoor activity among older adults.
S14	Environmental and Psychosocial Interventions in Age-Friendly Communities and Active Ageing: A Systematic Review	Diego Sánchez et al. (2020)	To determine the available empirical evidence in relation to the characteristics, content and effectiveness improving environmental and psychosocial risk factors for older people	Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)	Review	Qualitative	Review	Environmental and Psychosocial Interventions	Spain	Elsevier	Interventions focused on personal and organisational aspects might have positive e ects in the longer term.
S15	Equality in access to urban green spaces: A case study in Hannover, Germany, with a focus on the elderly population	Chen Wen et al. (2020)	Understanding the spatial disparity in access to urban green and blue infrastructure (UGBI), with a special focus on the elderly.	"2SFCA" approach	Review	Quantitative and Qualitative (Mixed Method study)	Semi-structured interviews	Allocation of green spaces	Germany	Elsevier	Key locations for allocating green spaces and improving the connection between residential areas and UGBI.
S16	Equity to Urban Parks for Elderly Residents: Perspectives of Balance between Supply and Demand	Meng Guo et al. (2020)	quantitative evaluation of the equity of di erent levels of urban park under multiple traffic modes.	Integrated Spatial Equity Evaluation (ISEE) framework	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Semi-structured interviews	Suggestions for urban parks planning and decision-making.	China	Elsevier	Efficiency of urban parks provision
S17	Exercise intervention outdoor proJect in the communitY for older people – results from the ENJOY Seniors Exercise Park project translation research in the community	Pazit et al. (2020)	To implement and evaluate the effects of sustained engagement in physical activity on mental, social and physical health outcomes through the use of the Seniors Exercise Park physical activity program for older people	Test battery evaluating physical activity & measures of ANOVA	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Semi-structured interviews	Sustaining older people's wellbeing	Melbourne	Elsevier	Seniors Exercise Park may be an effective modality for improving and sustaining older people's physical function and wellbeing
S18	Exploring the disparities in park accessibility through mobile phone data: Evidence from Fuzhou of China	Yuying Lin et al. (2020)	To properly measure the accessibility of park.	Two-step floating catchment area (2SFCA)	Geographically weighted regression (GWR) technique.	Quantitative and Qualitative (Mixed Method study)	Observation and interview	accessibility of park by elderly	China	Elsevier	Different key factors of park accessibility are identified
S19	Health-oriented vegetation community design: Innovation in urban green space to support respiratory health	Jiayu Wua et al. (2020)	Could urban green space exert a significant effect on respiratory diseases? In what way (vegetation cover, vegetation community, or dominant species) does urban green space affect respiratory health?	Conceptual Framework	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Observation and interview	Green space affect respiratory health	China	Elsevier	From the vegetation coverage perspective, the area with a high degree of greenery is highly conducive to respiratory health.
S20	Health risk for older adults in Madrid, by outdoor thermal and acoustic comfort	María et al. (2020)	To analyse the outdoor thermal and acoustic comfort of older adults in public spaces	Physiological Equivalent Temperature (PET) and Universal Thermal Index (UTCI).	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Observation and interview	acoustic comfort of older adults	Madrid	Elsevier	Environmental conditions as well as the subjective perception of thermal and acoustic comfort, are statistical related to older
S21	How Do Older Women Perceive their Safety in Iranian Urban Outdoor Environments?	Azadeh Lak et al. (2020)	To explore the perception of older women about safety and its related features in outdoor spaces according to promoting Active Ageing	Qualitative content analysis Analytic hierarchy process	Review and Survey	Mixed-method study	Semi-structured interviews	Women Safety in outdoor spaces	Tehran	Elsevier	Both personal and environmental features that can be targeted to meet the needs of vulnerable population.
S22	How to accurately identify the underserved areas of peri-urban parks? An integrated accessibility indicator	Jinguang Zhang et al. (2020)	The integrated accessibility index can be employed to accurately monitor underserved areas and strategies for improving residential access to peri-urban landscapes.	Huff-2SFCA (two-step floating catchment area) model	Review and Survey	Peri-urban park quality index	Semi-structured interviews	An integrated accessibility index for peri-urban parks	China	Science Direct	Integrated accessibility index can be employed to accurately monitor (potentially) underserved areas.

S23	Humanistic demand and spatiotemporal perspective in the evaluation of urban life quality—A case study of Shandong Province in China	Wen Zeng et al. (2020)	Study on people-environment relationship by combining Maslow's Hierarchy of Needs with urban development.	Spatiotemporal evolution pattern.	Review and Survey	Geographical analysis	Review	People-environment relationship	China	Elsevier	Growth rate of safety factors, social factors, and respect factors has differences between cities and regions,
S24	Improving City Vitality through Urban Heat Reduction with Green Infrastructure and Design Solutions: A Systematic Literature Review	Helen Elliott et al. (2020)	It investigates how green infrastructure, passive design and urban planning strategies—herein termed as green infrastructure and design solutions (GIDS)—can be used to cool the urban environment and improve city vitality.	Systematic literature Review based on PRISMA Model	Review and Survey	Qualitative	Review	Green infrastructure and design solutions	Australia	Elsevier	GIDS manage urban energy flows to reduce the development of excess urban heat
S25	Inclusive Parks across Ages: Multifunction and Urban Open Space Management for Children, Adolescents, and the Elderly	Elin P. Sundevall et al. (2020)	To make parks more inclusive, UOS management may need to consider multifunction and the perspectives of various age groups in future development and maintenance activities.	Conceptual Framework	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Semi-structured interviews	Concerning a ordances and UOS management.	Sweden	Elsevier	Social multifunction can be developed in programmed or non-programmed ways
S26	Modeling the dynamics and walking accessibility of urban open spaces under various policy scenarios	Xun Liang et al. (2020)	The study proposes a new Open-Space simulation model using cellular automata (OS-CA) for creating new OS with different construction time-lags.	Conceptual Framework	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Observation and documentation	OS-CA is an effective tool for assessing the policies for creating new OS.	South China	Elsevier	Effectiveness of creating new OS is assessed using the walking accessibility and the population coverage rate.
S27	Open Access Neighborhood's locality, road types, and residents' multimorbidity: evidence from China's middle-aged and older adults	Xuexin Yu et.al (2020)	The aim is to depict variations in the number of non-communicable chronic diseases (NCDs) as a function of urban vs. rural settings and road types.	Cross-sectional study	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Semi-structured interviews	The improvement in neighborhood-level characteristics alleviate the increasing disease	China	Elsevier	Urban vs. rural disparities in multimorbidity appeared to result from within-neighborhoods characteristics.
S28	Neighbourhood environment and depressive symptoms among the elderly in Hong Kong and Singapore	Winnie W. Y.et al. (2020)	This study aims at identifying the relevant neighbourhood attributes, separate from the individual-level characteristics, that are related to the onset of depressive disorders among the geriatric population.	Structural equation modelling (SEM) approach	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Semi-structured interviews	Neighbourhood attributes related to the onset of depressive disorders	Hong Kong and Singapore.	Elsevier	Geriatric depression can be achieved by neighbourhood environment in an ageing society.
S29	Public Open space, Green exercise and well-being in Chittagong, Bangladesh	Alak Paul et al. (2020)	The study aims at explored visitors' activities in POS and their perception on well-being outcomes	Cross-sectional study	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Structured interviews	Green exercise could be an important public health	Bangladesh	Elsevier	Enagement of POS such as urban green spaces, green exercise could be an important public health intervention
S30	Quality of urban parks in the perception of city residents with mobility difficulties	Magdalena Baszczyk et al. (2020)	To study the importance of access increases for residents with limited mobility to surrounding physical space, are exposed to social exclusion.	Empirical Investigation	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Semi-structured interviews	Accessibility to public space for Social cohesion	Poland	Elsevier	Differences included preferences towards the neighbourhood and destination parks
S31	Designing Urban Green Spaces for Older Adults in Asian Cities	Zheng Tan et al. (2019)	Information regarding how to plan and design urban green spaces with certain characteristics that could improve the accessibility and aesthetic quality	statistical model (moderation analysis)	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Semi-structured interviews	UGS and its association with mental health	China and Taiwan	Elsevier	The duration of visits to UGSs (urban green space) was positively associated with mental health and social functioning
S32	The associations between neighborhood walkability attributes and objectively measured physical activity in older adults	Bo-Chen et al. (2019)	This study aimed to examine geographic information systems-derived neighborhood walkability attributes and accelerometer measured PA in older adults.	Multiple linear regression	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Semi-structured interviews	High sidewalk availability in neighborhood supportive for older adults'	Taiwan	Google Scholar	Study objective measures to examine the associations between the built environment and physical activity (PA) among older adults
S33	Study of open spaces in urban residential neighbourhood – Madurai	R.Shanthipriya et al. (2019)	Exploring provision of open space to create an identity to the neighborhood.	Cross-sectional study	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Semi-structured interviews	Open Space creating identity	India	Google Scholar	Importance of the usage of open spaces serving as a seed for the social interaction.
S34	Associations between Neighborhood Open Space Features and Walking and Social Interaction in Older Adults—A Mixed Methods Study	Tanja Schmidt et al. (2019)	Mixed methods study to investigate the association between built environment features, social interaction, and walking within NOS, among older adults living in a low socio-economic neighborhood	Exploratory sequential mixed methods study	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Community Park Audit Tool, System for Observing Play and Recreation in Communities (SOPARC)	Open Space and features of built environment in older adults	Copenhagen	PubMed	The importance of social interaction within NOS.

S35	Digital Inclusion for elderly citizens for a sustainable society	Jesper Holgersson et al. (2019)	focuses on digital inclusion for elderly citizens, addressing goal 10 of the United Nations global sustainability goals	Conceptual Framework	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Semi-structured interviews	Digital inclusion and elderly	Sweden	AIESel	a cross-generational teaching and learning approach – young people (digital natives) interacting with elderly
S36	Older Adults' Needs and Preferences for Open Space and Physical Activity in and Near Parks: A Systematic Review	Lene et.al (2018)	To analyse the link between open space and physical activity promotion for older adults	Descriptive and correlational study	Review and Survey	Qualitative	Review	Link between open space and physical activity	Los Angeles	Google Scholar	Major gaps exist in the literature regarding the link between open space and physical activity promotion for older adults.
S37	Neighbourhood adaptability for Hong Kong's ageing population	Peng Zang et.al (2018)	This investigation generates conclusions of built enviornment characteristics which are different with those in low-density environment observed in the Western societies.	Descriptive and correlational study	Review and Survey	Qualitative	Semi-structured interviews	Built enviornment features and elderly	China	Springer	Built environment characteristics influence the physical activity of Hong Kong's older adults.
S38	A Conceptual Guideline to Age-Friendly Outdoor Space Development in China: How Do Chinese Seniors Use the Urban Comprehensive Park? A Focus on Time, Place, and Activities.	Yang Zhai et al. (2018)	Aim of this paper is to narrow the gap between the theoretical findings from past studies and current open space development through evaluating the behavior pattern and landscape preferences of seniors in urban parks	Cross-sectional study	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Semi-structured interviews	Behavior pattern and landscape preferences	China	Web of Science	New perspectives for further investigations have been pointed out for landscape establishing a successful age-friendly outdoor space.
S39	Co-creation Model to Design Wearables for Emotional Wellness of Elderly	Usman Warraich et al. (2018)	The objective of this research is to find the role of technology in order to improve emotional wellness for the elderly population.	Co-creation model	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Semi-structured interviews	technology to improve emotional wellness	Finland	AIESel	Need for focused efforts to develop digital interventions for emotional wellness for elderly.
S40	Assessment of and Improvement Strategies for the Housing of Healthy Elderly: Improving Quality of Life	I-Ming Feng et al. (2018)	This study aims to effectively assess and improve the housing environment of the elderly in order to enhance their quality of life	Multi-Criteria Decision Analysis model, a combination of the DEMATEL, ANP DANP	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Review	Housing environment of the elderly	Taiwan	Elsevier	Effectively assess and improve the housing environment of the elderly in order to enhance their quality of life
S41	Urban Living Room: An explorative study of elderly and public space in high density living	Maing et.al (2017)	Public-housing developments with varying associated amenities and public space impacts on ageing	Exploratory study	Review and Survey	Qualitative	Review	Public space impacts on ageing	Hong Kong	Google Scholar	Public space planning affects elderly behavior in different living conditions.
S42	Designing User Interfaces for the Elderly: A Systematic Literature Review	Connor Dodd et.al (2017)	A systematic literature review to provide a structured overview of the current state of the literature regarding user interface development for elderly users over a variety of domains.	Conceptual Framework	Review and Survey	Qualitative	Review	User interface development for elderly user	Australia	AIESel	Provides a direct benefit to system designers looking to produce a user interface that addresses the needs of elderly users.
S43	Public Open Space Development for Elderly People by Using the DANP-V Model to Establish Continuous Improvement Strategies towards a Sustainable and Healthy Aging Society	Bo-Wei Zhu et al. (2017)	Relationship between healthy ageing society and impact of open space on it	DANP-V model	Review and Survey	Qualitative	Review	cognitive differences between expert and elderly groups.	China	Web of Science	Findings have both theoretical and practical implications for POS and healthy ageing of elderly
S44	The Safety of Walking Space for the Elderly People Living in Communities in Beijing, China	Shuwen Yang et al. (2017)	The walking space in the communities is important for the safety of the elderly people.	Cross-sectional study	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Semi-structured interviews	Safety of Walking Space for the Elderly	China	Google Scholar	Importance of walking space of the elderly people living in the communities.
S45	Social Media as Enabler for ICT Inclusion to Achieve Active Ageing	Celeste J. Chan et al. (2017)	To study the participation of the elderly in the urban area in the country who are experiencing first-level digital divide.	Social cognitive theory	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Semi-structured interviews	Social media is a potential tool to promote the active engagement	Philippines	AIESel	The elderly in the urban area in the country are experiencing first-level digital divide.
S46	Older Adults in Public Open Spaces: Age and Gender Segregation	Rinat Ben Noon et al. (2017)	Activities of older adults in public open spaces	Narrative Descriptions	Review and Survey	Qualitative	Observation and documentation	activities of older adults in public open spaces	Isreal	Oxford Academic	To date, there has been limited research on everyday activities of urban older adults in public open spaces
S47	Physical activity and healthy ageing: A systematic review and meta-analysis of longitudinal cohort studies	Daskalopoulou et al. (2017)	To study Physical activity (PA) can influence the ageing process but the specific relationship with healthy ageing (HA)	Systematic review and meta-analysis of longitudinal studies	Random-effect meta-analysis	Qualitative	Observation and documentation	Physical activity (PA) can influence the ageing	UK	Elsevier	PA is positively associated with HA, regardless of definition and measurement.

S48	Modeling Elderly Accessibility to Urban Green Space in High Density Cities: A Case Study of Hong Kong	Fangying Gonga et al. (2016)	Improving elderly accessibility to green space is useful in promoting more physical activity	landscape fragmentation index (LFI) of green space patches and accessibility analysis	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Observation and documentation	Elderly accessibility to green space	Hong Kong	Elsevier	To increase the green space accessibility either by improving the walking routes
S49	Classifying community space at a historic site through cognitive mapping and GPS tracking: The case of Gulangyu, China	Yuan Li et al. (2016)	This article adopts a quantitative approach to identify various types of community spaces, by overlaying cognitive maps of the local community with data on the behavioral patterns of tourists via GPS tracking.	Cognitive mapping, GPS tracking, and GIS visualization methods.	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Observation and documentation	community spaces on the behavioral patterns via GPS tracking.	China	Springer	New analytical frameworks for the sustainable development of historic sites by the classification of community spaces
S50	A Model for Reflective Participatory Design - The Role of Participation, Voice and Space	Birgitta et al. (2015)	To improve the health and wellbeing of older people in the northern periphery regions of Europe, through new mobile services.	Reflective participatory design	Review	Qualitative	Review	systems development and user participation.	Northern periphery regions of Europe,	AIESel	qualitative fieldwork in a participatory project aimed to improve the health and wellbeing of older people
S51	The Role of Open Space in Urban Neighborhoods for Health-Related Lifestyle	Katarina et al. (2014)	Open space quality affects health-related behavior of elderly	behavior observation and mapping	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Observation and documentation	Influence of variables on physical activity	Ljubljana, Slovenia	Pub Med	strong influence of a set of socio-economic variables on physical activity and self-perceived health status of people
S52	Healthy campus by open space design: Approaches and guidelines	Stephen Siu et al. (2014)	This paper examines the architectural and landscape design strategies and intentions for green, open spaces facilities targeting stress alleviation for learning environments such as those of university campuses in a compact urban setting.	Corresponding design approaches	Review	Qualitative	Observation and documentation	Landscape design targeting stress alleviation	China and US	Elsevier	A healthy campus should encompass diverse open spaces to satisfy different purposes.
S53	Relation between visitors'behaviour and characteristics of green spaces in the city of Granada, South-eastern Spain	Cristiano Adinolfia et al. (2014)	The relation between visitor behavior and certain features of a number of major green spaces.	behavior observation and mapping	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Observation and documentation	relation between visitor behaviour and certain features of a number of major green spaces	Spain	Elsevier	Findings indicated that these spaces were used largely for purposes directly related to well-being
S54	New urbanism design principles and young elderly active lifestyle: An analysis of TTDI neighbourhood in Kuala Lumpur, Malaysia	Hanan Elsawahli et al. (2014)	This article aims to explore the relationship between young elderly active lifestyle and the built environment.	New Urbanism design principles, correlation and multiple regression	Descriptive research	Qualitative	Observation and documentation	Active lifestyle of elderly and the built environment	Malaysia	Springer	The results showed that New Urbanism design principles promoted active lifestyles among the young elderly.
S55	Open spaces increase the quality of built up areas	K. Lestan et al. (2013)	How size and equipment of open spaces influence the ways in which they are used.	experimental method of observations and behavioral mapping	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Observation and documentation	evaluating selected urban design indicators	Ljubljana	Google Scholar	It explores how size and equipment of open spaces influence the ways in which they are used.
S56	Comparative analysis of utilisation of open space at neighbourhood level in three Asian cities: Singapore, Delhi and Kuala Lumpur	Sadasivam Karuppannan et al. (2013)	This article investigates the utilisation of open space at the neighbourhood level is more associated with the physical and functional properties of open space or if it varies across different cultures and contexts of cities.	Conceptual Framework	Review	Quantitative and Qualitative (Mixed Method study)	Observation surveys	open space as an important component of a healthy urban environment	Asian Cities: Singapore, Delhi and Kuala Lumpur	Springer	The utilisation of public space at various levels of neighbourhood significantly differs between cities because of the local context, such as culture, social values and climate
S57	Associations between physical activity and characteristics of urban green space	Jasper Schipperijn et al. (2012)	The study focus on the association between UGS and outdoor PA in general, as well as PA in the nearest UGS	Descriptive and correlational study	Review and Survey	Quantitative and Qualitative (Mixed Method study)	Observation surveys	Association between UGS and outdoor PA	Denmark	Elsevier	PA in a UGS might be stimulated by providing these features

3. Data Extraction And Synthesis

This section outlines how the details from the collected publications are extracted and interpreted. Each primary analysis has been carefully read and the related data from the report have been collected using the Mendeley program and the Microsoft Excel chart. Microsoft Excel data was entered based on Study ID, Title, Author/Year, Purpose, Theory/Model, Analysis Strategy (R&M), Technique, Data Collection Process, Subject, Location, On-line database, Publisher/Theme. The items were included in the analysis based on the study's established research goals and research questions. The relevant aspects of these items are listed (See Table-4).

Table 4: The extracted data from primary studies. (Niknejad et al., 2020).

Extracted data	Description
Study ID	A unique identity for each primary study.
Author(s)	The name of the authors.
Publication year	The year in which the paper was published.
Title of study	The title of the paper that is visible in the searching step.
Source type	Journal, conference proceeding, workshop, and book chapter.
Country	The place where the empirical studies were conducted.
Subject	The representative group (subject) of data collection in empirical studies.
Methodology	Design science, quantitative, qualitative, mixed method etc.
Research strategy	Case study, survey, experiment, action research, archival research,
Data collection method	Interview, questionnaire, observation, secondary data, etc.
Theory/Framework	The theory or framework the paper had adopted.
Objectives	The main objective of the papers.
Findings/Factors	The factors or findings of the empirical studies.
Future work	The future works suggested in the primary articles.

The figure (see Figure 3) introduces a weighted cloud theme, which was generated by Jason Davies word cloud generator. Most of the primary studies discussed the mixed-method study approach for Open Space study, observation, and semi-structured interviews as tools. It can be concluded that most of the primary studies discussed the mixed-method study approach for Open Space study, observation, and semi-structured interviews as tools, whereas research was majorly focussed on attributes of Open spaces like accessibility, activity, environment, social, urban space, outdoor walking.

Figure 3:Weighted focus cloud generated by Jason Davies word cloud generator

3.1 An Overview Of The Publication Sources

(See Figure 4) indicates key research publishing sources. Of the 100% key research, 5.5% reported at the conference, 73.8% journals, 8.7% published in reviews and 5.2, % published in book chapters, and 5.4% published in books, although other sources retain 1.4%.

The distribution of primary studies based on hypotheses and models. Much of the primary studies were chosen from eminent conferences and reliable and high-impact papers. Much of the papers examined were written in Springer (4 Articles), accompanied by Google scholars (6 papers), AISeL (5 papers), and Elsevier (30 papers). The remaining studies were published in Science Direct (7 papers), Oxford Academic (1) and Web of Science (2 papers), and Pub Med (2 papers). The studies reflected that most of the research articles had adopted a review and survey approach to objectively measure the various attributes influencing the elderly to visit Open spaces. However, few researchers had also attempted to develop a conceptual framework and model to analyze the significant impacts of certain key features influencing the visit to these Open spaces by the elderly as their research strategy (See Figure 5)

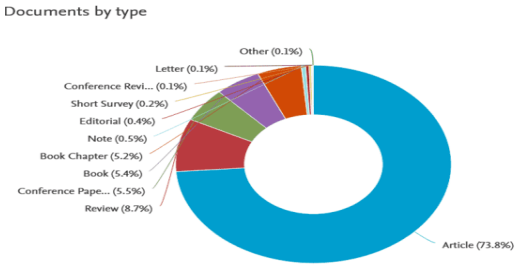


Figure 4: Publication Sources (Source: Author)

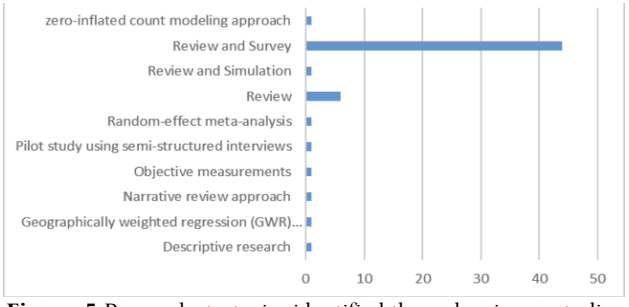


Figure 5:Research strategies identified through primary studies (Source: Author)

3.2 Temporal View Of The Publication

As mentioned above, academic papers reported in this systematic review between 2011 and 2021 have been selected. The distribution of the primary studies over this period (See Figure 6). Consistent progress has been achieved in the field of research, as can be seen from the figure when it is year-wise reviewed. The International Journal of Environmental Research and Public Health has shown an increase in the number of publications from 2014 to the date followed by other journals. The reason for choosing these journals as a research archive is primarily due to the number of publications in the research field defined by the researchers undertaking the SLR review process.

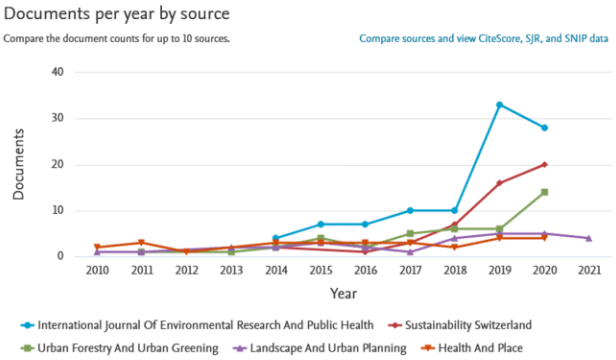


Figure 6:Documents per Year as per Source (Source: Author)

3.3 Research Methods

Saunders et al. (See Figure 7: "Research Methods for Business Students" Chapter 4: Understanding research philosophy and approaches to theory development) defined 'research method' as the techniques and processes employed to obtain and analyze data. This definition includes both the data collection methods (interview, questionnaire, etc.) and the data analysis techniques and procedures (Qualitative, Quantitative, etc.). This study used the term 'research methodology' to refer to the techniques for analyzing data. The relevance of this approach in our SLR is mainly due to the mixed-method approach which had been adopted by most of the researchers identified from primary studies.

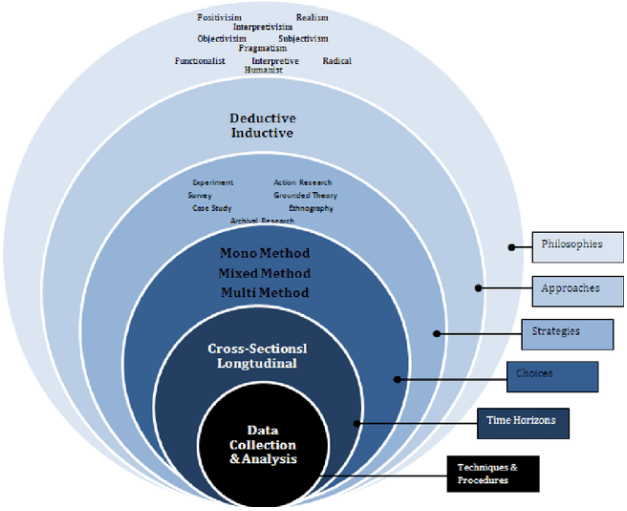


Figure 7: Research" Onion" proposed by Saunders et al.

The figure (See Figure 8) presents the methodologies that were adopted by the selected studies. The majority of the primary studies applied a mixed-method study (both qualitative and quantitative) while the rest adopted the qualitative, geographical analysis, and Peri-Urban Park Quality index (PQI).

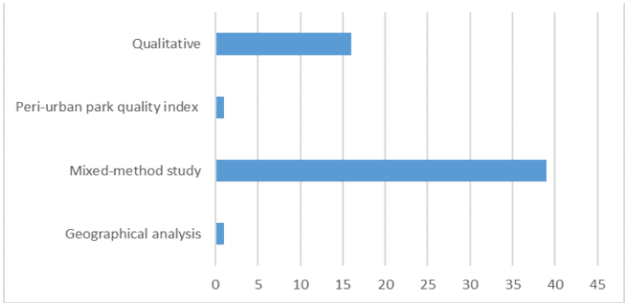


Figure 8:Methodologies adopted in the studies (Source: Author)

It has also been found through the primary studies that various conceptual and theoretical frameworks had been incorporated to objectively measure the effects and impacts of spatial characteristics on the visit to these spaces like greenery, street view, area level associations, outdoor thermal comfort, physical activities aspects, landscape preferences, etc. (See Figure 9).

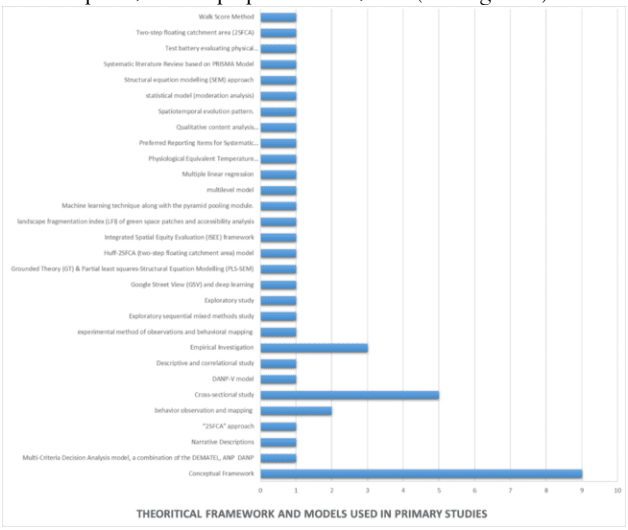


Figure 9: Theoretical Framework and Models used in primary studies (Source: Author)

4. Research Question (Rq) Results

The aim of this systematic review, as stated in Section 1, was to answer research questions concerning open space visits and social cohesion for the elderly. The answers to each study query are addressed in this segment.

RQ1. What are the characteristics of Open Spaces that influence the visit of the elderly to these Spaces which have been addressed in the literature?

Research into the potential health and well-being advantages of residing near parks and spending time in and around 'green space' is prevalent (Model, 2005). The temperature of the skin was considered to be a strong predictor of outdoor thermal comfort (Lai et al., 2020). (Wang & Kang, 2020) found a strong positive association between the preference of elderly people for the general acoustic climate and their requirements for the inclusion of natural sounds. Green areas require water supplies to stay green, and often blue areas are part of green infrastructures (e.g. park reservoirs, river towpaths)

Nevertheless, blue areas within these ecosystems have their range of threats and benefits for human health and advantages (White et al., 2020). Some concerns ought to be considered independently from green space as a whole. In the study of urban greenness and walking behavior, the significance of eye-level greenery is necessary, since an evaluation of the effect of Greenery Street on walking activities is also significant (Ki & Lee, 2021b). Similarly, (Lak, Aghamolaei, Baradaran, et al., 2020) proposed that in environments - as the non-physical aspects of the POSs - the mechanism in which the elderly reside has an essential effect in outdoor environments (social climate, cultural and sense of belonging). The locational functions (access to services, urban scenery, and clean environment), as well as the preferences for location (crime security, fear of dropping security, and the appearance of the elderly), are more likely to fulfill the needs of elders in urban areas. From the study, it is therefore concluded that influential factors are affecting the visit of elderly to these Open spaces which were supported through various literature and previously published works (See Figure 10). Many researchers have also marked significant ideal characteristics of Open Spaces which have a major role towards the visit to these Spaces by elderly. However, each factor is addressed with certain challenges which as designers, architects, need to intervene to make these Urban Spaces accessible and eventually could develop a sense of belonging to the visitors to enable them to visit these spaces more regularly. Further research in this regard could be how to make these spaces: Emerging (whether formal or informal), dynamic (avoiding one-size-fit-all), Accessible (with secure rights and protections), Delineated (clearly accessible through their use), participating (designing in-active uses), Meaningful (incorporating prominent features and facilities), Civic, integrated (between traffic and pedestrian), relaxed (feeling protected and restful) and vigorous (encouraging social participation).

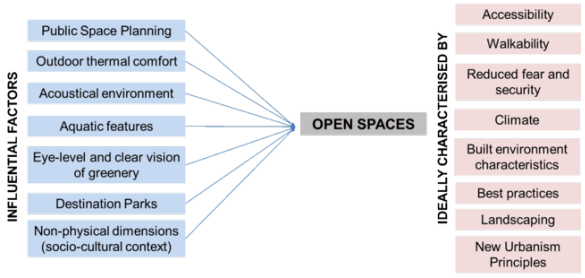


Figure 10: Factors influencing visit to Open space and its identified characteristics. (Source: Author)

RQ2. What are the most influential factors affecting Social Cohesion aspects in these Open Spaces for enhancing visits of the elderly?

Social cohesion influences the proximity and existence of urban green areas in an urban context (Francis et al., 2012). Different activities and well-being promoting practices in green spaces in the neighbourhood will foster social connection and the other way around. Urban green spaces help and ultimately affect the social structure of urban areas and will play a key role in the development of community relations. The mechanisms by which neighbourhood green parks can promote social unity stimulate the need to expand our point of view on their role in open spaces. The characteristics of the integrated environment and courtesies in neighbourhood open spaces can be linked to social cohesion along these lines. The degree of engagement inside the open space (e.g. administration and volunteering) may vary depending on the characteristics. The processes by which community green parks can foster civic harmony stimulate the need to extend our viewpoint on their role in open spaces. Community benefits of environmental and general well-being systems may help educate green spaces in the region. An example of these interactions is the paradigm of environmentally sustainable ecosystem services. Some researchers have suggested that social interaction and networking are the advantages of nature to the social biological system administration. We should use our expertise to encourage interdisciplinary collaborative activities to enhance individual, cultural well-being networks. Social cohesion at individual level and community level had been proved through various empirical investigations. As far as we are conscious, no experimental research on social cohesion takes the formal institutional perspective (the characteristic of the third stage of social cohesion). The impact of and within levels in the design and implementation of strategies will be discussed in future studies. The various factors influencing social cohesion attributes in open spaces for elderly analysed through primary studies is represented (See Figure 11).

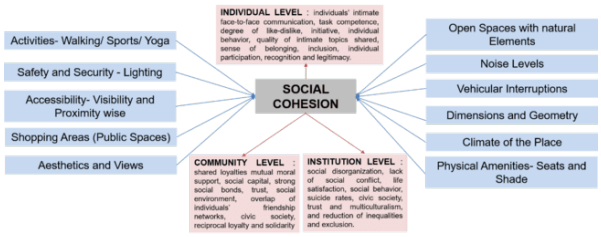


Figure 11:Factors influencing Social Cohesion attributes in Open spaces for Elderly. (Source: Author)

RQ3. What are the gaps, limitations, and future work recommendations for Open Space correlation with Social Cohesion on elderly for their well-being?

From the study it has been found that since Open Space plays an integral role in well-being, investigating the relationship between open spaces and social cohesion can guide crucial intercessions to address the challenges of well-being. High community associations can lead to an increase in engagement and support for the community. This mostly benefits emotional attachment, hence there is a need to enhance the increased experiences to participate in social welfare with personal desires with the perception of green spaces as a social condition which will improve communities to promote physical activity and other sound activities. Many research indicates that regions, where people are comfortable and willing to walk, are valuable for optimistic attitudes regarding social experiences and generate appreciation for open spaces. However, the studies have certain limitations like how each attribute of spatial planning within these open spaces is going to influence the user's visits to these spaces and to what level. The various attributes have been identified to enhance the wellbeing of the elderly by fostering social cohesion in these open spaces summarized

within the conceptual framework (See FIGURE 12). Further research needs to be directed towards prioritizing the various attributes and an empirical investigation on these attributes analysing their impacts on the wellbeing which need to be addressed in further scope of research.

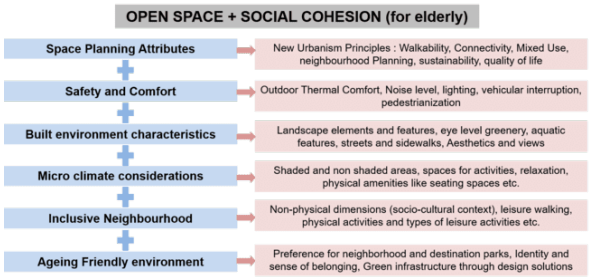


Figure 12: Conceptual framework for integrating Open Space attributes and Social Cohesion for the well-being of the elderly (Source: Author)

5. Discussion

The analysis of the systematic review presented us with a wide awareness of the open space characteristics that lead to better social cohesion for the elderly. Firstly, it is shown that good health and social cohesion build a neighborhood-friendly atmosphere inside an elderly residential society. Conceptual and methodological aspects related to existing studies are topics that must be taken into account when investigating health inequalities at the population level, such as range, aggregation, different measurement attributes, and the nature of features as objective and complex characteristics. The living conditions promote social cohesion, which contributes to an increase in safe life expectancy. Examining the significance of various social contexts thus helps us to better consider and cope with heterogeneity, resulting in consistent assumptions. Focusing public health services on the most critical issues will assist them in lowering costs and improving overall health. Therefore, planning of Public Spaces to enhance social cohesion is a major challenge for the designers which is a primary aspect of Urban planning. Nonphysical dimensions like socio-cultural contexts have been addressed as one of the key aspects of a visit to Open Spaces by the elderly and therefore, design considerations should focus on integrating elements of local culture and social activity spaces to foster social cohesion in these areas.

Secondly, in "livable neighborhoods," a sense of belonging and personal satisfaction play an essential role as it reduces fear and enhances safety factors. According to the findings, modern residential developments built by the "Livable Neighborhoods" model yield positive outcomes such as access and independence, while also improving feelings of safety. A broad variety of interventions compatible with public health and traffic regulation, many of which were based on international literature, may become mandatory in suburban policies. While there are lifestyle and pleasure motivations, it can also be demonstrated that they are incompatible. There are several various styles of housing to create strong living neighborhoods. Built environment characteristics including the aspect of outdoor thermal comfort are an integral element of fostering social cohesion. Furthermore, a study utilizing a variety of factorial and interdisciplinary approaches can help to elucidate and cater to the different needs (including physical, psychological, and emotional) of the elderly to make them socially active and fit.

Thirdly, there is a need to build on literature on climate, social, environmental, and behavioral influences to better understand smaller components of the urban environment to foster social cohesion. People that migrated, for example, are preparing to gather new human health data and introduce longitudinal approaches to study the health of the elderly in a well-planned community. It has been investigated that there is an impact of perceived residential environment efficiency on urban local community identity (ULCI). While neighborhood attachment (NA) is an essential component of urban local identification, upkeep and care now establish a local identity more than neighborhood attachment. Destination parks play a significant impact in this regard. Aspects like eye-level greenery, with the acoustical environment with aquatic features, have proved to foster elderly visits to these places.

Fourthly, mobility aspects have been seen as a remarkable influence on social life fostering safety and security of the elderly. Increased group engagement in outdoor practices such as cycling is expected to improve public wellbeing as well as social well-being. Changing the residential atmosphere to render safe habits and activities more available can be a requirement for preserving existing positive lifestyles. The importance of access to facilities, the need for protection, and the demand for scenery and cleanliness are more prominent in urban environments.

6. Conclusion

Previous research findings have shown a close connection to engagement in communities' social resources, path efficiency, natural characteristics, and seating quality (Chang, 2020). The physical feature: the seating aspect was shared only by the relationship with nature and social interaction. Social interaction was also the activity that was most influenced. The positive impact of social characteristics on performance was much greater than the positive effects on them of physical characteristics. To encourage active aging in society it is necessary to consider the impact of the social context on the well-being of older adults. We explained the characteristics of open spaces, which improve the welfare of elderly people to encourage social cohesion. Through a comprehensive review of the literature the influential factors of open space and social cohesion, such as offering affective support and improving self-esteem and empathy for one another, may be established to achieve an overall quality of life through physical-psychosocial processes. All levels of social cohesion must be established. It is necessary to take account of the socioeconomic attributes of individuals, and even the contexts of the everyday life, of health and well-being promotion strategies, so that they can frequent these areas more often. The literature review showed that there is a significant gap in co-relation of the attributes of open space and social cohesion that researchers have to fix in this direction as a potential area of study. There is also a need to prioritize the factors concerning its impact on the visit. This will enable the designers to make design decisions while intervening in these

spaces. More research into the usage of the park should involve the identification of mechanisms for deciding visits to urban space, particularly parks for the community with reduced mobility. Nevertheless, the desire for good quality research is a major direction to promote more successful age-friendly initiatives and provide essential

References

Saunders M.K, Lewis Philip, Thornhill Adrian (2019)(PDF) "Research Methods for Business Students" Chapter 4: Understanding research philosophy and approaches to theory development. (n.d.). Retrieved January 19, 2021, from https://www.researchgate.net/publication/330760964_Research_Methods_for_Business_Students_Chapter_4_Understanding_research_philosophy_and_approaches_to_theory_development.

Adinolfi, C., Suárez-Cáceres, G. P., & Cariñanos, P. (2014). Relation between visitors' behavior and characteristics of green spaces in the city of Granada, south-eastern Spain. Urban Forestry and Urban Greening, 13(3): 534–542. https://doi.org/10.1016/j.ufug.2014.03.007

Assisstant, F. (2019). ISSN : 0008-6452 Study Of Open Spaces In Urban Residential Neighbourhood – Madurai ISSN : 0008-6452. 53(2): 9–10.

Badland, H., Hooper, P., Timperio, A., Sugiyama, T., & Foster, S. (2019). action area 1 – *Built environments*. 14–22.

Bergvall-kåreborn, B., Wikman, A. M., Eriksson, C. I., & Ståhlbröst, A. (2015). A Model for Reflective Participatory Design - The Role of Participation, *Voice and Space*. 1–10.

Berkman, L. F., Glass, T., Brissette, I., & Seeman, T. E. (2013). From social integration to health: Durkheim in the new millennium. In The Sociology of Health and Illness: A Reader. https://doi.org/10.4324/9781315013015-18

Björk, J., Albin, M., Grahn, P., Jacobsson, H., Ardö, J., Wadbro, J., & Ostergren, P. O. (2008). Recreational values of the natural environment in relation to neighbourhood satisfaction, physical activity, obesity and wellbeing. *Journal of Epidemiology and Community Health,* 62(4). 1-7. https://doi.org/10.1136/jech.2007.062414

Błaszczyk, M., Suchocka, M., Wojnowska-heciak, M., & Muszyńska, M. (2020). Quality of urban parks in the perception of city residents with mobility difficulties. 1–25. https://doi.org/10.7717/peerj.10570

Cao, X., Handy, S. L., & Mokhtarian, P. L. (2006). The influences of the built environment and residential self-selection on pedestrian behavior: Evidence from Austin, *TX. Transportation*, 33(1): 1–20. https://doi.org/10.1007/s11116-005-7027-2

Chan, C. J., & Chan, C. J. (2017). Social Media as Enabler for ICT Inclusion to Achieve Active Ageing Social Media as Enabler for ICT Inclusion to Achieve Active Ageing Completed Research Paper.

Chang, P. (2020). Landscape and Urban Planning Effects of the built and social features of urban greenways on the outdoor activity of older adults. Landscape and Urban Planning, 204(November 2019), 103929. https://doi.org/10.1016/j.landurbplan.2020.103929

Cramm, J. M., Dijk, H. M. Van, & Nieboer, A. P. (2012). The Importance of Neighborhood Social Cohesion and Social Capital for the Well Being of Older Adults in the Community. 0: 142–150. https://doi.org/10.1093/geront/gns052

Daskalopoulou, C., Stubbs, B., Kralj, C., Koukounari, A., Prince, M., & Prina, A. M. (2017). Physical activity and healthy ageing: A systematic review and meta-analysis of longitudinal cohort studies. *Ageing Research Reviews*, 38: 6–17. https://doi.org/10.1016/j.arr.2017.06.003

Diego, S., Rojo-p, F., & Rodr, V. (2020). Environmental and Psychosocial Interventions in Age-Friendly Communities and Active Ageing : A Systematic Review.

Dodd, C., Adam, M., & Dodd, C. (2017). Association for Information Systems AIS Electronic Library (AISeL) Designing User Interfaces for the Elderly : A Systematic Literature Review Designing User Interfaces for the Elderly Designing User Interfaces for the Elderly : A Systematic Literature R.

Edwards, N., Hooper, P., Trapp, G. S. A., Bull, F., Boruff, B., & Giles-corti, B. (2013). Development of a Public Open Space Desktop Auditing Tool (POSDAT): A remote sensing approach. *Applied Geography,* 38: 22–30. https://doi.org/10.1016/j.apgeog.2012.11.010

Elliott, H., Eon, C., & Breadsell, J. K. (2020). *Improving City Vitality through Urban Heat Reduction with Green Infrastructure and Design Solutions : A Systematic Literature Review*. 1–28.

Elsawahli, H., Ahmad, F., & Ali, A. S. (2013). New urbanism design principles and young elderly active lifestyle : An analysis of TTDI neighbourhood in Kuala Lumpur , Malaysia. 19(4): 249–258. https://doi.org/10.1057/udi.2013.22

Fabisiak, B., Jankowska, A., & Kłos, R. (2020). Attitudes of Polish Seniors toward the Use of Public Space during the First Wave of the COVID-19 Pandemic.

Feng, I. M., Chen, J. H., Zhu, B. W., & Xiong, L. (2018). Assessment of and improvement strategies for the housing of healthy elderly: Improving quality of life. Sustainability (Switzerland), 10(3). https://doi.org/10.3390/su10030722

Fonseca, X., Lukosch, S., & Brazier, F. (2019). Social cohesion revisited: a new definition and how to characterize it. Innovation, 32(2), 231–253. https://doi.org/10.1080/13511610.2018.1497480
Fortune, N., Singh, A., Badland, H., Stancli, R. J., & Llewellyn, G. (2020). Area-Level Associations between Built Environment Characteristics and Disability Prevalence in Australia : An Ecological Analysis.

Francis, J., Giles-Corti, B., Wood, L., & Knuiman, M. (2012). Creating sense of community: The role of public space. *Journal of Environmental Psychology*, 32(4): 401–409. https://doi.org/10.1016/j.jenvp.2012.07.002

Gong, F., Zheng, Z.-C., & Ng, E. (2016). Modeling Elderly Accessibility to Urban Green Space in High Density Cities: A Case Study of Hong Kong. Procedia Environmental Sciences, 36: 90–97. https://doi.org/10.1016/j.proenv.2016.09.018

Guo, M., Liu, B., Tian, Y., & Xu, D. (2020). Equity to Urban Parks for Elderly Residents : Perspectives of Balance between Supply and Demand.

Hanafizadeh, P., Keating, B. W., & Khedmatgozar, H. R. (2014). A systematic review of Internet banking adoption. *Telematics and Informatics* 492-510. ?https://doi.org/10.1016/j.tele.2013.04.003

He, H., Lin, X., Yang, Y., & Lu, Y. (2020). Urban Forestry & Urban Greening Association of street greenery and physical activity in older adults : A novel study using pedestrian-centered photographs *Urban Forestry & Urban Greening.* 55(April): 1-25. https://doi.org/10.1016/j.ufug.2020.126789

Hu, X., Wei, Y., & Tang, J. (2020). Design Strategy of Friendly and Healthy Environment for Urban Aging Community Design Strategy of Friendly and Healthy Environment for Urban Aging Community. *IOP Conference Series: Earth and Environmental Science*. 598: 1-7. https://doi.org/10.1088/1755-1315/598/1/012044

Int, U. Des, & Carmona, M. (2018). Principles for public space design , planning to do better. URBAN DESIGN International, Carmona 2015. *Urban Design Internationa*l 24: 47-59 https://doi.org/10.1057/s41289-018-0070-3

Int, U. Des, Zang, P., Xue, C. Q. L., Lu, Y., & Tu, K. (2018). Neighbourhood adaptability for Hong Kong ' s ageing population. *Urban Design Internationa*l 24: 1-19 https://doi.org/10.1057/s41289-018-0074-z

Jeannotte, M. S. (2003). Singing alone? The contribution of cultural capital to social cohesion and sustainable communities. *International Journal of Cultural Policy*, 9(1): 35–49. https://doi.org/10.1080/1028663032000089507

Kaczynski, A. T., Koohsari, M. J., Stanis, S. A. W., Bergstrom, R., & Sugiyama, T. (2014). Association of street connectivity and road traffic speed with park usage and park-based physical activity. *American Journal of Health Promotion,* 28(3), 197–203. https://doi.org/10.4278/ajhp.120711-QUAN-339

Kaczynski, A. T., & Mowen, A. J. (2011). Does self-selection influence the relationship between park availability and physical activity? *Preventive Medicine,* 52(1): 23–25. https://doi.org/10.1016/j.ypmed.2010.10.003

Karuppannan, S., & Sivam, A. (2012). Comparative analysis of utilisation of open space at neighbourhood level in three Asian cities : Singapore , Delhi and Kuala Lumpur. *Urban Design International* 18(2): 145–164. https://doi.org/10.1057/udi.2012.34

Ki, D., & Lee, S. (2021a). Analyzing the effects of Green View Index of neighborhood streets on walking time using Google Street View and deep learning. *In Landscape and Urban Planning* 205: 1-11. https://doi.org/10.1016/j.landurbplan.2020.103920

Ki, D., & Lee, S. (2021b). Landscape and Urban Planning Analyzing the effects of Green View Index of neighborhood streets on walking time using Google Street View and deep learning. *Landscape and Urban Planning,* 205(August 2020), 103920. https://doi.org/10.1016/j.landurbplan.2020.103920

Kondo, M. C., South, E. C., & Branas, C. C. (2015). Nature-Based Strategies for Improving Urban Health and Safety. *Journal of Urban Health. Journal of Urban Health*. 92: 1-15 https://doi.org/10.1007/s11524-015-9983-y

Koohsari, M. J., Kaczynski, A. T., Giles-Corti, B., & Karakiewicz, J. A. (2013). Effects of access to public open spaces on walking: Is proximity enough? *Landscape and Urban Planning*, 117, 92–99. https://doi.org/10.1016/j.landurbplan.2013.04.020

Lai, D., Lian, Z., Liu, W., Guo, C., Liu, W., Liu, K., & Chen, Q. (2020). Science of the Total Environment A comprehensive review of thermal comfort studies in urban open spaces. *Science of the Total Environment*, 742: 140092. https://doi.org/10.1016/j.scitotenv.2020.140092

Lak, A., Aghamolaei, R., Baradaran, H. R., & Myint, P. K. (2020). Urban Forestry & Urban Greening A Framework for Elder-Friendly Public Open Spaces from the Iranian Older Adults ' perspectives : A Mixed-Method Study. *Urban Forestry & Urban Greening*, 56(January), 126857. https://doi.org/10.1016/j.ufug.2020.126857

Lak, A., Aghamolaei, R., & Myint, P. K. (2020). How Do Older Women Perceive their Safety in Iranian Urban Outdoor Environments ? 411–433.

Lau, S. S. Y., Gou, Z., & Liu, Y. (2014). Healthy campus by open space design: Approaches and guidelines. *Frontiers of Architectural Research,* 3(4): 452–467. https://doi.org/10.1016/j.foar.2014.06.006

Lenzholzer, S., Carsjens, G., Brown, R. D., Tavares, S., Vanos, J., Kim, Y., & Lee, K. (2020). Urban Climate Awareness of urban climate adaptation strategies – an international overview. *Urban Climate*, 34(December 2019), 100705. https://doi.org/10.1016/j.uclim.2020.100705

Lestan, K. A., Eržen, I., & Golobič, M. (2014). The role of open space in urban neighbourhoods for health-related lifestyle. *International Journal of Environmental Research and Public Health*, 11(6), 6547–6570. https://doi.org/10.3390/ijerph110606547

Lestan, K., Golobič, M., Eržen, I., & Goličnik Marušić, B. (2013). Open spaces increase the quality of built up areas. *WIT Transactions on Ecology and the Environment*, 179(1): 423–436. https://doi.org/10.2495/SC130361

Levinger, P., Panisset, M., Dunn, J., Haines, T., Dow, B., Batchelor, F., Biddle, S., Duque, G., & Hill, K. D. (2020). Exercise interveNtion outdoor proJect in the cOmmunitY for older people – results from the ENJOY Seniors Exercise Park project translation research in the community.

Levy-Storms, L., Chen, L., & Loukaitou-Sideris, A. (2018). Older Adults' needs and preferences for open space and physical activity in and near parks: A systematic review. In *Journal of Aging and Physical Activity* 26(4): 682–696. Human Kinetics Publishers Inc. https://doi.org/10.1123/japa.2016-0354

Levy, Y., & Ellis, T. J. (2006). A systems approach to conduct an effective literature review in support of information systems research. *Informing Science*, 9: 181–211. https://doi.org/10.28945/479

Li, Y., Ye, Y., Xiao, L., Xu, W., Law, A., & Wang, D. (2016). Classifying community space at a historic site through cognitive mapping and GPS tracking : The case of Gulangyu , China *Urban Design*

International. 22: 127-149 https://doi.org/10.1057/s41289-016-0010-z

Liang, X., Tian, H., Li, X., Huang, J., Clarke, K. C., Yao, Y., Guan, Q., & Hu, G. (2021). Landscape and Urban Planning Modeling the dynamics and walking accessibility of urban open spaces under various policy scenarios. *Landscape and Urban Planning*, 207(August 2020): 103993. https://doi.org/10.1016/j.landurbplan.2020.103993

Lin, Y., Zhou, Y., Lin, M., Wu, S., & Li, B. (2021). Exploring the disparities in park accessibility through mobile phone data : Evidence from Fuzhou of China. *Journal of Environmental Management*, 281(August 2020): 111849. https://doi.org/10.1016/j.jenvman.2020.111849

Liu, Z., Kemperman, A., & Timmermans, H. (2021). Correlates of frequency of outdoor activities of older adults : Empirical evidence from Dalian , China. *Travel Behaviour and Society*, 22(August 2019): 108–116. https://doi.org/10.1016/j.tbs.2020.09.003

Lott, A. J., & Lott, B. E. (1965). Group Cohesiveness As Interpersonal Attraction: A Review Of Relationships With Antecedent And Consequent Variables 1. In *Psychological Bulletin*. 64(4).
Maing, M. (2017). O-0802 Urban Living Room: An explorative study of elderly and public space in high density living UIA 2017 Seoul World Architects Congress. Seoul, Korea

Marakhimov, A., & Joo, J. (2017). Consumer adaptation and infusion of wearable devices for healthcare. *Computers in Human Behavior*, 76: 135–148. https://doi.org/10.1016/j.chb.2017.07.016

Model, A. C. (2005). The Significance of Parks to Physical Activity and. 28. https://doi.org/10.1016/j.ampre.2004.10.024

Niknejad, N., Ismail, W., Ghani, I., Nazari, B., Bahari, M., & Hussin, A. R. B. C. (2020). Understanding Service-Oriented Architecture (SOA): A systematic literature review and directions for further investigation. *Information Systems*, 91: 101491. https://doi.org/10.1016/j.is.2020.101491

Noon, R. Ben, & Ayalon, L. (2018). Older Adults in Public Open Spaces: Age and Gender Segregation. *The Gerontologist*, 58(1): 149–158. https://doi.org/10.1093/geront/gnx047

Owen, N. (n.d.). Public open space, physical activity , urban design and public health : Concepts , methods and research agenda. 1–28.

Paul, A., Kumar, T., Jahan, S., Mohaiminul, M., & Mark, A. (2020). Urban Forestry & Urban Greening Public Open space , Green exercise and well-being in. Urban Forestry & Urban Greening, 55(April): 126825. https://doi.org/10.1016/j.ufug.2020.126825

Schipperijn, J., Bentsen, P., Troelsen, J., Toftager, M., & Stigsdotter, U. K. (2013). Associations between physical activity and characteristics of urban green space. *Urban Forestry and Urban Greening*, 12(1): 109–116. https://doi.org/10.1016/j.ufug.2012.12.002

Schmidt, S. J. (2008). The Evolving Relationship Between Open Space Preservation and Local Planning Practice. XX(Xx). *Journal Of Planning History 7: 91-12 https://Doi.Org/10.1177/1538513207304714*

Sundevall, E. P. (2020). Inclusive Parks across Ages : Multifunction and Urban Open Space Management for Children , Adolescents , and the Elderly. *International Journal of Environmental Research and Public Health*, Switzerland

Teresa, M., Larriva, B., & Higueras, E. (2020). Urban Climate Health risk for older adults in Madrid , by outdoor thermal and acoustic comfort. *Urban Climate*, 34(August): 100724. https://doi.org/10.1016/j.uclim.2020.100724

Type, A., & History, A. (2019). ن ی ب ر د ن آ ب ا ط ب ت ر م ل م ا و ع و ی گ د ن ز ت ی ف ی ک ن ا د ن م ل ا س. 3(6), 145–151. https://doi.org/10.29252/jech.6.3.145

Uchiyama, Y. (2020). Access and Use of Green Areas during the COVID-19 Pandemic : Green Infrastructure Management in the " New Normal ." *Sustainability*. 12:1-9

Veitch, J., Salmon, J., Carver, A., Timperio, A., Crawford, D., Fletcher, E., & Giles-Corti, B. (2014). A natural experiment to examine the impact of park renewal on park-use and park-based physical activity in a disadvantaged neighbourhood: The REVAMP study methods. BMC Public Health, 14(1): 600. https://doi.org/10.1186/1471-2458-14-600

Wang, L., & Kang, J. (2020). Acoustic demands and influencing factors in facilities for the elderly. *Applied Acoustics*, 170, 107470. https://doi.org/10.1016/j.apacoust.2020.107470

Warraich, M. U., & Sell, A. (2018). Co-creation Model to Design Wearables for Emotional Wellness of Elderly.

Webster, J., & Watson, R. T. (2002). ANALYZING THE PAST TO PREPARE FOR THE FUTURE: WRITING A LITERATURE REVIEW. In *MIS Quarterly* 26(2): 8-18 http://www.misq.org/misreview/announce.html

Wen, C., Albert, C., & Haaren, C. Von. (2020). Urban Forestry & Urban Greening Equality in access to urban green spaces : A case study in Hannover , Germany , with a focus on the elderly population. *Urban Forestry & Urban Greening,* 55(August): 126820. https://doi.org/10.1016/j.ufug.2020.126820

White, M. P., Elliott, L. R., Gascon, M., Roberts, B., & Fleming, L. E. (2020). Blue space , health and well-being : A narrative overview and synthesis of potential benefits. *Environmental Research*, 191(August),: 110169. https://doi.org/10.1016/j.envres.2020.110169

Wu, J., Yang, M., Xiong, L., Wang, C., & Ta, N. (2021). Landscape and Urban Planning Health-oriented vegetation community design : Innovation in urban green space to support respiratory health. *Landscape and Urban Planning* 205(500): 1-8 https://doi.org/10.1016/j.landurbplan.2020.103973

Yang, S., & Zhu, Q. (2017). The Safety of Walking Space for the Elderly People Living in Communities in Beijing, China. *Open Journal of Social Sciences,* 05(04): 153–158. https://doi.org/10.4236/jss.2017.54014

Yu, X., & Zhang, W. (2020). Neighborhood ' s locality , road types , and residents ' multimorbidity : evidence from China ' s middle-aged and older adults. 1–11.

Zeng, W., Huo, X., & Yu, Z. (2020). Humanistic demand and spatiotemporal perspective in the evaluation of urban life quality — A

case study of Shandong Province in China. *IOP Conference Series: Earth and Environmental Science*.580: 1-16 https://doi.org/10.1088/1755-1315/580/1/012065

Zhai, Y., Li, K., & Liu, J. (2018). A Conceptual Guideline to Age-Friendly Outdoor Space Development in China: How Do Chinese Seniors Use the Urban Comprehensive Park? *A Focus on Time, Place, and Activities. Sustainabili*ty, 10(10), 3678. https://doi.org/10.3390/su10103678

Zhang, J., Cheng, Y., & Zhao, B. (2021). How to accurately identify the underserved areas of peri-urban parks ? An integrated accessibility indicator. *Ecological Indicators,* 122: 107263. https://doi.org/10.1016/j.ecolind.2020.107263

Zhang, Z., Fisher, T., & Feng, G. (2020). Assessing the Rationality and Walkability of Campus Layouts. 1–21.

Zhu, B.-W., Zhang, J.-R., Tzeng, G.-H., Huang, S.-L., & Xiong, L. (2017). Public Open Space Development for Elderly People by Using the DANP-V Model to Establish Continuous Improvement Strategies towards a Sustainable and Healthy Aging Society. *Sustainability*, 9(3): 420. https://doi.org/10.3390/su9030420

IJBES

International Journal of Built Environment and Sustainability
Published by Penerbit UTM Press, Universiti Teknologi Malaysia
IJBES 9(1)/2022,73-87

Parametrising Historical Islamkoy Courtyard-Dwellings: Spatial Quality Parameters and Examination Based on AHP Method

Makbulenur Onur
Department of Landscape Architecture, Karadeniz Technical University, Trabzon, Turkey

Selver Koç Altuntas
Department of Interior Architecture, Karadeniz Technical University, Trabzon, Turkey

ABSTRACT

Throughout the historical process humans have shaped the environment that they lived in and developed it according to their needs. The living culture has been formed with various spatial setups in dwellings which are the most basic habitats of humankind. Today, functionality comes into prominence in this living culture which is referred to as traditional dwellings. This shows that the continuity is ensured by presenting mass and cultural harmony between spatial setups and the garden and neighboring dwelling relations. Amongst the traditional dwellings, Turkish house is also considered as an important example, which provides continuity with its diverse plan organizations and spatial characteristic. The courtyard character in traditional dwellings is the space that is effective in the organization of spatial which sheds light on present day with various parameters. This is because the dwelling is located in the courtyard. Moreover, the courtyard, which starts with the entrance and where the households carry out their daily lives, is very significant for the Turkish dwelling as it contains both natural and cultural characteristics. The traditional dwellings of the village of Islamköy, which is located in the Atabey district in Isparta province of Turkey, are discussed within the scope of the study, which examines how the concept of courtyard that contains the functional and aesthetic values of the Turkish dwelling, forms various plan organizations and spatial characters in many cultures, affects the spatial quality. Spatial quality parameters were examined on five second-degree registered traditional dwellings located on Okul Street in the Islamköy village. Three basic principles have been determined which are functional, aesthetic and ecological and the sub-parameters of these determined principles have been introduced with the information and documents obtained from the literature. The AHP method was used to determine the priorities of the parameters in this direction. Thus, taking into account the spatial quality parameters, the priority parameters of the courtyard character in the traditional dwellings of Islamköy were determined.

Article History [Perpetua, Bold, 9pts]

Received : *13 September 2021*
Received in revised form : *16 December 2021*
Accepted : *17 December 2021*
Published Online : *31 December 2021*

Keywords:

Islamkoy, Turkish house, traditional houses, spatial quality

Corresponding Author Contact:

mnurbekar@ktu.edu.tr

DOI: 10.11113/ ijbes. v9.n1.886

1. Introduction

From a historical architectural perspective, traditional dwellings have been shaped by culture and requirements. Thus, the characteristic forms in the plan schemes emerge. Moreover, the unique architectural texture and identity of the region is formed (Asquith and Vellinga, 2006). The spaces that show the typology of traditional dwellings from every culture are different. Dwelling typologies that allow classification have taken its place in traditional architecture with ideal space (Johnson, 2003). Many examples can be given to these places such as room, hall, patio and courtyard. The courtyard, which Hasol defines as "the open space in the middle of a building or group of buildings, surrounded by walls or buildings"; at the same time, it shows the characteristics of both open and semi-open spaces. With this feature, it is important for traditional dwellings and plays an important role in shaping the dwellings.

Courtyard structure is seen in many parts of the world (Taleghani, Tenpierik, and van den Dobbelsteen, 2012) and plays a leading role in the oldest architectural organization planning (Almhafdy, Ibrahim, Ahmad, and Yahya, 2013). Even though the courtyard has different functions in different spaces, it is generally considered for the dwelling, which is the most basic building unit (Hyung-Ock Hong and et al., 2001). For instance, the gathering area where social and family-oriented activities are held such as cooking, working, playing and satisfying the shelter needs of animals are just a few of them (Almhafdy, Ibrahim, Ahmad, & Yahya, 2013). In addition to the functional aspect of the dwelling such as determining the typology, the courtyard also has an important task such as determining the cultural values. So it can be said that the courtyard is a place that symbolizes culture (Edwards, Sibley, Land, Hakmi, 2006).

Courtyards, which are considered as developing social relations and providing a flexible and dynamic spatial effect, show different physical formations from place to place (Rapoport, 2007). These places are called the open, semi-open or semi-public space of the house. Cultural factors, social and individual identity factors are the main determinants in the formation of this difference. For instance; Chinese dwellings' courtyard type are classified as inner courtyard. This structure is a result of the need to maintain family control (Xu, 1998). The same structure has emerged with the need for privacy in the courtyard types of southeast dwellings in Turkey.

Courtyard spaces have functional and cultural features as well as many ecological features. In fact, it is seen in many studies that ecological features have important effects on the shaping of the courtyard. Especially in the courtyard spaces that are formed in a climatic sense; the central courtyard type was often used in tropical countries. All rooms face the central courtyard, and the design of the courtyard functions as natural cooling in hot weather, turning the indoor environment ergonomic. The courtyard, which is supported by auxiliary building elements and materials such as the water element, serves as a place where thermal comfort is obtained (Dunham, 1961). This structure ensures the sustainability of ecological features by adapting it to cold climates.

1.1. Research Objective

In the studies, the concept of courtyard in traditional dwellings has been mentioned frequently. In addition, many analyses and evaluations have been conducted on the courtyard character of traditional dwellings. In particular, dozens of studies have been carried out on "the importance and place of the courtyard in the Turkish dwelling" as the most basic subject. Unlike the previous studies, in this study, a detailed examination of the spatial quality parameters of traditional dwellings with courtyard features has been made. Isparta/Islamköy, which constitutes the main material of the study, has a very characteristic planning in terms of housing and courtyard typology. In this study, it is foreseen to complete the deficiency in the literature in terms of both "the originality of the field study" and "the parameters examined". At this point, considering the parameters discussed in the intersection of Turkish dwelling and spatial quality, answers to the following questions was sought within the scope of the study.

- What are the social, cultural and ecological quality parameters which determine the courtyard character of the Turkish dwelling?

- How are these determined parameters exclusively observed in Isparta Islamköy traditional dwelling?

- How is the relationship and significance level between these parameters statistically?

As a result of the study, primarily determined spatial quality parameters are a base for future studies. Parameters can be evaluated for further studies. The parameters obtained with statistical data and the relationship/importance levels between them are strategic information for the design and planning decisions to be made for traditional dwellings. In addition, it is foreseen that the study complements the deficiency in the literature.

2. The Courtyard In Turkish Dwelling

Turkish dwelling has been classified according to many features such as location, climate, plan features, facade layout, and number of floors, building material, construction system or window-door ratios. For instance, it is classified in terms of plan features; without hall, with outer hall, with inner hall, with middle hall (Eldem, 1955: 24). It provides continuity as a whole with space organization and mass order, and reveals a value with various typologies. Among these typologies; open, closed and semi-open spaces form the spatial setup. In the Turkish dwelling, where open and semi-open spaces gain importance with the combination of culture and needs; courtyard character seems to come forward.

The concept of courtyard, which plays an important role in determining the typology of the Turkish dwelling, in its most

basic sense; it refers to an open, walled area in the middle of a building or building group, patio, vestibule, hall (TDK, 2021). According to the art encyclopedia; it is defined as a closed, open, square-like space (Arseven, 1943). When considered architecturally; it emerges as spaces that are compatible with the building, shaped in various forms and integrated with open patio as a result of needs (Erdoğan, 1996). The history of the courtyard dates back to ancient times. Courtyards were found in settlements belonging to the Neolithic period such as Çatalhöyük, Hacılar and Çayönü in Anatolia. Courtyards in geometric fiction are clearly perceived (Aydın, 2000). In terms of spatial setup, the courtyard; basically aims defense to protect from the outside world. Apart from this, it has been made functional with requirements such as providing air and light and throwing waste (Esin, 1994). In addition, the pit where the garbage is put and toilet are also located in this place (Mellaart, 1970). It is possible to see examples of the courtyard, which was shaped by the materials, technology and lifestyle, brought by the culture and needs along with the process.

Courtyard has been discussed by many researchers as it has a strong history and has been shaped by various factors. Courtyards are classified according to various parameters. One of these; is the classification made according to ground floor locations and indoor-outdoor area ratios (Pfeifer and Brauneck 2008) (Figure 1)

Another classification is Reynolds' (2001) classification on spatial setup. In this classification, criteria were determined according to the entrance locations of the courtyard and access to the courtyard after the entrance. Apart from this, the typological form of various countries, the plan scheme, and the relationship with the facade facing the courtyard were also taken into consideration (Ekim, 2012). The place indicated by the arrow sign in the figure is expressed as the entrance area to the residence from the street. The pink colored areas symbolize the courtyard (Figure 2).

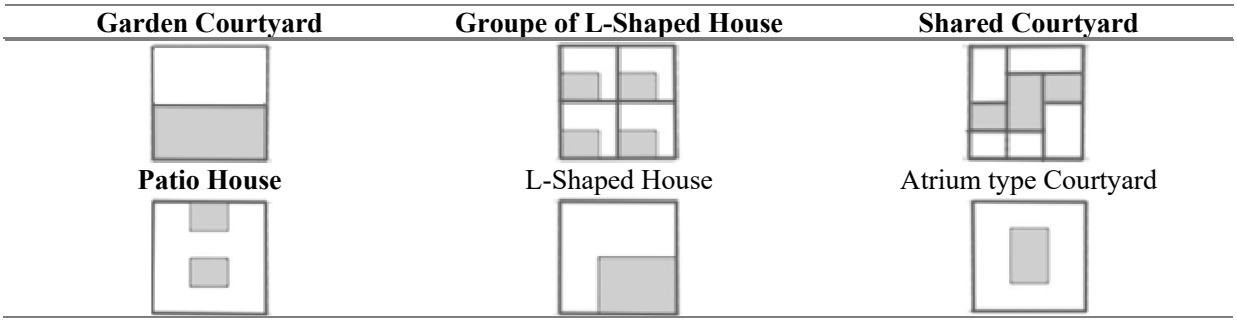


Figure.1 Courtyard types (Pfeifer and Brauneck 2008; Ekim, 2012)

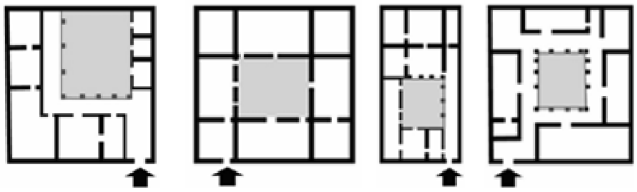


Figure.2 Types of entrance to the courtyard (Reynolds, 2001)

Although the typological elements of different countries are revealed in the classifications shown above, the courtyard features of the Turkish dwellings are also shaped in the same way. In this typology variety, functionality is considered the main point (Kuban, 2002). Apart from this, there are many factors that affect shaping. The courtyard character in the Turkish dwelling can be examined in the most general sense under two titles, physical and social. Physical factors can be considered as; climate, topography, geological structure, vegetation (Taşçıoğlu, 2013), and social factors can be considered as; culture, security, privacy, lifestyle, flexibility. All these factors affect the form of the courtyard in the Turkish house, the elements used in the courtyard, the materials, the functional units in the courtyard, the positioning and provide diversity. In the Turkish dwelling particularly, many examples of this diversity can be given.

Climate from physical factors is one of the factors that affect shaping the most (Taşçıoğlu, 2013). There are sub-factors of local climate such as temperature, radiation, humidity and wind, and the effect of these factors on the courtyard design ensures sustainability. For example; In Diyarbakır dwellings, the importance of the courtyard is extremely large. Climatic transformation is applied in the dwellings where there are solutions according to the climate. In the courtyard, the materials such as pool and tiered, ornamental fountain are generally used, and the materials on the flooring are designed to protect them from the hot weather climate (Direk, 2006). Dwellings with courtyards where the topography is effective can be found in Mardin. Terracing system is seen in residences in Mardin, which has a high-rise land structure. The courtyard types shaped accordingly also change their form according to economic and climatic factors (Karagülle and Demir, 2011). As another example; the courtyard space in Erzurum dwellings has

become an element included in the dwelling due to the climate and topographic features. The decrease in air temperature in winter caused the courtyard to be closed by combining with the tandoor house (Gök and Kayserili, 2013).

One of the most important social factors is culture. Culture contains information that sheds light on lifestyle, family and society structure. Due to that, the effect of privacy on the formation of the Turkish dwelling courtyard is huge. For example, in Erzurum dwellings, the men and women sitting in separate spaces affected the formation of the courtyard and obliged to pass these spaces separately (Gök and Kayserili, 2013). In Beypazarı dwellings, the courtyard emerged as a result of social needs and became a place where neighbor relations were strengthened by being called the place of women (Hatipoğlu, 2015). Another example is the Urfa dwellings. In the region where privacy is experienced at a high level, the space is oriented inward and lined up around the courtyard. The facade of the courtyard facing the street is surrounded by high walls and shows a massive formation without any openings (Güzel, 2013).

To sum up, the courtyard space in the Turkish dwelling, with various forms, is a very important place that displays multifaceted features with social, cultural and ecological factors and acts as a buffer between housing and public space.

2.1. Landscape Features in Turkish Dwelling

Among the main defining features of the Turkish dwelling, the presence of the courtyard character reflects the traditional lifestyle. For this reason, it plays an important role in shaping the traditional rural settlement landscape (Köse, 2007). In other words, local vegetation emerges as effective elements in the courtyard character of the Turkish dwelling.

The physical and social features that play a role in the shaping of the courtyard in the Turkish dwellings are also applicable to the plant elements in the courtyard. For example, climatic features affect the landscape character of the courtyard and therefore the use of plants. In order to provide thermal comfort in hot regions, shading vegetal elements are used. In narrow courtyard types; small-leaved, compact plants are used in order to benefit from sunlight and daylight (Johnston and Newton, 2004, Cooper, 2003; Hindistan, 2006). In addition to all these, soil depth and structure are important in terms of the type and presence of plants grown in the courtyard.

The herbal elements in the Turkish dwelling have an ecological architectural structure that is compatible with nature. Due to that reason, it is possible to see herbal elements in almost every courtyard in the Anatolian geography. It is seen that flowering plants and fruit trees are frequently used in Turkish dwelling courtyards, as physical and social factors are also effective. Although these elements do not have any order or criteria, they appear as striking elements both horizontally and vertically (Bozkurt and Altınçekiç, 2013). Apart from this, decorative plants can be seen grown in pots or local accessories. Thus, the courtyard landscape in the dwellings is diversified and shows a characteristic feature with physical and social factors.

2.2 Courtyard Features of İslamköy Dwellings

Islamköy dwellings have been started to be built since the 1900s and many residences have managed to reach the present day without destroying their original structure. Islamköy dwellings, which show typical Turkish dwelling characteristics usually consists of an outer hall, and examples with an inner hall are also seen. Plan types with outer halls are classified within itself according to the feature of having 2, 3, 4 and 5 rooms. In the dwellings where local materials and construction techniques are seen, there are local places such as a house from the ground, haney altı, and main places such as a room, hall, headroom, barn, and hayloft (Koç, 2019).

Courtyard is one of the common usage areas in the Turkish dwelling; where family relations are intensely experienced as a result of needs and cultural accumulation. For this reason, they are places where many functions can be performed and are compatible with the environment. The location of the courtyard is also very important in İslamköy dwellings. Due to the absence of active homeowners in many residences, the courtyard character was damaged due to environmental conditions and lost its original function (Figure 3).

Figure.3. Example of courtyard in Islamköy traditional dwellings

Considering the cultural structure and lifestyle of the region and the village, it turns out that the courtyard is quite characteristic. The courtyard, which starts with patio, appears as a place where circulation is intense. Vertical circulation (stairs) is also mostly included in patio. Apart from this, there are also various venues and units. Figure 3 shows the courtyard character, which is

about to lose its quality due to neglect, since most of the houses do not have permanent homeowners. However, some residential courtyards have spatial boundaries, and various functions, units and plant elements are seen within themselves. The spaces located in the courtyards of the İslamköy residences; are grouped under three titles as open, semi-open and closed spaces. Open spaces are used for seating and various activities; semi-open spaces are used for storage areas such as warehouses, depots, and closed areas consist of places such as barn and hayloft. There are units in open spaces; such as trough, molasses pool, poultry house. These units vary or differentiate due to the need for each residence. Considering the landscape features, it can be found fruit trees such as apple, pomegranate, quince and pear trees. Apart from this, there are also trees such as poplar, pine and herbal elements.

3 .Study Area

The village of Islamköy, which is in the Atabey district of the city of Isparta, located in the south of Turkey, was considered as the study area. Islamköy is an important residential area due to its strong history, rich socio-cultural characteristics and ecological structure. Apart from these, it is frequently mentioned in the political sense as it is the village where the ninth President of the Republic of Turkey Süleyman Demirel was born and grew up (Koç, 2019) (Figure 4, Figure 5).

Islamköy has come until today with the status of municipality and town, and has been continuing as a village since 2014. Its history dates back to ancient times. The village has a transitional climate. It has flat land from a topographic point of view. In the region, which has quite a lot of arable land; apple and vegetable orchards are mostly seen. Apart from agriculture, there are also livestock and industrial activities (Üstün, 2016). The village, which has tourism potential; is located on important tour routes. Besides, with the mausoleum and Social Complex (Kulliye) of Süleyman Demirel, the ninth President of the Republic of Turkey in the village, it is becoming an important village with the presence of a first-degree registered cistern and second-degree registered traditional residences (Koç, 2019).

There are two main arteries in the village, namely "Hürriyet" and "Cumhuriyet" Street. Demirel and 100. Yıl parks are found between two arteries.

Working route was chosen as Okul Street because it is on an important artery. On the route; 5 traditional registered second-degree dwellings; investigated within the scope of the study. The five dwellings discussed in the study reflect the cultural structure of the region and embody the plan typology of the Islamköy dwelling. In this context; dwellings 1, 2 and 5 have a plan type with outer hall, and dwellings number 3 and 4 have a plan type with inner hall. Dwelling number 1 has four rooms, dwelling number 2 has three rooms and dwelling number 5 has two rooms. There are no permanent residents in the residences.

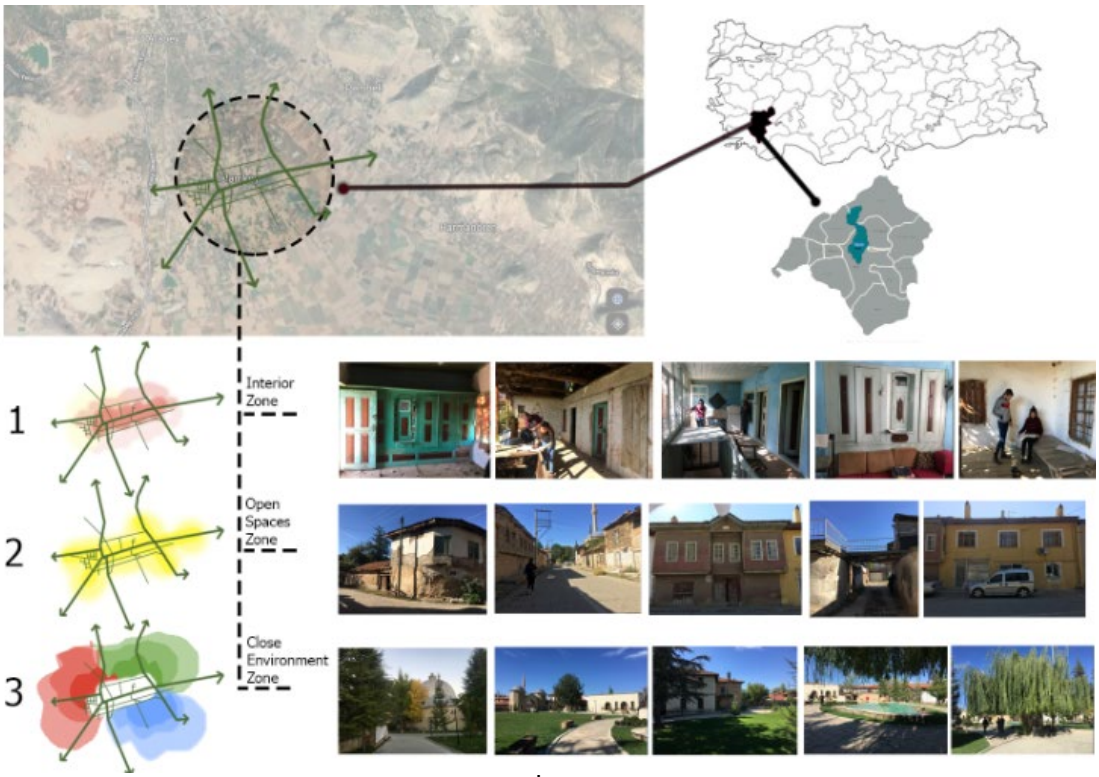


Figure 4. Location of İslamköy (Google Earth)

Figure 5. Location of İslamköy/Okul Street and second-degree registered residences

4.. Method

The method was carried out in 3 stages. These stages are;
- Field and observation study,
- Establishment of criteria
- The statistical method (AHP) (Figure 6).

More than one method was used for the purpose of the study. Each stage follows each other and forms the basis for the previous one. In the first stage of the method, Isparta / İslamköy was visited for field and observation studies. With a study of approximately 10 days, 5 second-degree registered traditional dwellings were selected, observed, photographed and measured.

After the observation, land and measurement studies of the houses, the literature data was searched in order to create "spatial quality criteria" specific to the traditional houses suitable for the study purpose. At the end of the stage, "spatial quality criteria" specific to traditional houses were established.

In the last stage of the study, the reliability of the field and literature studies with the statistical method, the relations between them and the priorities of the criteria were measured. The general flow diagram of the study is as in Figure 2.

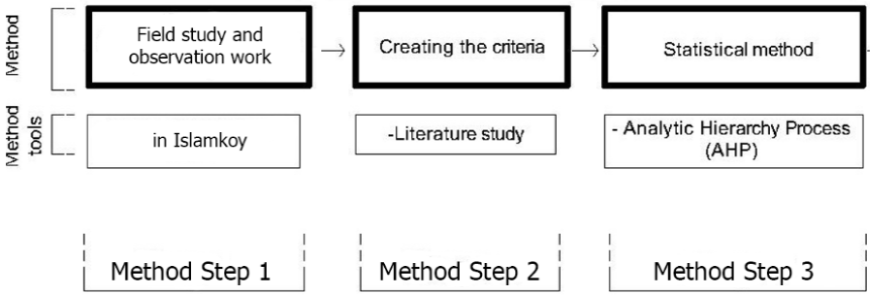


Figure 6. Methodological framework

In the second stage, statistical methods were used to determine the relationship between the criteria created by the literature study. AHP is a method that allows individuals or groups to make decisions in a complex situation. Thanks to AHP analysis; 12 scale criteria created in literature studies by means of the weights of the criteria calculated, it will be decided which ones should be gathered under the same group. For the analysis, a hierarchy of criteria was created in the first stage. This is called decision modeling (Figure x). Decision modeling was created by following the steps below (Saat, 2010, Leal 2020).

1- The main purpose of the decision-making process has been identified (analysis of the spatial quality of the court). The purpose is written at the top of the modeling.
2- At the second level of the matrix, alternatives that meet the primary goal are identified. Alternatives were created in 3 groups; social quality, cultural quality, ecological quality.
3- At the third level of the matrix, 12 criteria are defined, each of which defines the alternative.
4- Calculate the priorities of each alternative within each criterion ascending in the matrix to the main objective.

After these steps were carried out and the matrix was created, another stage was started. This is the stage where expert opinions are included. The comparison of the criteria is done both among themselves and among all alternatives for which each criterion is determined (Dağdeviren and Eren, 2001). Thus, a transition is ensured from producing solutions to the decision stage. This shows the (weighted) comparison between these criteria. Experts (urban planner, landscape architect, and architects) were interviewed for the comparison (pattern weighting) between the criteria (Figure.7).

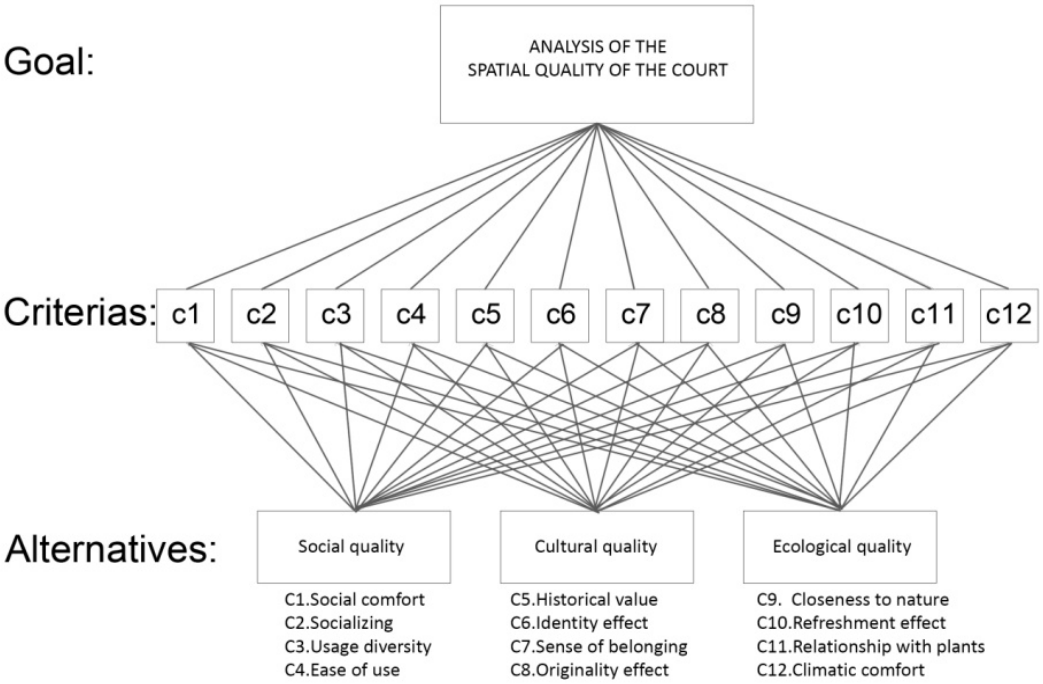


Figure 7. Hierarchy of spatial quality criteria for AHP process

The final step in the AHP process is to establish their relative priorities (weights) for the criteria. The relative weights of the criteria with respect to each other were obtained. The importance or weight of each criterion is different, and therefore, comparisons were made with a numerical scale developed by Saaty (2012) (Table 1). This scale enables to establish the relative priority of each criterion over the others through pairwise comparisons. In order to determine the consistency of pairwise comparisons, the consistency ratio was calculated. Since this rate was below 0.10, it was accepted that it showed sufficient consistency (Kuruüzüm and Atsan, 2001). As a result of the AHP, it was determined which criteria had more weight under which alternative and groups were formed.

Table 1. Fundamental scale of Saaty.

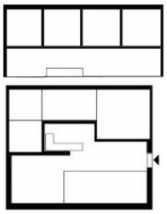
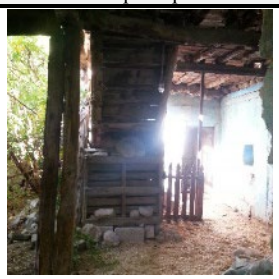
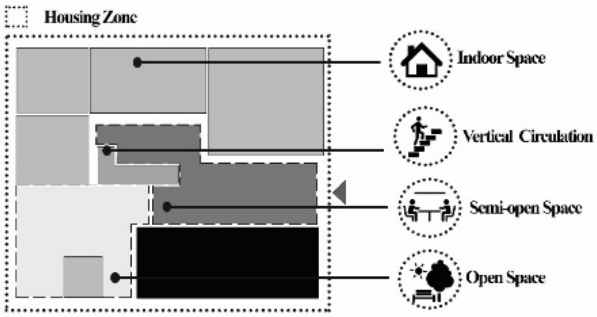
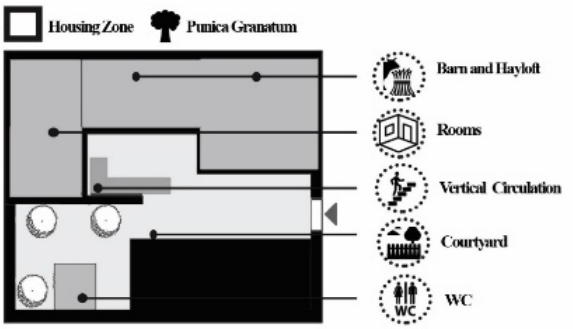
Intensity of importance	Definition1
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance

5.0. Findings
5.1. Findings on the field studies carried out

Within the scope of the study method, Isparta/Islamköy was visited for field studies. Drawings and measurements were obtained in about 10 days of work. Following that, 5 second-degree registered traditional residences containing the courtyard space were examined with "spatial quality parameters". 5 registered traditional residences on Okul Street have been examined with the following graphical schemes. These are; Hüseyin TUNCEL, Zübeyde ATILGAN, Sevim ATILGAN, Ahmet Salim ÜSTÜN-Rafet ÜSTÜN and Emine İSTANBUL Housing.

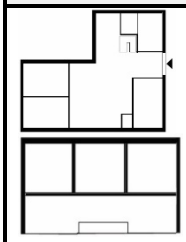
House 1, which belongs to Table 2, has a plan type with 4 rooms and an outer hall belonging to Hüseyin TUNCEL. In terms of open-semi-open space organization; "patio" is accepted as a semi-open space, the rooms of the house are described as closed spaces, and the other areas outside the residential area are described as open spaces. Life begins with the entrance. There is a restroom in the open area of the residence. There are also herbal elements in the open space with pomegranate trees.

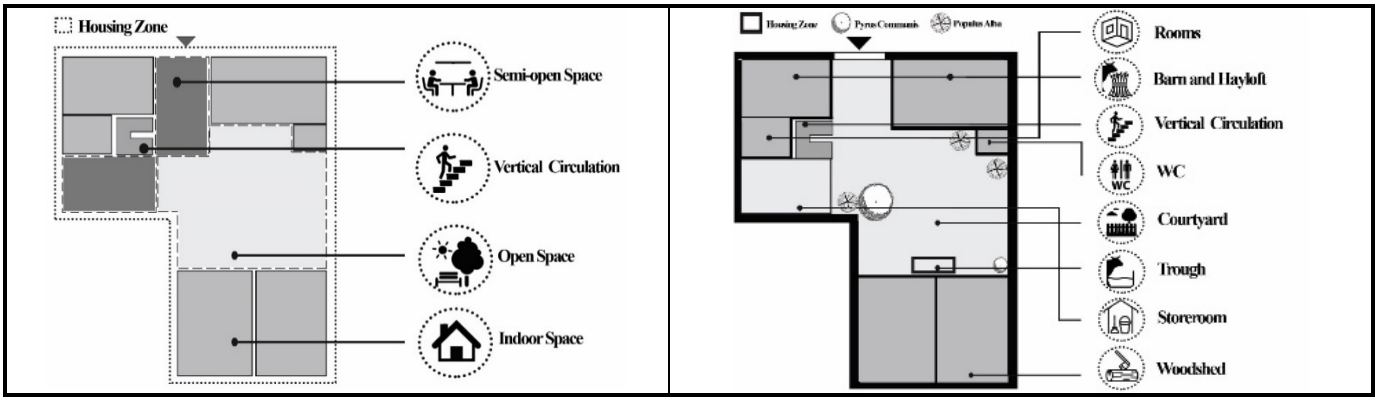
Table 2 Courtyard Features of Residence 1

Ground Floor and First Floor	Facade Photo	Courtyard Photo	Open - Semi Public Space photo
			
Courtyard Plan Lejand		Plan Lejand	
			

The house in Table 3 has a three-room plan type with outer hall owned by Zübeyde ATILGAN. Life begins with the entrance. There is a restroom, trough, woodshed, and storage in the open area of the house. There are also herbal elements in the open space where pear and poplar trees are located.

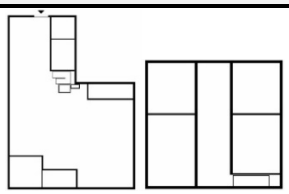
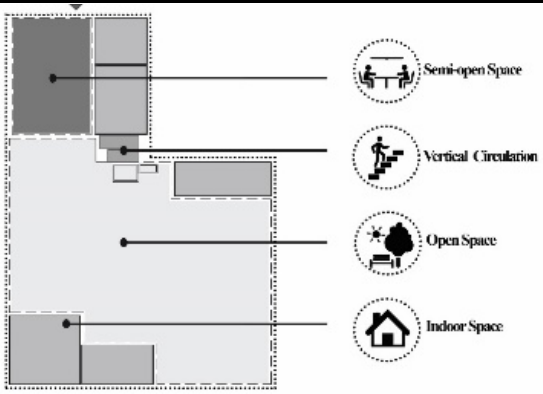
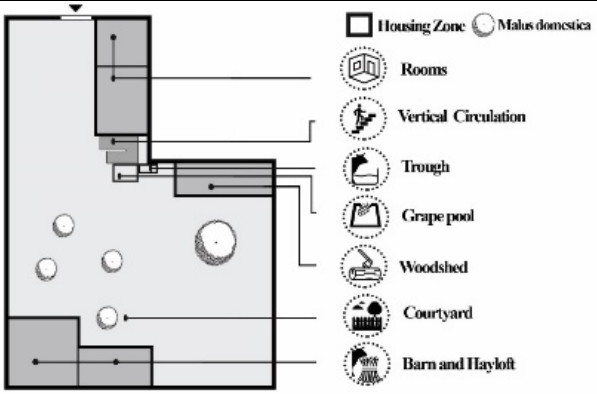
Table 3 Courtyard Features of Residence 2

Ground Floor and First Floor	Facade Photo	Courtyard Photo	Open - Semi Public Space photo
			
Courtyard Plan Lejand		Plan Lejand	



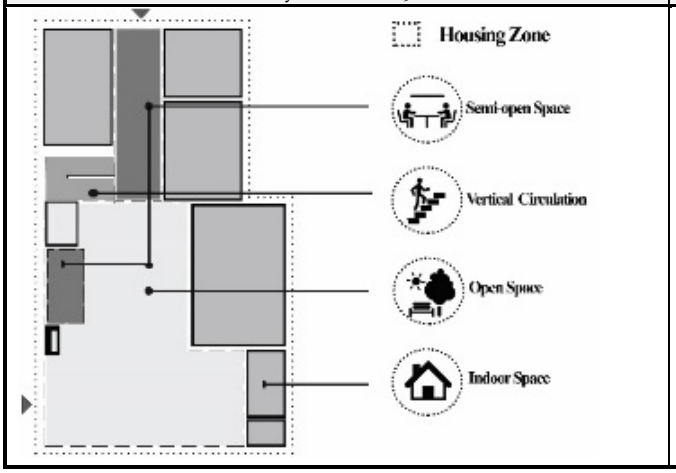
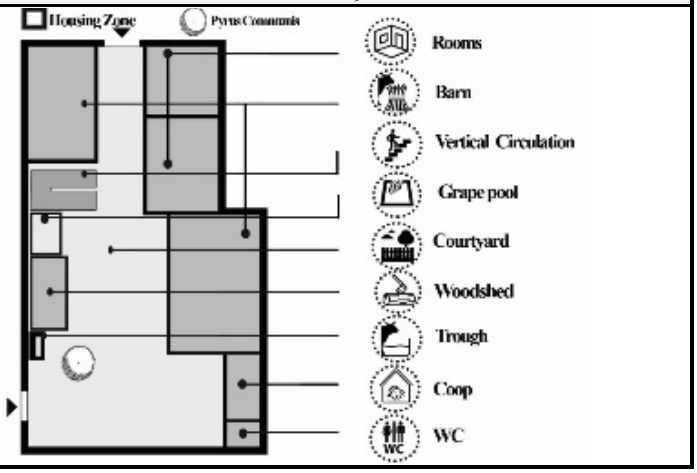
The house in Table 4 has a plan type with an inner hall owned by Sevim ATILGAN. Life begins with the entrance. In the open space of the house, there is a trough, woodshed, grape-molasses pool and woodshed. There are also herbal elements in the open space with apple trees.

Table 4 Courtyard Features of Residence 4

Ground Floor and First Floor	Facade Photo	Courtyard Photo	Open - Semi Public Space photo
			
Courtyard Plan Lejand		Plan Lejand	
			

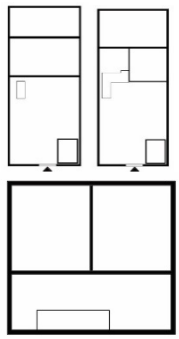
The house in Table 5 has a plan type with an inner hall owned by Ahmet Salim ÜSTÜN-Rafet ÜSTÜN. Life begins with the entrance. In the open area of the house, there is a trough, poultry house, grape-molasses pool and restroom. There are also herbal elements in the open space with pear trees.

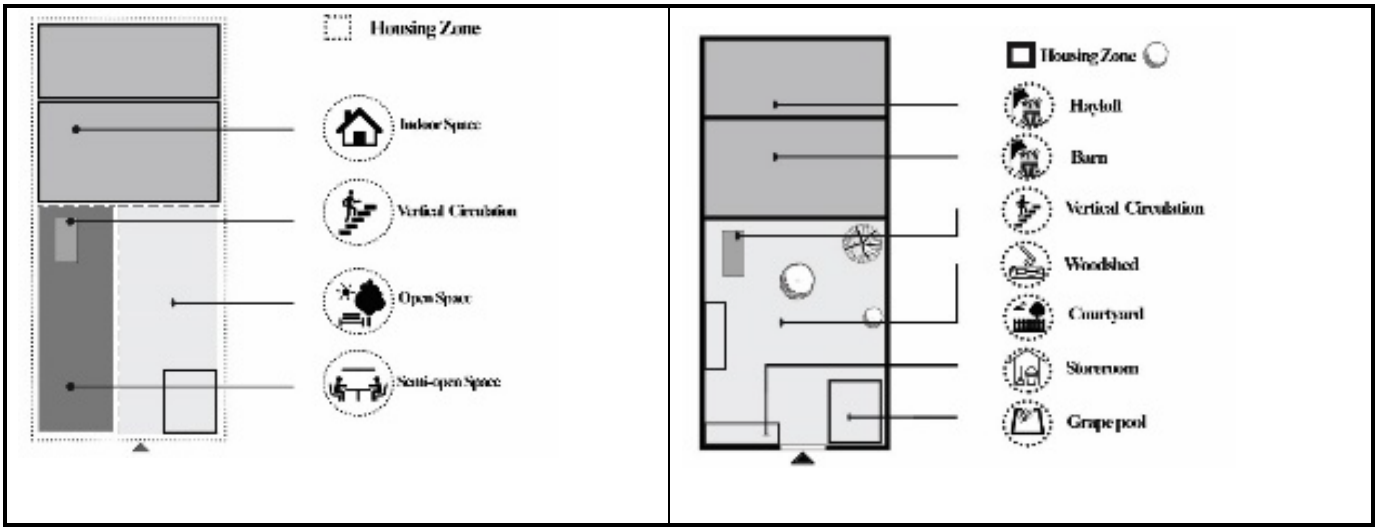
Table 5 Courtyard Features of Residence 4

Ground Floor and First Floor	Facade Photo	Courtyard Photo	Open - Semi Public Space photo
			
Courtyard Plan Lejand		Plan Lejand	
			

The house in Table 6 has a plan type with two rooms and an outer hall owned by Emine ISTANBUL. The open space of the courtyard begins with the entrance. There is a grape-molasses pool, warehouse and woodshed in the open area of the house. There are also herbal elements in the open space with pomegranate and poplar trees.

Table 6 Courtyard Features of Residence 5

Ground Floor and First Floor	Facade Photo	Courtyard Photo	Open - Semi Public Space photo
			
Courtyard Plan Lejand		Plan Lejand	



5.2. Findings on the AHP Method

The AHP method matrix is constructed with 3 alternatives in total and 12 sub-parameters that make up these alternatives. In total, 12 relative comparison matrixes were created for each parameter. Relative matrixes were calculated according to 12 sub-criteria (social comfort, socializing, usage diversity, ease of use, historical value, identity effect, sense of belonging, originality effect, closeness to nature, refreshment effect, relationship with plant, climatic comfort) (Table 7, Table 8). After that, the data were normalized and the result of the normalized matrix was obtained (Table 9).

Table 7 Matrix of Comparisons by Social Quality (SQ)

C1.Social comfort	Social quality (Sq)	Cultural quality (Cq)	Ecologial quality (Eq)
Social quality (Sq)	1	9	0,111
Cultural quality (Cq)	0,111	1	7
Ecologial quality (Eq)	9	0,143	1
Total	10,111	10,143	8,111
C2.Socializing	Social quality (Sq)	Cultural quality (Cq)	Ecologial quality (Eq)
Social quality (Sq)	1	9	0,111
Cultural quality (Cq)	0,111	1	7
Ecologial quality (Eq)	9	0,143	1
Total	10,111	10,143	8,111
C3.Usage diversity	Social quality (Sq)	Cultural quality (Cq)	Ecologial quality (Eq)
Social quality (Sq)	1	9	9
Cultural quality (Cq)	0,111	1	7
Ecologial quality (Eq)	0,111	0,143	1
Total	1,222	10,143	17
C4.Ease of use	Social quality (Sq)	Cultural quality (Cq)	Ecologial quality (Eq)
Social quality (Sq)	1	9	9
Cultural quality (Cq)	0,111	1	7
Ecologial quality (Eq)	0,111	0,143	1
Total	1,222	10,143	17

Table 8 Matrix of Comparisons by Cultural Quality (Cq)

C5.Historical value	Social quality (Sq)	Cultural quality (Cq)	Ecologial quality (Eq)
Social quality (Sq)	1	5	9
Cultural quality (Cq)	0,2	1	9
Ecologial quality (Eq)	0,111	0,111	1
Total	1,311	6,111	19
C6.Identitiy effect	Social quality (Sq)	Cultural quality (Cq)	Ecologial quality (Eq)
Social quality (Sq)	1	0,140	0,140
Cultural quality (Cq)	7	1	9
Ecologial quality (Eq)	7	0,110	1
Total	15	1,250	10,140
C7.Sense of belonding	Social quality (Sq)	Cultural quality (Cq)	Ecologial quality (Eq)
Social quality (Sq)	1	7	0,2
Cultural quality (Cq)	0,140	1	9
Ecologial quality (Eq)	5	0,110	1
Total	6,140	8,110	10,200
C8.Originality effect	Social quality (Sq)	Cultural quality (Cq)	Ecologial quality (Eq)
Social quality (Sq)	1,0	5	0,110
Cultural quality (Cq)	0,200	1	9
Ecologial quality (Eq)	9	0,110	1
Total	10,200	6,110	10,110

Table 9 Matrix of Comparisons by Ecological quality (Eq)

C9.Closeness to nature	Social quality (Sq)	Cultural quality (Cq)	Ecologial quality (Eq)
Social quality (Sq)	1	7	7
Cultural quality (Cq)	0,140	1	5
Ecologial quality (Eq)	0,140	0,2	1
Total	1,280	8,2	13
C10.Refreshment effect	Social quality (Sq)	Cultural quality (Cq)	Ecologial quality (Eq)
Social quality (Sq)	1	5	3
Cultural quality (Cq)	0,2	1	3
Ecologial quality (Eq)	0,330	0,330	1
Total	1,530	6,330	7
C11.Relationship with plant	Social quality (Sq)	Cultural quality (Cq)	Ecologial quality (Eq)
Social quality (Sq)	1	9	9
Cultural quality (Cq)	0,110	1	7
Ecologial quality (Eq)	0,110	0,140	1
Total	1,220	10,140	17,000
C12.Climatic konfor	Social quality (Sq)	Cultural quality (Cq)	Ecologial quality (Eq)
Social quality (Sq)	1	7	3
Cultural quality (Cq)	0,140	1	3
Ecologial quality (Eq)	0,330	0,330	1
Total	1,470	8,330	7

After the normalized matrix results, the result table in Figure 8 was obtained. Comparative matrix results of the alternatives were obtained according to 12 criteria. In this, as in the other steps, a matrix was created using the values in the standard preference table (Table 10). When we look at the final results obtained with the AHP method, social quality (.510-52%) has the highest weight, followed by cultural quality (.260 - 26%) and ecological quality (.230 - 23%). When we reach this result, we can say that "traditional dwellings with courtyard feature increase the social quality.

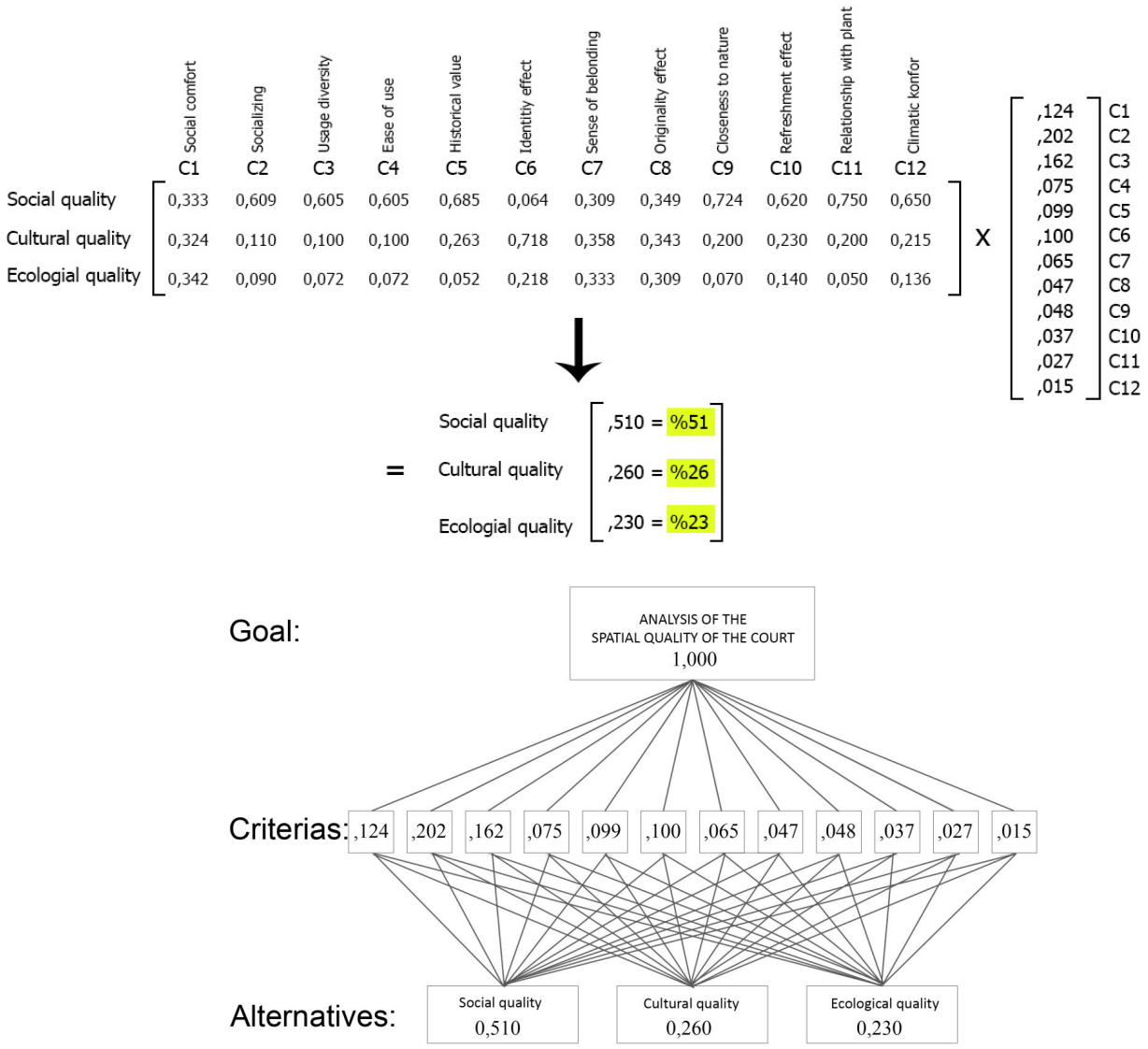


Figure 8 Comparative matrix results

6 Results and Discussion

In this article, a framework and methodology based on blurry logic is presented to evaluate the spatial quality parameters of traditional houses with courtyard characteristics, which are created by literature studies. In this context, 5 second-degree registered traditional dwellings with courtyard space were examined.

The results obtained within the scope of the study are grouped under two titles as "results obtained as a result of field and observation studies" and "results obtained as a result of the AHP method". The grouped results can be listed as follows:

Results obtained as a result of field and observation studies:

- Islamköy is a very important area with its cultural, historical and touristic values. The traditional dwellings among the various registered buildings in the village constitute the most unique texture of the area. Considering the courtyard character examined in the subject of traditional residences; it is possible to come across a courtyard in almost every residence.
- Just like in the Turkish dwelling, in the traditional dwellings of Islamköy, there is a courtyard that reflects the sociological and cultural structure of the region, but offers limited concrete clues about the lifestyle. Because there are no permanent landlords living in the houses.
- As a result of the observation and photographing studies of the 5 registered traditional dwellings, the sociological and cultural structure were seen and clues about the lifestyle were obtained.
- The dwellings have borders built with high walls for privacy reasons. The entrance to the courtyard is made through the door on this wall. The doors are double-winged to provide convenience for the courtyard and daily work. Entrance begins with patio.
- There are various spatial units and elements in the open space classified as open, semi-open and closed space that was discussed. The trough, molasses pool, sitting units and areas

where daily work is done reflect the lifestyle. There are also fruit trees in the open area.

- The semi-open space creates patio. Patio is one of the main venues seen in many regions in Turkey, and it has emerged as an area where the circulation is intense and where family actions take place.
- Among the indoor spaces; barn and hayloft. The presence of the barn and the hayloft shows the socioeconomic orientation of the region. They are places that have emerged out of necessity in the region where cattle breeding is common. Apart from this, there are also closed areas such as warehouse, depot and woodshed.

The findings obtained as a result of the AHP method:

- There are lots of studies have been carried out on traditional houses and courtyards. Despite the studies, the values that the courtyard character adds to the space are complex. The AHP method was used within the scope of the study as it became quite complex to comment and decide on the subject.
- As a result of the literature studies, 4 main criteria and 12 sub-criteria were created.
- In the ranking made relative to the criteria, it was seen that the most weighted criterion was the "social quality (.510)" alternative and the 4 criteria that formed it (social comfort, socializing, usage diversity, ease of use).
- In the weighting among the criteria, the second place was the "cultural quality (.260)" alternative and the 4 criteria (historical value, identity effect, sense of belonging, originality effect) were obtained.
- In the criterion weighting of the AHP stage, the third place is the “ecological quality (.230)” alternative and the result of 4 criteria (closeness to nature, refreshment effect, relationship with plant, climatic comfort) that make up it.
- Besides, it was stated that the results obtained in the study were consistent and appropriate.
- Socializing (.202)” has the highest weight and “ease of use (.075)” criterion has the lowest weight in social quality parameters.
- Among the cultural quality parameters, “Historical value (.99)” has the highest weight and “originality effect (.047)” criterion has the lowest weight.
- Among the ecological quality alternatives, the "Closeness to nature (.048)" criterion has the highest weight and the lowest weight is the "climatic comfort (.015)" value.
- When we examine the results, it is possible to say that the most important quality alternative that represents the courtyard character for users is the "socialization parameter”.

In the light of the results and findings obtained within the scope of the study, the following suggestions can be made;

- The courtyard, which is an important place of the urban structure and housing unit; since it contains ecological, socio-cultural and socio-economic values, it should be given sufficient importance and planned in line with the needs of the region where it is located.
- Parameters should be considered in the modern and contemporary designs of the courtyard in traditional dwellings, which are the subject of various disciplines such as architecture, interior architecture and landscape architecture.
- Each parameter used within the scope of the study has a special value and character for the courtyard. But when we look at the weighting between them; it can be said that while planning traditional courtyard characters, more attention should be paid to “socializing” and the criteria that make it up, and this parameter should be given special attention while making planning decisions. At the same time, the data obtained from the study is a base for future studies.

Acknowledgement

Between 2018-2020, Prof. Dr. The Scientific Research Project (08) supported by Higher Education Institutions named "Creating a Design Guide in Terms of Cultural Tourism Landscape and Traditional Housing Architecture: The Example of Isparta-Islamköy" led by Atilla GUL and Assoc. Dr. To the Scientific Research Project (06) Supported by Higher Education Institutions named "Reading the Interior Design of Traditional Houses with Local Identity Elements: The Example of Islamköy", conducted by Sebnem ERTAS BESIR; we thank them for give a place to position as "researcher", enabling fieldwork and providing the necessary facilities.

References

Almhafdy, A., Ibrahim, N., Ahmad, S. S., Yahya, J. (2013). Courtyard design variants and microclimate performance. Procedia-Social and Behavioral Sciences, *Elsevier*, 101:170-180.

Arseven, C. E., (1943). Sanat Ansiklopedisi, M.E.B. Yayınevi, Remzi Kitabevi, ıstanbul.

Asquith, L., and Vellinga, M. (Eds.). (2006). Vernacular architecture in the 21st century: *Theory, education and practice*. Taylor & Francis.

Aydın, Ö., (2000). Anadolu Mimarlıgında Avlu (Neolitik Dönemden Tunç Çagı Sonuna), Yüksek Lisans Tezi, Gazi Üniversitesi, Fen Bilimleri Enstitüsü, Ankara.

Direk, Y. S., (2006). Sosyo-Kültürel Yapının Konut Olusumuna Etkisi: Diyarbakır Örnegi. *Elektronik Sosyal Bilimler Dergisi*, 5(16): 105-113.

Dunham, D. (1961). The courtyard house as a temperature regulator. *Ekistics,* 11(64): 181-186.

Edwards, B., Sibley, M., Land, P. ve Hakmi, M. (Eds.), (2006). *Courtyard Housing: Past, Present and Future*. Taylor and Francis.

Ekim, E., (2012). Türk Evinde Yasam Alanı: Avlu, Yüksek Lisans Tezi, ıstanbul *Teknik Üniversitesi*, Fen Bilimleri Enstitüsü, ıstanbul.

Eldem S. H. (1955). Türk Evi Plan Tipleri. Istanbul Teknik Üniversitesi, *Mimarlık Fakültesi, Pulhan Matbaası*, Istanbul, Türkiye.

Erdogan, E., (1996). Anadolu Avlularının Özellik ve Düzenleme lkeleri Üzerinde Karsılastırmalı Bir Arastırma, Doktora Tezi, Ankara Üniversitesi Fen Bilimleri Enstitüsü, Ankara.

Esin, U., (1994). Akeramik Neolitik Evrede Aşıklı Höyük, XI. Türk Tarih Kongresinden Ayrı Basım , *Türk Tarih Kurumu*, Ankara.

Gök, Y., Kayserili, A., (2013). Geleneksel Erzurum Evlerinin Kültürel Coğrafya Perspektifinden İncelenmesi. *Eastern Geographical Review,* 18(30): 175-216

Güzel, A., (2013). Coğrafi Özellikleri Bakımından Anadolu Şehirlerindeki Geleneksel Konutlar: Şanlıurfa Örneği, *International Periodical For The Languages, Literature and History of Turkish or Turkic* . 8/12:569-590, Ankara, Turkey.

Hatipoğlu, E., (2015). Geleneksel Beypazarı Evlerinin Sürdürülebilir Mimarlık İlkeleri Kapsamında Değerlendirilmesi, Yüksek Lisans Tezi.

Hindistan, A., (2006). Avluların Peyzaj Tasarım Karakterleri Yönünden Değerlendirilmesi, Yüksek Lisans Tezi, İstanbul Teknik Üniversitesi, Mimarlık Fakültesi, İstanbul.

Hong, Hyung-Ock and et al, (2001), A Study of the Ecological Perspectives in Traditional Korean Homes. *Journal of Korean Home Economics Association English Edition*: 2(1): 123-134 www.khea.or.kr/InternationalJournal/2001/8.PDF.

Johnson, M. H. (2003). Housing culture: traditional architecture in an English landscape. Routledge.

Karagülle, C., Demir, Y. (2011). Yerel Verilerin Konut Tasarım Sürecinde Değerlendirilmesi: Mardin Örneği. İtüdergisi/A, 9(2): 83-94

Koç, S., (2019). Geleneksel Konutların İç Mekan Kurgusunu Yerel Kimlik Unsurları İle Okumak: İslamköy Örneği, Yüksek Lisans Tezi, Karadeniz Teknik Üniversitesi Mimarlık Fakültesi, Fen Bilimleri Enstitüsü, Trabzon.

Köse, A., (2007). Balıkesir çevresinde geleneksel kırsal avlu peyzajı ve değişimi. *Eastern Geographical Review* 18: 7-38.

Kuban, D., (2002). Mimarlık Kavramları: Tarihsel Perspetif İçinde Mimarlığın Kuramsal Sözlüğüne Giriş, YEM Yayınları, İstanbul.
Leal, J. E. (2020). AHP-*express: A simplified version of the analytical hierarchy process method. MethodsX,* 7, 100748.

Mellaart, J., (1970). Excavations at Hacılar, *The British Institude of Archacology at Ankara*, Edinburg.

Pfeifer, G., ve Brauneck P., (2008). Courtyard Houses: A Housing Typology, Birkhauser, Berlin.

Rapoport, A. (2007). The Nature Of The Courtyard House: A Conceptual Analysis. *Traditional Dwellings And Settlements Review,* 18 (2): 57-72.

Reynolds, S.J., (2001). Courtyards: Aesthetic, Social and Thermal Delight, John Wiley&Sons, New York.

Taleghani, M., Tenpierik, M. ve van den Dobbelsteen, A. (2012). Environmental impact of courtyards- a review and comparison of residential courtyard buildings in different climates. *Journal of Green Building*, 7(2): 113-136.

Taşçıoğlu, S., (2013). Tarihi Kentlerde Kimlik Sorunu: Kilis Örneği, Yüksek Lisans Tezi, Mustafa Kemal Üniversitesi, Fen Bilimleri Enstitüsü, Hatay.

TDK, (2021), Avlu Kavramı https://sozluk.gov.tr/, (Date of Access: 12.03.2021).

Üstün, R., (2016), İslamköy Tarihi, Yeni Matbaa, 1. Baskı, Isparta

Xu, P., (1998). Feng-Shui Models Structured Traditional Beijing Courdyard Houses. *Journal Architectural Planning Researc*h, 15:4 (Winter, 1998), 271- 282, Locke Science Publishing, Inc., Chicago. www.japr.homestead.com/files/Xu.pdf, 25.02.2006 sf: 279-280

IJBES

International Journal of Built Environment and Sustainability
Published by Penerbit UTM Press, Universiti Teknologi Malaysia
IJBES 9(1)/2022, 89-97

How to Reveal the Meaning of Space in Vernacular Architecture?

Parmonangan Manurung
Department of Architecture and Planning, Faculty of Engineering, Universitas Gadjah Mada, Indonesia

Sudaryono Sastrosasmito and Diananta Pramitasari
Department of Architecture and Planning, Faculty of Engineering, Universitas Gadjah Mada, Indonesia

ABSTRACT

Vernacular architecture is a modest style of building used to maintain the balance of human relations with nature. This architectural style is specific to a region and passed down from one generation to another to embody cultural values. However, its development is currently facing globalization and modernization challenges, thereby leading to a gradual shift of this ancestral heritage to modern buildings. Change is unavoidable due to continuous evolution, however, the meaning inherent architecture buildings need to be maintained because it contains the cultural and social values of the associated local community. Furthermore, vernacular building space is a place for social activities and contains historical meaning applicable to modern buildings. Its functionality responds to changes and the needs of times while maintaining the local essence. Therefore, this research aims to determine the suitable method needed to reveal the meaning of vernacular architectural space. Data were collected from the conscious mind of space users through in-depth interviews by applying *epoche,* which were further reduced, categorized, and integrated to determine its meaning. The data collected through a literature review were analyzed using the *content analysis* method. The results showed that transcendental phenomenology is the right method to determine the meaning of vernacular architectural space. Based on the results, it is concluded that the meaning passed down from one generation to another could be expressed through the conscious experience of space users. Furthermore, transcendental phenomenology helped reveal the meaning without the intervention of the author's knowledge, therefore it is unbiased and applicable in modern buildings.

Article History

Received : *28 September 2021*
Received in revised form : *16 December 2021*
Accepted : *17 December 2021*
Published Online : *31 December 2021*

Keywords:

Vernacular architectural space, space meaning, transcendental phenomenology, epoche, noema, noesis.

Corresponding Author Contact:
monang@staff.ukdw.ac.id

DOI: 10.11113/ ijbes. v9.n1.890

1. Introduction

The concept of space is considered to be of fundamental importance to the existence of a place (Norberg-Schulz, 1980). Architecture is a field of science closely related to space and place, therefore it creates various phenomena felt by daily users. Norberg-Schulz (1980) further stated that a place is a qualitative phenomenon that comprises character and atmosphere, thereby making it inseparable from its elements, such as relationships, without losing the concrete nature of the scene. The importance of architecture is also expressed by Deleuze & Guattari (1994) as art that starts with the house.

According to Oliver, vernacular architecture is a modest style of building adopted by a community to represent their values, culture, and economic needs (Oranratmanee, 2018). Cultural

heritage contains tangible and intangible values such as social, historical, aesthetic, and environmental values that need to be maintained (Philokyprou & Michael, 2020). However, the development of modernization, transportation systems, and changes in lifestyle tend to affect the existence of this architecture style in various traditional settlements. Vernacular architecture is slowly going into extinction and being replaced by modern buildings (Baski and Wesołowska, 2010, cited by Li & Hu, 2019). Traditional settlements as historical heritage, which plays a role in maintaining cultural sustainability, are also threatened by this development, leading to uniformity and monotony (Atık & Erdoğan, 2017).

The loss of vernacular architecture is a phenomenon that occurs in various parts of the world. According to Michiani & Asano (2016), it is caused by the pressure of modernization, the development of technology, and changes in people's lifestyles. Humans build settlements in response to the environment (Wu, 2001, cited by Zhang et al., 2018), however, urbanization and reconstruction carried out in rural areas have changed the settlement structure of traditional communities (Zhang et al., 2018). Currently, traditional people are asked to understand the developments of the modern era, which leads to modern architecture buildings (Dayaratne, 2018).

Kant stated that space plays an important role in creating user experience and awareness. Kant emphasized the importance of space because it tends to create an experience that becomes the basis for the consciousness of its users (Wilson, 2014). An interesting meaning is associated with the relationship between humans and their surrounding space formed to accommodate social activities and vernacular architecture (Lefebvre, 1991).

Vernacular architectural transformation is unavoidable due to modernization and globalization, therefore, it needs to be maintained. Baharudin & Ismail (2016) stated that da'wah mosques in Malaysia have evolved from the pre-independence period to the present. However, despite this physical evolution, a da'wah mosque generally is still associated with the surrounding community. Therefore, to determine the meaning of a vernacular building, the space contained need to be explored using the right method. Furthermore, appropriate approaches and methods are needed to explore the meaning of vernacular architectural space. Based on the importance of this background, this research aims to explore methods used to reveal the meaning of vernacular architectural space for it to be applied to modern buildings. Hence, the formulated research question is "How to reveal the meaning of vernacular architectural space?"

2. Methodology

The content analysis method was used to carry out this research with data collected from various related published online and offline scientific journals and books on vernacular architecture and research methodology. These data were collected to gain an adequate understanding of these topics. Furthermore, data were collected through literature studies related to various methods used to explore the meaning of vernacular architectural space.

All the collected data were then analyzed to obtain an in-depth study of the appropriate method used to reveal the meaning of vernacular architectural space. The results are compiled and discussed in a qualitative descriptive manner to determine relevant conclusions.

3. Results and Discussion

3.1 Vernacular Architecture

Buildings are designed and built as a socio-cultural manifestation, which changes in shape in response to climatic conditions, environmental context, method of development, materials, and technology owned (Rapoport, 1969). Therefore Rapoport emphasized that the socio-cultural factor is the main component of a building. This is in line with the research carried out by Koentjaraningrat (2004), which stated that physical products, such as architecture, are among the 3 factors that form cultures. Meanwhile, Rapoport (1969) stated that buildings were originally built to protect humans from climatic and weather conditions.

The artificial physical area created by humans is referred to as the built environment. This area is created by humans to deal with nature, thereby manifesting into houses, cities, communities, farms, kitchens, and bathrooms (Altman & Chemers, 1980). Conversely, humans create a physical environment to fulfill their needs (Maslow, 2016; Poonia & Sharma, 2017). In contrast, Altman & Chemers (1980) stated that the physical environment is an embodiment of culture, houses, community structures, and public buildings, which are reflections of the values and beliefs of a culture. Although both statements are different, they conclude that physiological and psychological needs are the basis for humans to create a physical environment capable of meeting the basic needs of society. Meanwhile, cultural factors give value to the form of the built environment. Figure 1 illustrates the techniques used by humans to make the built environment, values, and beliefs of cultural embodiments.

Figure 1: Scheme of the built environment creation (Processed based on Poonia & Sharma, 2017;Altman & Chemers, 1980; Maslow, 2016; and Koentjaraningrat, 2004)

3.2 Traditional Vernacular Architecture

In several architectural scientific publications, the term vernacular is often used to describe architecture or buildings, a hereditary heritage of an ethnic group. The terms vernacular and traditional architectures are often used interchangeably. Therefore Amos Rapoport (1969) carried research aimed at

categorizing both terms. According to Rapoport, vernacular architecture is categorized into 2, namely traditional and modern, both of which are people's buildings developed without the supervision of an architect. Vernacular buildings are identified based on their process and method of construction. Traditional vernacular building models are passed down from one generation to another. In traditional vernacular buildings, skilled craftsmen are only needed for a few specific details, while dimensions, layout, and relation to the site, are formulated in the discussion.

Amos Rapoport's statement shows that vernacular and traditional vernacular buildings mean the same thing. Rapoport uses traditional vernacular "building" terminology and does not refer to it as traditional vernacular "architecture." The difference between both terms is the word "architecture," defined as a professional worker, and "building," which is a non-professional (Turan, 1990, cited by Purbadi, 2010). According to Oliver (1997, cited by Purbadi, 2010), "traditional architecture" is one of the terminologies commonly used as a synonym for vernacular architecture. Therefore, based on these developments, it can be stated that the term "traditional vernacular building" in Rapoport's understanding is currently used with the term "traditional architecture" or "traditional vernacular architecture."

3.3 Meaning of Vernacular Architecture

Architectural images play essential roles in reflecting external life ideas and images (Pallasmaa, 2006). According to Gomez (2006), architecture is poetic, which means that it needs to be well known. Similar to poetry, its character is brought into presence, which elevates the meaning and end of its experience. In Gomez's understanding, architecture does not tell a real experience as it appears, rather it takes a search to get to the real meaning. Therefore, in the vernacular architectural space, the real meaning is revealed through research.

An understanding of vernacular architecture shows its journey as a legacy of architectural works built by ordinary people and contains important values, which are the locality and the surrounding context. Therefore, different contexts have varying design approaches. Koentjaraningrat (2004) formulated the first form of culture associated with values. This shows that vernacular architecture had gone through a long journey with many meanings because of its intersection with various disciplines. Furthermore, it also has a very close relationship with anthropology and history (Turan, 1996, cited by Ara & Rashid, 2016). The relationships between anthropology and history show that vernacular architecture plays an important role in the development of knowledge, especially on humans and the culture of an ethnic group and their environment.

In a more macro context, vernacular settlements are built by the community by applying local wisdom, knowledge, and skills inherited from one generation to another. This heritage is used to solve environmental problems by utilizing various natural resources. Locality factors enable vernacular settlements to contribute to create a sustainable environment (Dayaratne, 2018). According to studies, vernacular architecture has values that remain relevant to the modern world and create a sustainable environment. However, this is in contrast to the shape that has changed due to globalization and modernization.

3.4 The Fading Meaning of Vernacular Architecture

The physical environment inhabited by humans today is due to the uncontrolled design of vernacular architecture. According to Rapoport (1969), the best way to define the meaning of vernacular is to understand the design process, which generally consists of several characteristics. Furthermore, the architectural design is open to adjustments, changes, and additions. Therefore, it is important to achieve the relationship between elements in vernacular architecture, which is a collaboration between people from different generations, as well as creators and users (Rapoport, 1969).

The visible and invisible meanings in vernacular architecture must be maintained (Philokyprou & Michael, 2020). Furthermore, vernacular architecture provides an adequate understanding of previous architectural works philosophically and deeply with clarifications on the constant and changing elements. This type of building does not try to dominate nature rather, it tends to maintain a balance in the relationship between humans and nature. In terms of design, the various vernacular building types are associated with culture, ritual, way of life, social organization, climate, landscape, materials, and available technology. Meanwhile, the similarity of types is shown by the region as well as the needs and desires of humans (Rapoport, 1969).

Paul Oliver and Amos Rapoport are two important figures in the field of vernacular architecture (Ara & Rashid, 2016). Paul Oliver reported the importance of vernacular settlements in maintaining a sustainable environment through *the Encyclopedia of the Vernacular Architecture of the World*. Meanwhile, Amos Rapoport explored vernacular architecture through the ideas conceived and implemented from a cultural perspective (Dayaratne, 2018).

Based on the theoretical studies, it can be concluded that vernacular architecture is a physical work that embodies values and human needs/behavior through reasoning. It comprises 2 categories, namely traditional and modern vernacular architecture. Traditional vernacular architecture is a human physical work produced without the professional assistance of an architect and passed down from one generation to another. It is sustainable, contains deep values and meanings, and has the ability to respond to change. Its form varies due to its response to the environment and the availability of materials and technology.

Traditional vernacular architecture, which is sustainable and full of values, is threatened by technological development and modernization. The values contained are inherited from one generation to another, and therefore need to be maintained for sustainability due to modernization and changes in lifestyle. Maintaining traditional vernacular architecture while carrying out extreme transformations erodes the meaning contained. Therefore, it is important to main sustainability by exploring the meaning contained in traditional vernacular architecture and combining it with contemporary contextual architecture. This is realized in new modern buildings, hence it creates a locality-

oriented design while being able to fulfill the modern humans' needs.

3.5 The Meaning of Space

According to Meiss (2013), space is a "container," with boundaries on the outside and content on the inside. In terms of function, Ching (2015) described it as a medium that serves as a function and responds to its context. Space is created by the formation of physical and horizontal elements on each side. Meanwhile, Ford (2000) stated that certain spaces tend to change for the better or worse due to societal effects. Conversely, different groups of people are likely to use space in a variety of ways than preliminary generations. Ford's statement is in line with the current society condition associated with the use of inherited vernacular architectural space, which tends to transform in accordance with differences between generations.

George Herbert Mead and Herbert Blumer emphasized the importance of meaning and interpretation as essential human processes. Meaning is created through human interaction before becoming a reality (Patton, 2015), Blumer (1969, cited by Patton, 2015) stated that meaning is the basis of human action towards something that comes from social interaction and is transformed through interpretation. The human ability to give meaning to something makes them different from animals. Naturally, humans have the ability to integrate and interpret their experiences (Loevinger, 1976, cited by Patton, 2015). Therefore, based on this understanding, meaning is produced from humans interactions with each other and their surrounding environment. User relations and interactions with vernacular architectural spaces produce meaning which acts as a reference for them to respond to these spaces.

In the architectural context, the built environment is the result of the 4 elements, namely space, time, communication, and meaning. The 4 elements interact with each other, the environment and humans (Rapoport, 1977). Rapoport further stated that meaning is closely related to space, time, and communication. It is also created from the relationship between these 3 attributes and with adequate understanding of space needed to be possessed by humans. According to Amos Rapoport (1990), "meaning" is a non-verbal communication from the environment to humans. This is different from "communication," which comprises verbal and non-verbal communication strategies. The organization of space also expresses meaning, which is often expressed through various physical products such as signs, materials, colors, shapes, dimensions, furniture, landscaping, and maintenance activities. Furthermore, the communicated spatial meaning is expressed through permanent, semi-permanent, or non-permanent elements.

Henri Lefebvre (1991) emphasized that the spaces formed based on social activities such as landscapes, monuments, and buildings have meaning and contain various messages. The meaning is conveyed to the single or collective subject that lives and acts in the space. Meanwhile, according to Archea et al. (1980, cited by Weisman, 1981), meaning is one of the eleven main concepts in the relation of the physical environment to human behavior. Furthermore, it refers to the extent to which the environment provides individual and cultural meaning to humans, such as attachment, challenge, or beauty. Gerald D. Weisman (1981) formulated the meaning along with other concepts into a model system of environmental relations with behavior as attributes experienced by humans. According to Weisman, environmental attributes are the result of the 3 sub-systems' interactions, namely organization, individual, and physical settings. Furthermore, Lefebvre (1991) stated that it is very useful to understand the communication conveyed by space. Figure 2 shows the process used to form the meaning of vernacular architecture between space and its users. The result shows that spaces are formed to accommodate social activities, hence it has meaning and contains messages. The meaning of vernacular architectural space is formed as a result of human relations with the physical environment. Humans as subjects that live and experience this space, tend to have an understanding of meaning. Each space in a different vernacular architecture produces varying meanings and experiences.

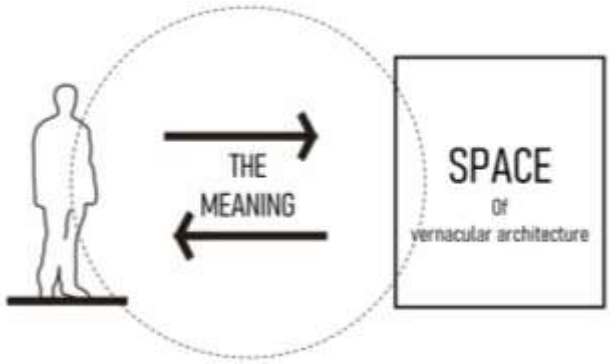


Figure 2: Meaning as non-verbal communication between the user and the vernacular architectural space (Processed based on Rapoport, 1990; and Lefebvre, 1991)

According to Rapoport (1990), the meaning of space starts with the whole phenomenon that occurs naturally. In vernacular architecture, space is a physical setting or environment with non-verbal communication to the subject, hence its meaning is created. Therefore, understanding communication is very important, which can be extracted from the subject as people experience their environment.

Based on the literature review, space is concluded as a physical embodiment of culture and a product of human values and activities. Its meaning is in accordance with the result of the user's relationship. Furthermore, it affects human actions towards space and their surrounding environment because it is a two-way relationship between the environment and humans explored by revealing the non-verbal communication between space and users. In determining the relationship between space and the user, exploring their awareness and experience is necessary.

3.6 Revealing the Meaning of Vernacular Architectural Space

An appropriate approach is needed to reveal the meaning of vernacular architecture space by exploring the user's conscious experience. The choice of method is an important part of uncovering the meaning because it is contained for tens or even hundreds of years. Vernacular architecture with hundreds of years shows that its users have changed from one generation to another. Therefore, the exploration of meaning needs to be carried out carefully through a study with the right method. According to Creswell (2014) and Jansson-Boyd (2019), philosophical considerations consist of the research procedure, methods, techniques, data collection, analysis, and discussion that guide determining the appropriate methodology. Another consideration as a reference is the research problem and participants' experiences. On the other hand, Jansson-Boyd (2019) stated that selecting research methodologies needs to be objective and oriented towards goals. Therefore, authors need to use quantitative, qualitative, and mixed methods to fulfill the research objectives.

Dawson (2007) stated that the meaning of space is implemented using a qualitative approach because the research aims to explore the 'experience' of users. Dawson further stated that research questions containing words such as 'discovery,' 'motivation,' 'experience,' 'thought,' 'problem,' or 'behavior,' refer to qualitative methodologies. A qualitative approach contributes to science, revealing the meaning and understanding of a person or group (Patton, 2015).

Questions on the meaning of life as experienced by humans need to be answered using phenomenology. This process is used to determine the origin and meaning of phenomenology, such as 'curiosities', 'words', and 'the world' (Van Manen, 2016). Furthermore, Manen stated that phenomenology is not only associated with a problem that needs to be solved, rather it is in line with questions that must be answered. Phenomenology is also oriented towards 'meaning' that emerges from a human experience. Therefore, it is clear that the meaning of vernacular architectural space is extracted from the conscious experience of space users using phenomenological methods. Moreover, it aims to achieve the eidetic and essential meaning of a phenomenon (Van Manen, 2016), which is extracted by carrying out an eidetic reduction (Husserl, 1970, cited by Sudaryono, 2012).

Phenomenology is a philosophy and research method that describes the meaning of life experience and awareness in the form of concepts (Creswell, 2007; Sokolowski, 2000; Stewart & Mickunas, 1974; Van Manen, 2017). This method contributes to a deeper understanding of the experience by explaining the accepted assumptions (Starks & Trinidad, 2007). Creswell (2007) stated there are two types of phenomenological methods, namely Hermeutical or empirical, and transcendental or psychological. Hermeneutic phenomenology is a method used to carry out qualitative educational research and other human sciences, such as nursing. In many types of research, these methods are unclear or ambiguous. Hermeneutics is oriented towards historical and relative meaning. Phenomenology is described as studying essence, while hermeneutics is the process of interpretation (Kakkori, 2009).

According to Martirano (2016), transcendental phenomenology was developed by Husserl as a methodology used to explore experiences with objectivity as well as quantitative style through preconceptions. It is a methodology used to explore transcendental phenomenology with the ability to outperform other forms of qualitative research in producing results regarding the true essence of the phenomenon studied.

Research on the invisible things, such as experiences and feelings, is closely related to the phenomenological method because due to its ability to explore meaning or concepts based on the life experiences of a person or some community groups (Creswell, 2007; Sokolowski, 2000; Stewart & Mickunas, 1974; Van Manen, 2017). The life experience exploring architecture, both in terms of aesthetics (form), space, and place, is carried out using various phenomenological methods described by Zahafi (2018).

People that study phenomenology like to observe the symptoms that occur in something, which distinguishes them from positive science experts that collect information, look for relationships and functions, as well as make various theories and propositions. Phenomenology does not have systems, hypotheses, or theories, therefore it is not called science, rather a method of thinking (Brouwer, 1984). Edmund Husserl stated that transcendental phenomenology is a new field in philosophy and science rooted in the openness of the subject. Husserl faced many challenges, including criticism and ridicule, while carrying out a research on transcendental phenomenology, which is closely related to the concept of intentionality and awareness of an object. Moreover, 'intuition' is also an important factor in transcendental phenomenology (Moustakas, 1994).

Moustakas (1994) stated that the complex concepts in transcendental phenomenology are *intentionality, noema,* and *noesis.* According to Moustakas, an intentional experience and an act of awareness arise from the combination of trees. This is capable of leading to other future experiences on trees. Therefore, an experience is extended in the chain of meaning and essence with every experience open to other activities, therefore, there is no final reality. Moreover, to understand its essence, intentional experience is a combination of the real thing in its ideal state through thoughts, perceptions, memories, judgments, and feelings. Furthermore, meaning is the core of transcendental phenomenology, and it is inseparable from the object of consciousness.

According to Moustakas, intentionality is a synonym for awareness. This means that people are always aware of everything intentionally, which points in a direction with meaning. Husserl (1931, cited by Moustakas, 1994) first introduced the concept of *noesis* and *noema* in the book entitled *ideas. Noesis* is related to the thoughts and spirits that bring awareness of the meaning or feelings in perceptions, memories, and thoughts. It leads to awareness of something and refers to the act of perceiving, feeling, thinking, remembering, or judging something hidden from consciousness, which needs to be exposed. Meanwhile,

noema is related to *noesis* because it is defined as the perceived meaning of something remembered According to Ihde, *noema* is a way of experiencing and correlating a subject (Ihde, 1977, cited by Moustakas, 1994).

Moustakas stated that *noesis* and *noema* refer to the process of analyzing something to determine its essence and meaning. The perceptual meaning of an object is used to describe its meaning. Moustakas stated that Husserl developed a concept called '*Epoche,*' a Greek word that means to refrain from judgment and distance oneself from everyday worldviews. Epoche requires a new perspective in understanding a phenomenon. Various judgments, knowledge, and understanding must be put aside, a phenomenon must be seen clearly and reviewed openly. Therefore, the process used to reveal the meaning of space in this study is the communication between the vernacular architectural space and user as *noema*, and *noesis,* respectively. The meaning of space is hidden in the user's consciousness as *noesis,* which is formed from relations and interactions with *noema*. Furthermore, to determine the conscious experience of space users and discover the meaning of vernacular architectural space, researchers must put all their knowledge into brackets (*epoche*). *Epoche* has the ability to help this research to understand the meaning of space in a clear and bias-free manner. The research uncovers the hidden *noesis* in the consciousness of space users through in-depth interviews. The user's entire conscious experience of space is excluded without the intervention of the author's knowledge, as shown in Figure 3.

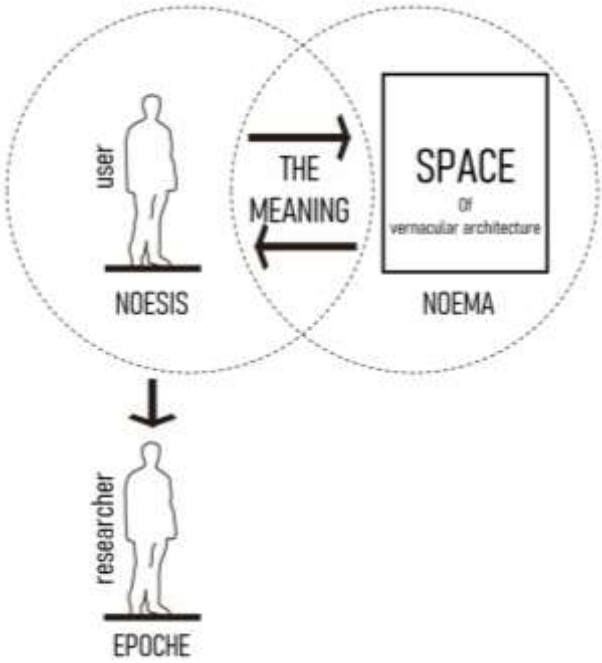


Figure 3: Bringing out the meaning of vernacular architectural space from the users of the space (Processed based on Moustakas, 1994)

According to Moustakas, the *epoche* phase is followed by Husserl's phenomenology, which is known as "*Transcendental-Phenomenological Reduction*." Each conscious experience of the space users is considered singular in this phase, with the phenomena perceived and described in new ways. Brouwer (1984) stated that reduction is the abstraction and attempt to view an object while ignoring others. Meanwhile, transcendental reduction analyzes a symptom from the supra-individual side of a general subject. Furthermore, information on users' conscious experience of the vernacular architectural space has been released through in-depth interviews. The information related is grouped on the one hand and non-relevant information on the other.

The phase that is passed after the phenomenological-transcendental reduction is "*The Imaginative Variation,*" which aims to understand the structural essence of an experience. Husserl (1977, cited by Moustakas, 1994) stated that imaginative variation leads to the structural differentiation between the multiplicity of an actual cognition related to objects and subsequently forms a unitary identification synthesis. The last reveals the meaning of vernacular architectural space from all the phases using Husserl's phenomenology by carrying out a "*Synthesis of Meanings and Essences.*" In this phase, an intuitive integration of structural and textural descriptions is conducted into a unified statement to determine the essence of the vernacular architectural space meaning as long as it interacts with the physical setting. This phase is also a guide for the eidetic sciences towards the formation of essence knowledge.

It is important to arrange the steps to ensure the phenomenological steps are traceable from beginning to end. Randles (2012) stated that there are several stages to exploring life experiences strategy of a person or community group, such as 1) experiences, 2) explaining the reasons for being interested in a phenomenon, explaining the reasons for carrying out the research, 3) importance of this phenomenon to the academic world, 4) collecting data through interviews, discussions, observations, FGDs, and notes and 5) compiling descriptions obtained and written by participants, researchers, and other related parties, to explain the essence of the phenomenon.

Meanwhile, Moustakas (1994) suggested that transcendental phenomenology needs to be organized systematically to obtain scientific findings. Some of the methods and procedures that need to be carried out are to determine topics and research questions rooted in social meanings and values. These include 1) conducting a comprehensive review of the literature, 2) selecting the right research team, 3) providing direction to the research team while emphasizing confidentiality and ethics, 4) developing questions or topics to guide the interview process, and 5) conducting interviews with participants focusing on grouped questions and topics. Furthermore, the next step is to conduct follow-up interviews by organizing and analyzing data for the development of individual textural and structural descriptions of meaning and essence. According to Moustakas, these methods are grouped into several stages such as "Preparation," "Data collection," and "Organizational and Data Analysis." Moreover, the method used in phenomenological and other qualitative research conducted on humans is open, which means that there are no absolute requirements.

Martirano (2016) uses Husserl's method to arrange the research sequence and determine the phenomenon studied. This method was also used to create awareness of epoche, perform phenomenological reduction, and collect data from respondents that have experienced the phenomenon. The data collected were analyzed using a frequency response free of bias texture (what) and structural descriptions (how).

Husserl's method suggests 4 important stages in the phenomenological research process, including intentionality, reduction, description, and essence (Baker et al., 1992; cited by Priest, 2002). Moustakas and Martirano have previously mentioned these 4 stages. Priest (2002) further stated that most data sources in phenomenological research are obtained through audio recordings during interviews, while others are the results of group discussions and notes.

The stages in data analysis include reflection, intuition, and textural descriptions. According to Moustakas (1994), some reflections provide logical, systematic, and coherent sources to produce the analysis and synthesis needed to describe essential experiences. This is followed by consideration and data management, which is used to record and read transcripts of interview results (Priest, 2002). At this stage, all participant statements related to the meaning being studied need to be identified or highlighted. Relevant statements are grouped under appropriate descriptions and repeated on the other obtained statements. After the completion of this stage, the grouped data is given to all participants to determine their responses to the phenomenology being studied with an understanding of the concept essence. Different methods can be used to compare these results with other studies.

This research was carried out using transcendental phenomenology as previously revealed by Priest is reduction and description. The method is gradually described by Moustakas (1994) into several stages, including *horizonalizing* (determining units of information), *thematizing* (formulating the theme), *textural description, structural description*, (describing), and integrating structure and texture to produce essence and meaning. Sudaryono (2003, cited by Wibowo, 2019) described the induction process using the sequential phenomenological method in a structured manner. The units of information are arranged in an empirical stage and then grouped into themes. Furthermore, subsequent themes generate concepts and local theories.

Based on the various literature reviews above, after receiving information on users' conscious experience of the vernacular architectural space, it is reduced by filtering to determine its real meaning. Relevant and relaintod information are then grouped in units (*horizonalizing*). Furthermore, the units of information that are related to each other are grouped into themes. A textural description containing information on 'what is experienced by space users during their stay and interacting in the vernacular architectural space. They also describe 'how' space users experience these interactions (*structural description*). The essence of the vernacular architectural space meaning is in the integration between textual and structural descriptions.

4. Conclusion

This research showed that vernacular architectural space results from the users' interaction and relations with their surroundings that accommodates social activities in a traditional building. Vernacular architectural space that is built across generations is a *noema* experienced by space users. Meanwhile, users' perceptions and thoughts towards the vernacular architectural space experienced are *noesis* and stored in their consciousness, which can be extracted using the transcendental phenomenology method. In the process of uncovering the spatial meaning of the user's consciousness, it is important to confine the knowledge and experience to ensure the user's conscious experience emerges purely.

Furthermore, various information related to the conscious experience of space users is reduced and grouped based on similarities. The integration between textural descriptions containing information related to 'what' experienced by space users with structural descriptions containing 'how' produces the essence of the vernacular architectural space meaning. This is successfully revealed and used as a concept in the design of modern buildings due to its functional approach. However, it still has a sustainable and locality-oriented vernacular essence.

Acknowledgments

The authors are grateful to the Doctorate Program in Architecture, Department of Architecture and Planning, Faculty of Engineering, Postgraduate Program, Universitas Gadjah Mada for all their support. The authors are also grateful to the Research Fund Management Institute (LPDP) for funding this doctoral program through BUDI-DN scholarship.

References

Altman, I., & Chemers, M. (1980). *Culture and Environment*. California: Wadsworth, Inc.

Ara, D. R., & Rashid, M. (2016). Between the built and the unbuilt in vernacular studies: The architecture of the Mru of the Chittagong Hills. *Journal of Architecture*, *21*(1): 1–23. https://doi.org/10.1080/13602365.2015.1137620

Atık, D., & Erdoğan, N. (2017). A model suggestion for determining physical and socio-cultural changes of traditional settlements in Turkey. *A/Z ITU Journal of the Faculty of Architecture*, *14*(2): 81–93. https://doi.org/10.5505/itujfa.2017.62534

Baharudin, N. A., & Ismail, A. S. (2016). Architectural Style of Da'wah Mosque in Malaysia: from Vernacular to Modern Structures. *International Journal of Built Environment and Sustainability*, *3*(2): 70–78. https://doi.org/10.11113/ijbes.v3.n2.122

Brouwer, M. A. W. (1984). *Psikologi Fenomenologis*. Jakarta: PT.Gramedia.

Ching, F. D. K. (2015). *Architecture: Form, Space, and Order* (4th ed.). New Jersey: John Wiley & Sons, Inc.

Creswell, J. W. (2007). *Qualitative Inquiry & Research Design*. London:

Sage Publications, Ltd.

Creswell, J. W. (2014). *Research Design: International student edition* (4th ed.). Los Angeles: SAGE Publication, Inc.

Dawson, C. (2007). *A Practical Guide to Research Methods. A User-friendly manual for mastering techniques and projects*. Oxford: How To Content.

Dayaratne, R. (2018). Toward sustainable development: Lessons from vernacular settlements of Sri Lanka. *Frontiers of Architectural Research*, *7*(3): 334–346. https://doi.org/10.1016/j.foar.2018.04.002

Deleuze, G., & Guattari, F. (1994). *What is Philosophy?* New York: Columbia University Press.

Ford, L. R. (2000). *The Spaces Between Building*. Baltimore: The John Hopkins University Press.

Gomez, A. P. (2006). The Space of Architecture: Meaning as Presence and Presentation. In S. Holl, J. Pallasmaa, & A. P. Gomez (Eds.), *Questions of Perception: Phenomenology of Architecture* 2: 7–25. San Francisco: William Stout Publishers.

Jansson-Boyd, C. V. (2019). Quantitative Research: Its place in consumer psychology. In P. M. W. Hackett (Ed.), *Quantitative Research Methods in Consumer Psychology: Contemporary and data-driven approaches*. New York: Routledge.

Kakkori, L. (2009). Hermeneutics and Phenomenology Problems When Applying Hermeneutic Phenomenological Method in Educational Qualitative Research. *Paideusis*, *18*(20): 19–27. https://doi.org/10.7202/1072329ar

Koentjaraningrat. (2004). *Bunga Rampai: Kebudayaan Mentalitas dan Pembangunan*. Jakarta: Gramedia Pustaka Utama.

Lefebvre, H. (1991). *The Production of Space* (E. by D. N. Smith (ed.); 1st ed.). Malden: Blackwell Publishing.

Li, G., & Hu, W. (2019). A network-based approach for landscape integration of traditional settlements: A case study in the Wuling Mountain area, southwestern China. *Land Use Policy*, *83*(January), 105–112. https://doi.org/10.1016/j.landusepol.2019.01.043

Martirano, M. M. (2016). Transcendental Phenomenology: Overlooked Methodology for Marketing Research. *International Journal of Marketing Studies*, *8*(3): 58–64. https://doi.org/10.5539/ijms.v8n3p58

Maslow, A. H. (2016). *A Theory of Human Motivation*. Midwest Journal Press.

Meiss, P. von. (2013). *Elements of Architecture: From form to place + tectonics* (2nd ed.). Lausanne: EPFL Press.

Michiani, M. V., & Asano, J. (2016). Influence of inhabitant background on the physical changes of Banjarese houses: A case study in Kuin Utara settlement, Banjarmasin, Indonesia. *Frontiers of Architectural Research*, *5*(4): 412–424. https://doi.org/10.1016/j.foar.2016.09.005

Moustakas, C. (1994). *Phenomenological Research Methods*. California: Sage Publications, Inc.

Norberg-Schulz, C. (1980). *Genius Loci: Towards a Phenomenology of Architecture*. New York: Rizzoli.

Oranratmanee, R. (2018). Vernacular Houses of the Shan in Myanmar in the South-East Asian Context. *Vernacular Architecture*, *49*(1): 99–120. https://doi.org/10.1080/03055477.2018.1524217

Pallasmaa, J. (2006). An Architecture of the Seven Senses. In S. Holl, J. Pallasmaa, & A. P. Gómez (Eds.), *Questions of Perception: Phenomenology of Architecture* 27–38. San Francisco: William Stout Publishers.

Patton, M. Q. (2015). *Qualitative Research and Evaluation Methods* (4th ed.). Los Angeles: Sage Publications, Inc.

Philokyprou, M., & Michael, A. (2020). Environmental Sustainability in the Conservation of Vernacular Architecture. The Case of Rural and Urban Traditional Settlements in Cyprus. *International Journal of Architectural Heritage*, *00*(00): 1–23. https://doi.org/10.1080/15583058.2020.1719235

Poonia, M. P., & Sharma, S. C. (2017). *Environmental Studies*. New Delhi: Khanna Publishing.

Priest, H. (2002). An Approach to the Phenomenological Analysis of Data. *Nurse Researcher*, *10*(2): 50–63. Retrieved from: https://www.researchgate.net/publication/10958296_An_approach_to_the_phenomenological_analysis_of_data. Retrieved date: 3 June, 2021.

Purbadi, Y. D. (2010). *Tata Suku dan Tata Spasial pada Arsitektur Permukiman Suku Dawan di Desa Kaenbaun di Pulau Timor*. Laporan Disertasi. Yogyakarta: Universitas Gadjah Mada.

Randles, C. (2012). Phenomenology: A review of literature. *National Association for Music Education*, *30*(2): 11–21. https://doi.org/10.1177/8755123312436988

Rapoport, A. (1969). *House Form and Culture*. Englewood Cliffs: Prentice-Hall, Inc.

Rapoport, A. (1977). *Human Aspects of Urban Form Towards a Man—Environment Approach to Urban Form and Design* (1st ed.). Oxford: Pergamon Press.

Rapoport, A. (1990). *The Meaning of the Built Environment: A non verbal communication approach*. Tucson: The University of Arizona Press.

Sokolowski, R. (2000). *Introduction to phenomenology*. Cambridge: Cambridge University Press.

Starks, H., & Trinidad, S. B. (2007). Choose Your Method: A comparison of phenomenology, Discourse analysis, and grounded theory. *Qualitative Health Research*, *17*(10): 1372–1380. https://doi.org/10.1177/1049732307307031

Stewart, D., & Mickunas, A. (1974). *Exploring phenomenology: A guide to the field and its literature*. Chicago: American LibraryAssociation.

Sudaryono. (2012). *Fenomenologi Sebagai Epistemologi Baru Dalam Perencanaan Kota Dan Permukiman. Pidato Pengukuhan Jabatan Guru Besar Pada Fakultas Teknik. 14 Maret 2012*. Yogyakarta: Universitas Gadjah Mada.

Van Manen, M. (2016). *Phenomenology of Practice: Meaning-Giving Methods in Phenomenological Research and Writing*. New York: Routledge.

Van Manen, M. (2017). Phenomenology in Its Original Sense. *Qualitative Health Research*, *27*(6): 810–825. https://doi.org/10.1177/1049732317699381

Weisman, G. D. (1981). Environmental Programming and Action Research. Environment and Behavior. *Journal of Man-Environment Relations*, *1*(2): 32–41.

Wibowo, S. H. B. (2019). *Arsitektur Omah Dudur Di Wilayah Urut Sewu, Kecamatan Grabag, Kabupaten Purworejo, Jawa Tengah*. Laporan Disertasi. Yogyakarta: Universitas Gadjah Mada.

Wilson, C. S. J. (2014). *Architectural Reflections: Studies in the philosophy and practice of architecture*. Oxford: Butterworth Architecture.

Zahavi, D. (2018). Introduction. In D. Zahavi (Ed.), *The Oxford Handbook of The History of Phenomenology*. 1–2. Oxford: Oxford University Press.

Zhang, Y., Baimu, S., Tong, J., & Wang, W. (2018). Geometric spatial structure of traditional Tibetan settlements of Digger County, China: A case study of four villages. *Frontiers of Architectural Research*, *7*(3): 304–316. https://doi.org/10.1016/j.foar.2018.05.005

UTM UNIVERSITI TEKNOLOGI MALAYSIA

IJBES

International Journal of Built Environment and Sustainability
Published by Penerbit UTM Press, Universiti Teknologi Malaysia
IJBES 9(1)/2022, 99-105

Personality and Walkability: Predicting Walking Behaviour in Urban Settings using the Higher Order Factors of the Big Five amongst Malaysian Adults

Ahmad Syukri Bashri
Malaysian Urban Design Association, Kuala Lumpur, Malaysia

Rohayah Che Amat
Razak Faculty of Technology and Informatics, Universiti Teknologi Malaysia, 54100 Kuala Lumpur, Malaysia

ABSTRACT

Walkability has now been a popular policy to be adopted in the city centre as traffic congestion and inefficient public transportation have affected the mobility of the urban users prior to the pandemic. The pandemic has paved more efforts to improve the design of urban spaces to increase walkability in the cities. In the attempt to predict walking activity amongst Malaysian adults psychologically, a personality test using Big Five Aspect Scales (BFAS) was conducted in relation to individual walking frequency in urban settings. Structural equation modelling (SEM) was used to analyze the predicting capacity of personality constructs control by general intelligence in relation to walking behaviour. The results show that the higher order meta-traits of the big five personality traits which are Stability (Neuroticism, Agreeableness, and Conscientiousness) and Plasticity (Extraversion and Openness to Experience) can be used as a reliable predictor for individual walking behaviour. As hypothesized, walking behaviour amongst Malaysians was characterized by reversed Stability (r = -.58) and high Plasticity (r = .76). The implication suggested the necessity of cognitive navigability and design predictability metrics of urban design cognitive performance in influencing the psychological factor of walking behaviour.

Article History

Received : *22 September 2021*
Received in revised form : *16 December 2021*
Accepted : *17 December 2021*
Published Online : *31 December 2021*

Keywords:

Environmental Psychology, Higher order factors, Meta-Traits, Stability, Plasticity, Walking Behaviour

Corresponding Author Contact:

syukbash@gmail.com

DOI: 10.11113/ ijbes. v9.n1.893

1. Introduction

The increasing concern on environmental and health problems resulted in the rise of studies on how built environment can influences public health through travel behaviour (Saelens et al., 2003; Ewing & Cervero, 2010; Adkins, Dill, Luhr, & Neal, 2012). The causal relationship between the increase in environmental walkability and the increase in pedestrian activity however seems to lack sufficient evidence to support the presupposition (Dovey & Pafka, 2020; Liao et al, 2020; Cambra & Maura, 2020). Cambra & Moura (2020) suggested that the scale of environmental interventions is a significant factor in influencing walking behaviour but not effective in increasing walking activity. The complexity is shown to be exclusively embodied in the urban morphology, and that it should not be measured simply by levels of walking (Dovey & Pafka, 2020). Jacob (1961) in Dovey & Pafka (2020) contended that the pioneer isolation of the city into mono-functional zones had the impact of avoiding near associations of domestic to work, school, shopping, and amusement. Jacobs centred on the significance of quality sidewalks for urban priorities, social integration, and security.

There is currently much talk about creating walkable environments and improving walkability. Walkability is the extent to which the built environment supports and encourages

walking by providing for pedestrian comfort and safety, connecting people with varied destinations accessible within a reasonable amount of time and effort, and offering visual interest in journeys throughout the network. Contributing attributes include urban density, land use mixing, street connectivity, traffic volume, distance to destinations, sidewalk width and continuity, city block size, topographic slope, perceived safety, and aesthetics. There are nine key themes that defined by walkability: traversable environments, compact places, safe for walking, physically enticing environment, lively and sociable, sustainable transportation, exercise-inducing environment, proxy for better design (Claris et al., 2016). Studies on the geographical factors of personality differences have supported the presupposition of the association between individual personality and different environmental attribution of regions (Allik et al., 2009; Buecker et al., 2020; Rentfrow, 2010), cities (Bleidorn et al., 2016; Wei et al., 2017) and neighbourhoods (Jokela, 2020; Jokela et al., 2015).

Significant evidence revealed the importance of individual traits such as personality in influencing behavioural choices (Tucker et al., 2006; DeYoung et al., 2007; Faullant et al., 2011; Liu & Campbell, 2017). Psychometricians have identified that you can measure personality into 5 factor traits also known as the Big Five which are Neuroticism, Agreeableness, Conscientiousness, Extraversion and Openness to Experience (McCrae & Costa, 1997). The personality traits can be further categorized into two meta-traits based on the underlying biological representation which are Stability (alpha) and Plasticity (beta) (DeYoung et al., 2007). The meta-traits of personality also known as the Big Two is characterized by Plasticity (exploration and goal creation), and Stability (goal maintenance) (DeYoung, 2015). Plasticity meta-trait consist of traits Extraversion and Openness to Experience (DeYoung et al., 2007). Extraversion is typically characterized by gregariousness, excitement-seeking, and positive affect (Mesurado et al., 2014) whilst Openness to Experience is characterized by intellect, creativity, aesthetic, religious, philosophy, and experience seeking (Goldberg, 1992; McCrae & Costa, 1997; Peterson et al., 2002). Gotz et al. (2020) claims that there is evidence to support the association between Extraversion with walkability in the relation with preference to interactive social urban settings.

Plasticity is generally characterized with the degree of flexibility of the individual. High in plasticity responds with environmental anomalies flexibly and seek out novelties of the unknown voluntarily (Liu & Campbell, 2017). Dopaminergic effect is associated with Plasticity because of the link to reward seeking and award (Hirsh et al., 2009). Stability however is characterized by the capacity to resist disturbance towards goal seeking. Stability is associated with reversed Neuroticism (emotional stability), Agreeableness and Conscientiousness (DeYoung et al., 2007). Neuroticism involves the degree of proneness to anxiety, worrying, and negative emotions (Friedman, 2019). Agreeableness is usually associated with cooperation and empathy, selflessness, and identification with others (Graziano & Eisenberg, 1997). Conscientiousness is characterized by the ability to control impulses and goal-driven behaviour (Bogg & Roberts, 2004). Serotonergic effect is usually associated with Stability because of the link to low levels of anxiety and the ability to remain calm (Liu & Campbell, 2017). In general, high Stability have low levels of impulsive behaviour (Hirsh et al., 2009).

In terms of environmental cognition, the existential effects towards those who are high in plasticity or stability are different but associated. High in plasticity facilitate the ability to navigate complex environmental setting. Wayfinding, a part of navigational process is a crucial spatial behaviour in navigating urban settings. It can also be understood as spatial problem solving. Kevin Lynch posited wayfinding must be "consistent use and organization of definite sensory cues from the external environment" (1960:3). The five elements that he introduced play an important role in integrating urban navigation and its environment. The cognitive process of familiar environment is the result of psychological process that people capture surrounding environment through their acquired knowledge of locations, distances, directions, elements, and patterns (Rapoport, 2013). People high in stability dislikes anomalies and complexities of the setting. Due to individual differences, the ability for the environmental setting to cater for both personality differences are necessary for to achieve maximum usability. As Jacobs (1961) suggested for the need of the street to cater for both locals and strangers equally to achieve safety.

The nature of car-depended society indicates that the possibility of primarily use of personal vehicles as the main transportation choice are associated to convenience as we perceive the world as tools and obstacles as claimed by Peterson (2012). The inference concluded is that walking as a primary mode of transportation is not convenient and that only those with high levels of plasticity would be more incline to walk due to the interest in novelties and experience. In this study, to suppress the halo effect which is the tendencies to answer positively for desirability, Stability and Plasticity will be analyzed independently as latent variables. Academic achievement was included in the model to test the additional hypothesis that general intelligence covariate with Openness should be positively associated with walking behaviour whilst direct relation should be negatively associated to behaviour (DeYoung et al., 2007). Therefore, based on the assumptions we hypothesized that:

H1: Stability is negatively associated with walking activities
H2: Plasticity is positively associated with walking activities
H3: Intelligence by Openness is positively associated, whilst intelligence by education background is negatively associated with walking activities

The urban setting or space is made up of various forms, such as different structures and colours, each of which visually and semantically conveys a message to the observer and, depending on its role, elicits different mental and emotional responses at other times. These reactions begin with the viewing and processing of the environment's form and colours, and these perceptual processes raise cognitive schemas that elicit a wide range of human emotions. Perceptions of environmental capability are heavily influenced by the personality traits and motivations of the individual or group. The necessity to understand the psychological implication of environmental attraction can be beneficial to examine the relationship between walkability and personality.

2. Methodology

2.1 Participants

110 participants were taken randomly online consisting of 66 females and 44 males. The samples were limited to those above 18 of age and Malaysian nationality. The oversampling of female was conducted unintentionally due to the nature of online surveying.

2.2 Measurement

2.2.1 Personality Questionnaire

The participants completed a multilingual version (English and Malay) of the Big Five Aspect Scales (BFAS) to measure the two higher order meta-traits of personality (DeYoung et al., 2007). Cronbach's alphas for the Big Five were .78 (Neuroticism), .60 (Agreeableness), .72 (Openness), .75 (Agreeableness), and .87 (Conscientiousness).

2.2.2 Walking Frequency Index

Self-report walking activity was measured using Likert scale on the frequency of walking categorized by purpose (Thielman et al., 2015). The item includes walking to work, walk to public transportation, walk to shop, walk to social activities, walk for leisure. The Cronbach's alpha for the self-report walk activities are .79.

2.2.3 Education Background

Intelligence is the best single predictor of academic achievement (Laidra et al., 2007). Therefore, education background was included in the questionnaire to imply association to general intelligence. Note that the most optimum result was to also conduct IQ test but due to limitations, g associated to education achievement was taken as a controlling variable for personality association. The item scale for education is from "SPM/Certificate to PhD".

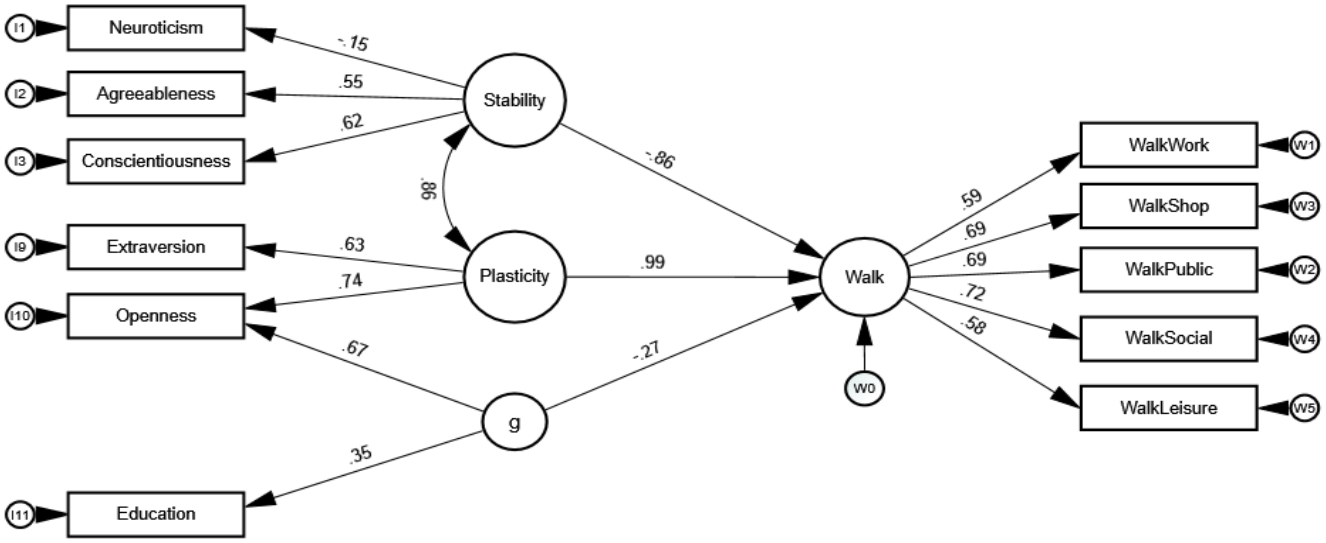


Figure 1 Stability, Plasticity, and g predict walking frequency. N= 110. All paths shown are significant at $p < .05$. g = General Intelligence. See Table 1 for model indices for fit.

3. Result

3.1 Structural Equation Modelling (SEM)

The relationship between Stability and Plasticity to walking frequency while controlling for general intelligence (g) was tested using structural equation modelling (Figure 1). Using Amos 26, the model was analyzed to predict the maximum likelihood of the full covariance matrix. Openness was loaded on g due to the independence between variance shared by openness and extraversion and variance of openness with general intelligence (DeYoung et al., 2007).

Rigdon (1961) claims that for a model to be fit enough to produce interpretable parameters and basis for further theory development, measuring the goodness-of-fit test of a model is necessary. For this SEM model, the parameters observed are chi-square, degree of freedom, probability of discrepancy, comparative fit index (CFI), Tucker–Lewis index (TLI), and root-mean-square error of approximation (RMSEA). Based on these parameters, the first model tested to be poorly fitted (see Table 1). Although initial testing indicated strong relationships between variables, the model fit suggests low performance probability. Initial testing indicated a root-mean-square error of approximation (RMSEA) value of above .05 indicate a poor model fit. To improve this, Amos modification indices suggested freeing certain paths of the model to achieve better fit for the model. The suggestions are that the latent variable of stability should be directly connected to certain observable variables of walking activities and covariances amongst walking activities. Hence, the model was revised (see Figure 2).

Table 1 Fit of the Models in Figures 1 and 2 of Traits Predicting Externalizing Behaviour

Model	χ^2	*df*	*p*	CFI	TLI	RMSEA	*P*(Close)	*Fit*
Figure 1	64.1	40	.009	.894	.855	.074	.120	Poor
Figure 2	43.2	37	.224	.973	.960	.039	.618	Good

Note. N = 110. $\chi 2$ = chi-square; df = degree of freedom; p = probability of discrepancy; CFI = comparative fit index; TLI = Tucker–Lewis index; RMSEA = root-mean-square error of approximation.

The revised structural hypothesis was tested by the model in Figure 2. The prediction of significant association between Stability (H1) and Plasticity (H2) control by intelligence (H3) with walking frequency are supported. Table 1 indicates the goodness of fit of the model. The revised model 2 indicated a better fit than the previous model 1. Sample size plays an influencing role in chi-square values and will often be significant at $p < .05$ (Kline, 2005). However, the lower the value, the higher the correlations between sets of data tested. For exploratory cases, the comparative fit index (CFI) is better suited for evaluation. CFI value of .95 or greater indicates a good model fit (Rigdon, 1996). The Tucker-Lewis index was valued above .90 which is an acceptable threshold for the model (Hoe, 2008). For confirmatory cases, RMSEA is better suited (Rigdon, 1996). RMSEA value of below .05 indicates close fit of the model (Kline, 2005). The P(close) indicates whether the RMSEA value is significantly greater than .05 (DeYoung et al., 2007).

Uniqueness's for walking to shops and walking for leisure were allowed to correlate because the similarity of these behaviors might render their correlation stronger. Therefore, walking to shop and for leisure were allowed to correlate and proven significant by .36. This indicates that those who prefer to walk to shops tend to prefer walking for leisure. Two additional paths were suggested and tested. Stability is shown to be more specific in association with walking to work (.17) and to shop (-22). However, the value indicated that the association was adequate but not significant enough. Generally, those high in Stability tend to walk to work more but less likely to shop. This is a possible indication of trait Conscientiousness in behaviour of dislike wasting time. However, the two new path decreases the association between meta-traits Stability and Plasticity by .28 and .23 respectively with walking activity.

Stability is shown to be negatively associated with walking activity. In general, those high in Stability tend to walk less. Stability is more specific in association with walking behaviour as compared to plasticity signifying suppressed goal-oriented mobility and possible perceived disruptive environmental obstacles. The significant correlation between Stability with Plasticity (.81) is typical for personality studies (DeYoung et al., 2007). Association of Agreeableness (.57) and Conscientiousness (.65) with walking activity is significant whilst Neuroticism (-12) is less significant. Therefore, fear or anxiety associated with walking is less significant as compared to cooperativeness or goal driven. In summary, these results substantiate Gotz et al. (2020) claims that distances in terms of conveniences of walking are necessary to improve walkability.

The model indicates that Plasticity is positively associated with walking frequency. The individual high in plasticity is likely to walk more. General intelligence plays a positively significant role in predicting walking activity. Direct association between generalized intelligence with walking behaviour is negative (-.26). However, intelligence associated with openness is positively significant. This result supports the presupposition on the association between trait Openness and cognitive ability (DeYoung et al., 2007). Intelligence through education is negatively associated with walking activity. To put it simply, the higher the education background, the less likely the person will walk.

4. Discussion

Stability is negatively correlated confirming **H1**. Stability is associated with habitual and routine behaviour (DeYoung, 2015). Based on the concern for Malaysia's car centric mobility, the data supported the presupposition that pedestrian journey should be legible and predictable for walking activity to be increase. The indication that walking in Malaysian cities is considered less convenient than driving is evident based on those who are high in Stability is negatively associated with walking. The characteristics of those who are high in stability is that they dislike disorders and unpredictability. Therefore, foot traffic mobility in Malaysia should be studied in its ability to achieve predictable navigability in the attempt to increase walking frequency effectively. However, further studies on predictable pedestrian path and the association with meta-trait Stability while controlling for walking frequency need to be conducted to support the claim.

High in conscientiousness and agreeableness is significant in predicting walking frequency. The traits are associated with dutifulness and cooperativeness. The evidence indicated that time concern is a possible factor towards the negative association between stability and walking. Those high in conscientiousness and agreeableness tend to be hard working but has a less aggressive temperament. A trait normally associated with woman who universally tend to be more agreeable than man. Whyte in Jensen (2017) argued that social and physical features of high-quality public spaces attract more people, and especially females, but without formally evaluating walkability as currently understood. In contrast with the earlier findings by Jensen et al. (2017) that men always outnumbered females, but they are consistent with those of walkability is about gender, especially on female proportions. To confirm the gender contribution towards these results, replications by controlling for gender is necessary.

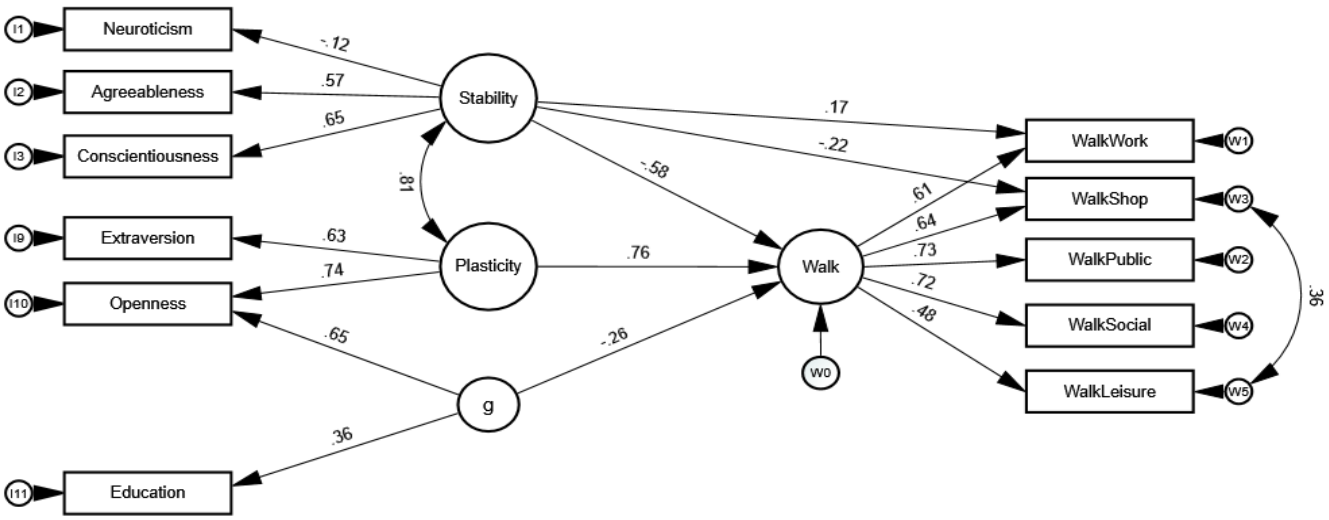


Figure 2 Revised Stability, Plasticity, and g predict walking frequency. N= 110. All paths shown are significant at $p < .05$. g = General Intelligence. See Table 1 for model indices for fit.

Neuroticism is associated with prone to fear and anxiety. Neuroticism is less significant in association with walking indicating the supposition of unlikeliness of safety in influencing walking. Perceived fear is a possible contributing factor towards the experience of walking. However, the evidence we found suggested that the relationship between fear or anxiety towards walking frequency is less significant. Indication of association between health consciousness is also negatively correlated. Stability is normally associated to healthy behavior indicating the disassociation between being healthy and walking in perceive value.

As hypothesized in **H2**, Plasticity is shown to be positively associated. Plasticity is a meta-trait associated to the degree of explorational ability. Those high in plasticity are better at navigating complicated environmental settings. High correlation is typical because individuals high in both Extraversion and Openness appear to be strongly motivated to explore and approach (Depue & Collins, 1999; McCrae & Costa, 1997). However, high positive correlation with Plasticity and negative correlation with Stability can also suggest the level of perceived complexity of foot traffic mobility. There is also possible suppression of habitual preferences in mobility choice. The evidence suggested that individuals high in plasticity would find it easier to navigate or possibly the interest in novelty of experience in wandering around cities. In the matter of Plasticity, a walkable environment should cater to individuals who are low in Plasticity to support the concept of universal design. Certain disorders such as autism spectrum disorder (ASD) possess neurological disability to abstract out of complex pattern would find it difficult to navigate in an environment catered for those high in Plasticity (American Psychiatric Association, 2013).

Intelligence is negatively associated with walking behaviour confirming **H3**. However, intelligence covariate with openness which is the openness trait intellect indicate the significance of cognitive ability in navigation. Education background is negatively associated to walking activity indicating that the possibility of suppression based on interest. The result suggested that intelligence in relation to navigate environment is significant in influencing walking frequency. This is related to Plasticity meta-trait ability in navigating complex situation. Direct correlation is negative supporting that academic achievement is negatively influencing walking activity. The higher the academic achievement, the less likely the person would walk. Further testing on the underlying variables of work positions and IQ is necessary.

According to Gehl's (2011) research in Life Between Buildings, urban design can either "integrate or segregate." The studies show that the presence of major streets can influence people's walking habits and social lives. Even in dense urban areas, traffic infrastructure can cause physical and social segregation, reducing accessibility between neighbourhoods. Jacobs (1961:348) statement clarifies the importance of walking in the cities as “consideration for pedestrians in the cities are inseparable from consideration for city diversity, vitality and concentration of use” and Speck (2012 :6) on “get walkability right and so much of the rest will follow”. He posits General Theory for walkability into four main variables: useful walk, safe walk, comfortable walk, and interesting walk.

5. Conclusions

The study indicated that personality could be used to predict walking behaviour in urban setting. This provides another boost in understanding the phenomena of walkable cities. Every person has different set of personality traits that can be generalized into Stability and Plasticity. The study highlights the necessity of the ability to navigate and the predictability of pedestrian journey in predicting pedestrian mobility. To manipulate the design of a city in catering to personality

differences, the study on cognitive navigability and predictability in design needs to be concentrated to maximize the utilization of urban design to achieve walkability. Although the factor size indicates that a large proportion of the phenomena of walking behaviour still unexplained, the predictability through personality can have practical utility in demographic studies to predict potential group walking behaviour.

Limitations

To validate these results, replication needs to be conducted with added constraints to the model. Sample sizes affect the correlation between personality even by personality study standard, hence the need to increase sample size for more accuracy. The addition of cognitive ability or IQ testing can help to clarify the association of walkability with general intelligence.

References

Adkins, A., Dill, J., Luhr, G., & Neal, M. (2012). Unpacking Walkability: Testing the Influence of Urban Design Features on Perceptions of Walking Environment Attractiveness. *Journal of Urban Design*, 17(4): 499–510.

Allik, J., Realo, A., Mõttus, R., Pullmann, H., Trifonova, A., & McCrae, R. R. (2009). Personality traits of Russians from the observer's perspective. *European Journal of Personality*, 23: 567–588.

American Psychiatric Association. (2013). Autism spectrum disorders. In Diagnostic and statistical manual of mental disorders (5th ed.).

Bogg, T., & Roberts, B. W. (2004). Conscientiousness and health-related behaviors: A meta-analysis of the leading behavioral contributors to mortality. *Psychological Bulletin*, 130(6): 887–919.

Bleidorn, W., Schönbrodt, F., Gebauer, J. E., Rentfrow, P. J., Potter, J., & Gosling, S. D. (2016). To live among like-minded others: Exploring the links between person-city personality fit and self-esteem. *Psychological Science*, 27: 419–427.

Bueker, S., Ebert, T., Gotz, F.M., Entriger, T.M., and Luhmann, M. (2020). In a lonely place: Investigating regional differences in loneliness. *Social Psychological and Personality Science*.

Claris, S, Lueblceman, C, Scopelliti, D and Hargrave, J (2016). Cities Alive: Towards a Walking World. London: Arup

Costa, P. T., & McCrae, R. R. (1992). Normal Personality Assessment in Clinical Practice: The NEO Personality Inventory. *Psychological Assessment,* 4(1): 5–13.

Depue, R. A., & Collins, P. F. (1999). Neurobiology of the structure of personality: Dopamine, facilitation of incentive motivation, and extraversion. *Behavioral and Brain Sciences*, 22(3): 530–531.

DeYoung, C. G., Quilty, L. C., & Peterson, J. B. (2007). Between Facets and Domains: 10 Aspects of the Big Five. *Journal of Personality and Social Psychology*, 93(5): 880–896.

Friedman, H. S. (2019). Neuroticism and health as individuals age. Personality Disorders: Theory, Research, and Treatment, 10(1): 25–32.

Graziano, W.G and Eisenberg, N. (1997). Agreeableness: A Dimension of Personality. *Handbook of Personality Psychology*795–824. San Diego: Academic Press,

Gehl, J. (1971). Life between buildings: using public space. London: Island Press

Götz, F.M., Yoshino,S., Oshio, A. (2020). The association between walkability and personality: Evidence from a large socioecological study in Japan. *Journal of Environmental Psychology*, 69: 101438, ISSN 0272-4944.

Hoe, S. L. (2008). Institutional Knowledge at Singapore Management University Issues and procedures in adopting structural equation modelling technique. 76–83.

Jacobs, J. (1961) The Death and Life of Great American Cities. New York: Random House.

Jensen, W.A., Stump, T.K., Brown, B.B., Werner, C.M and Smith, K.R (2017). Walkability, Complete Streets, and gender: Who benefit most? *Health Place*, 48: 80-89.

Jokela, M., Bleidorn, W., Lamb, M. E., Gosling, S. D., & Rentfrow, P. J. (2015). Geographically varying associations between personality and life satisfaction in the London metropolitan area. *Proceedings of the National Academy of Sciences*, 112: 725–730.

Jokela, M. (2020). Selective residential mobility and social influence in the emergence of neighborhood personality differences: Longitudinal data from Australia. *Journal of Research in Personality*, 86: 103953.

Kline, R. B. (2005*). Principles and practice of structural equation modelling.* New York: Guilford Press.

Laidra, K., Pullmann, H., & Allik, J. (2007). Personality and intelligence as predictors of academic achievement: A cross-sectional study from elementary to secondary school. *Personality and Individual Differences,* 42(3): 441–451.

Liu, D., & Campbell, W. K. (2017). The Big Five personality traits, Big Two meta traits and social media: A meta-analysis. *Journal of Research in Personality*, 70(August): 229–240.

Lynch, K. (1960). The Image of the city. London: The M.I.T Press

McCrae, R. R., & Costa, P. T. (1997). Personality Trait Structure as a Human Universal. *American Psychologist*, 52(5): 509–516.

Mesurado, B., Mateo, N. J., & Valencia, M. (2014). Extroversion: Nature, development and implications to psychological health and work life. *Psychology of Extraversion*, (October): 107–119.

Peterson, J. B., Smith, K. W., & Carson, S. (2002). Openness and extraversion are associated with reduced latent inhibition: Replication and commentary. *Personality and Individual Differences*, 33(7): 1137–1147.

Peterson, J. B. (2012). Three forms of meaning and the management of complexity. *The Psychology of Meaning*., (January 2013): 17–48.

Rapoport, A. (2013). *Human aspects of urban form: Towards a man-environment approach to urban form and design*. 3rd Edition. Oxford: Pergamon Oxford.

Raynor, D. A., & Levine, H. (2009). Associations between the five-factor model of personality and health behaviors among college students. *Journal of American College Health*, 58(1): 73–82.

Rentfrow, P. J. (2010). State-wide differences in personality: Toward a psychological geography of the United States. *American Psychologist*, 65: 548–558.

Rigdon, E. E. (1996). CFI versus RMSEA: A comparison of two fit indexes for structural equation modelling. *Structural Equation Modelling*, 3(4): 369–379.

Saelens, B. E., Sallis, J. F., & Frank, L. D. (2003). Environmental correlates of walking and cycling: Findings from the transportation, urban design, and planning literatures. *Annals of Behavioral Medicine*, 25(2): 80–91.

Speck, J. (2011). Walkable City: *How downtown can save America one step at a time.* New York: North Point Press

Thielman, J., Rosella, L., Copes, R., Lebenbaum, M., & Manson, H. (2015). Neighborhood walkability: Differential associations with self-reported transport walking and leisure-time physical activity in Canadian towns and cities of all sizes. *Preventive Medicine*, 77: 174–180.

Wei, W., Lu, J. G., Galinsky, A. D., Wu, H., Gosling, S. D., Rentfrow, P. J., Gui, W. (2017). Regional ambient temperature is associated with human personality. *Nature Human Behaviour*, 1: 890–895.