Exploring the Integration of Biophilic Design into Interior Spaces: Case of Public Libraries

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ABSTRACT

The benefits of the interaction between humans and nature in the interior spaces cannot be downplayed. The benefits have been stated in numerous studies, centering on the psychological and physiological aspects of human health, but also the reduced contact with nature has also been attributed to some illnesses in the interior space. However, the focus on the human-nature relationship in architecture has been explored by some movements like green architecture, sustainability, and biophilic design; here green architecture and sustainability have their core focus on sustaining natural resources and preserving nature, then biophilic design that focuses on the optimization of human health. Furthermore, with the increase in human development, the interaction with nature in the interior spaces, in particular learning spaces, like interior spaces of the public library are limited. Besides, there is no study on the integration of biophilic design in the interior spaces of public libraries. This has led to the research question which is “how biophilic design can be integrated into the public library’s interior spaces. Therefore, the aim of this study is to explore and investigate how biophilic design can be achieved in the interior spaces of public libraries.

To be able to achieve the aim of the study and provide an answer to the research question, the methodology that is employed in this study is an exploratory qualitative research method. The methodology is divided into two sections; the first section is the literature review of key terms like biophilic design and public library, which are critical to the study. The second section of the methodology involved the exploration of selected libraries. A framework has been created at the end of the first section,

therefore the literature review provided a theoretical base for the analyses of the biophilic design techniques employed in the public libraries.

The findings of the study are discussed under two approaches; the first approach involves the usage of biophilic design patterns in the selected cases; the commonly used patterns, patterns that have been achieved by the minimum number of concepts, and the rarely used patterns, while the second approach clarifying the elements of the interior space that can be utilized in achieving the maximum number of biophilic design patterns. Also, the findings showed the connectedness between the three used biophilic design approaches contents (patterns, attributes, and strategies).

Keywords: Biophilia, Biophilic design, Public library, Interior spaces, Biophilic design utilization.

ÖZ

İç mekanlarda insan ve doğa arasındaki ilişkinin kullanıcı üzerindeki yararları göz ardı edilmemelidir. Doğanın insan üzerindeki fizyolojik ve psikolojik yararlarına birçok çalışmada değinilmiş fakat kullanıcının doğal ortam ile bağının azaldığı durumlarda birçok hastalığın da artış gösterdiği belgelenmiştir. Mimarlıkta insan-doğa ilişkisinin konu edildiği birçok yaklaşım mevcuttur; örneğin sürdürülebilir tasarım, yeşik mimarlık ve biyofilik tasarım bunların başlıcalarıdır. Yeşil mimarlık ve sürdürülebilirlik kavramları daha çok doğal kaynakların kullanımı ve doğanın korunması konularına odaklanırken; biyofilik tasarım ise insan sağlığına ilişkin konulara odaklanmaktadır. Bunalara ek olarak, iç mekanların doğa ile ilişkisinin konu edildiği çalışmalar günden güne artış gösterirken, eğitim mekanlarında bu konuyu irdeleyen çalışmaların sayısının kısıtlı olduğu gözlemlenmiştir. Özellikle, kütüphane iç mekanlarında biyofilik tasarım yaklaşımlarını irdeleyen çalışmaların mevcut olmadığı tespit edilmiştir. Bu bağlamda; çalışmanın araştırma sorusu "Kütüphane iç mekanlarında biyofilik tasarım yaklaşımları nasıl entegre edilebilir?" olarak belirlenmiştir. Bu araştırma kütüphane iç mekanlarında biyofilik tasarım yaklaşımlarının incelenmesini ve belgelenmesini amaçlamaktadır.

Araştırmanın amacına ve araştırma sorusunun cevabına ulaşmak için nitel araştıma yöntemlerinden birisi olan açıklayıcı araştırma yöntemi tercih edilmiştir. Bu yöntem ile yürütülen çalışma 2 ana bölümden oluşmaktadır; birinci bölümde konuya ilişkin ana kavramların (biyofilik tasarım ve kütüphane) kapsamlı araştırmasını hedefleyen literatür taraması yapılmıştır. İkinci bölümde belirlenmiş olan ödüllü halk kütüphanesi

örneklerinin literatür taraması sonucunda geliştirilen değerlendirme kriterleri yardımı ile analitik değerlendirmesi yapılmıştır.

Çalışmanın bulguları iki yaklaşım altında tartışılmıştır; ilk yaklaşım seçilen vakalarda biyofilik tasarım desenlerinin kullanımını içermektedir. Örneğin, yaygın olarak kullanılan desenler, minimum konsept sayısı ile elde edilen desenler ve nadir kullanılan desenler. İkinci yaklaşım ise maksimum biyofilik tasarım desenlerinin elde edilmesinde kullanılabilecek iç mekan elemanlarını açıklığa kavuşturmaktadır. Ayrıca, bulgular biyofilik tasarım yaklaşımında kullanılan üç içeriğin (desenler, özellikler ve stratejiler) arasındaki bağlantıyı göstermiştir.

Anahtar Kelimeler: Biyofili, Biyofilik tasarım, Halk Kütüphanesi, İç mekan, Biyofilik tasarım yaklaşımları.

DEDICATION

TO MY FATHER,

To whom I promised to dedicate this dissertation before he left this world

TO MY AFFECTIONATE MOTHER,

For her absolute love and measureless support

TO MY WIFE,

For her support, patience & unconditional love

TO MY BROTHER AND GREAT SISTERS,

For their confidence & unlimited support

TO MY LOVELY KIDS MAYAR & FADEL

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INTRODUCTION

1.1 Background to Study

The beginnings of the ancient interrelatedness between nature and humans had been described as a harmonious connectedness. But later on, this in-tune connection has been affected by the humans' behavior towards an environmental declination & segregation as well. Due to the development of life in general and the technology in specific, humans started to utilize more practical methods to protect themselves through constructing different types of habitations, which had droved to promote increased growth in population and the necessity for ongoing sources for their habitation’ construction; yet, the segregation between the human and nature has obviously been observed, and that connection between the humans and nature has changed from a permanent relationship to something upon request.

Because of the environmental declination & nature segregation, it seems that the human-built environment became a poor and harmful living space due to its effects on their occupants' health and behavior, accordingly, several topics had appeared reflected this problem such as SBS "Sick Building Syndrome", and BRI "Building-Related Illnesses". For instance, SBS term was coined at the beginning of 1990 to clarify the link between specific buildings and their occupants' mental & bodily repeated sicknesses (Edwards, 1999). The specialist noticed that there are several reasons behind the SBS problem; these reasons are divided into two main sections,

first one is the deficiency of the presence of natural factors such as natural temperature, aural, and nature viewing, the second section is the existence of high rates of the air pollution and dust. For instance, psychologists have been noticing that the closed buildings which rely on mechanical ventilation and artificial lit are more prone to be SBS than buildings that relay on natural daylighting & ventilation (Hanie, 2010).

Thereby, when the construction's destructive effects on nature had been realized, alongside the power of interior spaces design and its impacts on the occupants' health, emotions, perception, productivity, and influences; many subjects raised up such as green building, environmental friendly architecture, sustainability, ecological design, and biophilia. These divergent subjects have appeared at different times with various names and targets, but yet nature and natural environment still are the common factors in all of them.

Among all of these convergent subjects, biophilia will be the main focus of this research study. Biophilia term was used first by Edward O. Wilson in 1984 to emphasize the innate indigence to interact with nature and its necessity to enhance the humans' mental & bodily health (Beatley, 2011). In 2008 biophilia was translated to the “biophilic design” term through various disciplines' publications that had focused on the ways to bring biophilia to the habitations made by humans the “built environment” (Kellert, Heerwagen and Mador, 2011). In other words, biophilic design is concerned about how to make humans the core focus of sustainability consideration.

Accordingly, since the biophilic design is concerned with how to integrate and simulate nature into all human-made habitations' types and scales, to get its benefits it should be utilized in all types of buildings such as residential, commercial, industrial,

airports, educational, and institutional civic buildings (ICB). ICB are those buildings founded and funded by fully or semi-governmental authorities, or even by community and national organizations for a particular public purpose such as hospitals, elderly homes, jails, and public libraries.

The accelerating advancement in the various aspects of life, especially in the technology field is one of the main reasons behind human isolation away from nature, and yet it also still negatively affects the interaction and communication between humans themselves. Consequently, public spaces are needed nowadays to treat and enhance people's communication & interaction as well; these public spaces could be gardens, cafes, public seating areas, and public libraries.

A public library is a place where the knowledge and the diversified information fields are freely provided for the public; it is also a safe commonplace where people can meet each other to learn, communicate and exchange their experiences (Munchen, 2001). On the other hand, for the time being, the general idea of the public library does not exceed as books store as well as providing limited educational facilities (Worpole, 2004). Therefore, public library design needs to be well thought and produced, to provide a place where people can easily reach and find their needful public multi-functional facilities while the public library still providing its main educational facilities in a successful contemporary way.

Many researchers have stated the importance of integrating several natural elements into the libraries and their effectiveness on the occupants. For instance, natural light has a considerable capability to affect positively on the libraries' users' satisfaction and comfort (Kilic & Hasirci, 2011; Shill & Tonner, 2004). Furthermore, it has been

confirmed that the natural light has a dynamic ability to generate convenient learning spaces, also it has stated that the comfortable seats, natural light accessibility, and providing seating areas next to openings are what may distinguish libraries than others (Loder, 2010; Foster & Gibbons, 2007). Moreover, diverse studies assured that noticeable library students preferred to use furniture made by natural wood, decorative carpets, and fireplaces' existence (Foster & Gibbons, 2007; Gfeller, Butterfield-Nagy & Grignon; 2011)].

Biophilic design is the most thorough field of study in terms of crystallizing the various aspects of nature integration and simulation into built-environments as it concentrates on enhancing human well-being through connecting humans to their original habitation "nature". Many studies and experiments have been made by scientists, researchers, and design practitioners on the biophilic design outcomes and they put forward that biophilic design can improve the occupants' mental & bodily abilities from different aspects such as: human' productivity, behavior, perception, and creativity, as well as it can reduce stress & anxiety (Browning, Ryan, & Clancy, 2014; Kellert, 2015).

1.2 Problem Statements

Several architectural movements such as green architecture and sustainability have appeared when it became clear that the wide prevalence of the built environment has negatively been affecting natural resource consumption. But, unfortunately, the prevailing of these approaches is only to maintain and reduce harm on nature and its resources. Although these approaches are needed and important to sustain natural systems, yet still insufficient; since there is huge neglect upon the significance of

obtaining long-term benefits through improving the interrelation between humans and nature in their built environments.

Furthermore, humans' disconnecting from nature nowadays seems evident and accelerating due to several reasons such as advancements in community lifestyle and modern built environment methods, nature simply is seen as resources to be invested & used or just a beautiful element but still not indispensable. On the other hand, it seems there is a misconception of how getting nature benefits indoors by specific integration methods and these techniques of integration are almost limited within the insertion of limited greenery into interior spaces such as planted pots or vertical green walls. However, getting nature benefits and outcomes into interior spaces are related to different aspects of integration and simulation where the biophilic design clarifying it properly.

Since human beings realized the importance of nature integration into interior spaces, many studies & investigations have been made concentrating on the biophilic design for different types of buildings such as houses, hospitals, elderly care houses, prisons. On the other hand, there are many studies have been carried out on the biophilic design in terms of different notions, but there is a lack of studies have been focused on biophilic design integration into interior spaces, moreover, several studies have been carried out on the relationship between the public library and the biophilic design in terms of its importance, benefits, and influences, however, there are no studies dealing with biophilic design utilization methods into the public library interior spaces.

1.3 Research Questions

Biophilic design can be considered as a wide and divergent topic; since it is focusing on bringing biophilia into the built environment interior spaces; accordingly, various

aspects of biophilic design can be studied and carried out such as its benefits, perception, influences, and importance. This study is delimited into the integration of biophilic design into the public libraries' interior spaces. Therefore, the research question is how biophilic design can be integrated into the public library's interior spaces?

1.4 Aim and the Objectives of the Study

Depending on the study problem stated above, which clarifies the research gap in utilizing the biophilic design into public libraries' interior spaces; this study aims to explore and investigate how biophilic design can be achieved in the public library's interior spaces.

The study' Three objectives are:

- Providing a comprehensive theoretical background of 'biophilic design' from different approaches and specializations fields.
- Provide an evaluation criteria based on the most popular biophilic design approaches that can be used for evaluation of different building types.
- Explore to which extent that the biophilic design has utilized in the study cases.

1.5 Methodology

The methodology of this study is an exploratory qualitative research method. The data collection consists of two sections. The first section is the literature review that derived from the various sources like articles, published theses, books, websites, and useful materials in order to understand the theory of the study' topic terms, the second section is to explore the selected public library cases in which the extracted literature framework could be utilized to explore the used biophilic design techniques in the cases separately.

1.6 Delimitations

In order to accomplish the aim of the study, this research is delimited in the main three aspects: 1) Biophilic design integration. 2) Public libraries. 3) Interior spaces.

While the public library is the concerned building among the other building types in this study, five public libraries were selected in this study; because they are the only public libraries that have won the IFLA "International Federation of Library Associations and Institutions" yearly competitions awards as the best public library.

1.7 Structure of the Study

Table 1 below clarifies the study structure; it shows ordered essential subjects for each chapter (Table 1).

Table 1: Thesis Structure

Introduction

Background to Study	Problem Statement	Research Questions	Aim & Objectives	Research Methodology	Delimitations

Literature Review

Biophilia
- Background
- Evidences of benefits

Biophilic Design
- Biophilic Design Background
- Biophilic Design Principles
- Biophilic Design Values
- Biophilic Design Goals
- Biophilic Design Approaches
  - 14 Patterns
  - Elements & Attributes
  - Strategies
- Frame of work

Public Libraries
- Definition
- Types of Libraries
- Future libraries design considerations
- Importance of public library

Evaluation of Biophilic Design Employment in Public Libraries

Oodi Helsinki Central Public Library	School 7 Public Library	Dokk1 Public Library	Kista Public Library	Craigieburn Public Library

Findings

Conclusion

Chapter 2

THEORETICAL BACKGROUND OF BIOPHILIA & BIOPHILIC DESIGN

2.1 Biophilia

2.1.1 Background

The word “biophilia” can be viewed in two parts; that is “bio” is a concern with living organism or life, while philia is about the inclination to love. Therefore, Biophilia is seen as the love of life or living organism. Biophilia as a school of thought has been comprehended and present in many cultures for a long period of time, but the term was adapted from Ancient Greek with a denotation of “love of life” and a germen social psychologist in person fascination and coordination concerning that has life (Fromm & Mazal Holocaust, 1973; Ojamaa, 2015).

The notion of Biophilia started from the comprehension evolution of humans, in which in history, 99% of the human species have not adjusted to the responds of human synthesized forces but to that, that is natural in biological development. Therefore, biophilia is the immense human tendency to be associated with nature, which has been very important to a person’s physiology and psychological wellbeing even in modern times (Kellert, 1997). Baganskas (2018) argues that biophilia is the reason people are inclined to natural places and activities like camping in the forest, holiday at nature and relaxation at the beach. Baganskas also gave credit to biophilia of the phenomena in which workers in offices prefer to stay outside the office building during the lunch

hour, taking a stroll around the park and even choosing a restaurant that has outdoor furniture. In addition, biophilia has been used to explain why people prefer a hotel room with a visual connection to nature, ocean, lake, hill, and mountain.

Wilson (1984) with other biophilia theorists also buttress the argument that main reason behind human's deep love for nature is rooted in human evolution, whereby nature with all its elements have contributed to the survival of the humans through phenomena like flowering, funning freshwater steams and fruit-bearing, which appeals to human. Wilson also the person that made the term popular in 1984with his book called Biophilia (Beatley, 2011).

The concept of biophilia argues that humans by default have the need to be in interaction with nature, which is very critical to psychological and physiological benefits. Developing and promoting human interaction with nature whether indoors or outdoors can offer so many benefits and happier lives.

2.1.2 Evidences of Benefits

Luttik (2000) & François et, al., (2002) argue that the proof of biophilia is seen everywhere in our everyday activities from the natural background (sunset at beaches, cascading waterfall) as our screen saver of our computers. They stressed that the photo of nature in our various devices shows how deep humans look for the aesthetic of the natural environment, even when they cannot be present physically. They pose a critical rhetorical question like, have one had a dream where he had a vacation at the beach or mountain escaping from their mechanistic urban setting? who has not thought of a walk through the park as restoration during stress, a nap for relaxation under the tree shade or energetic hike?

In support of the above argument on the evidence Greenleaf et al., (2014) in their article that explores the relationship between psychological health and nature proposes that stress is reduced when there is an interaction with nature, with an increase of cognitive functioning and attention aptitude. Contact with nature also helps individuals (adults and children) with attention deficit hyperactivity disorder (ADHD) to intensity impulse control and concentration (Berman et al., 2008). It has also been credited to improve productivity and job satisfaction (Lechtzin et al., 2010). Kuo and Taylor (2004) also claim that it decreases physiological pain and hastes healing of the body. It has also been suggested that there is a strong connection between a high intensity of psychological, physiological, spiritual and emotional wellbeing and natural environment (Burls, 2007; Louv, 2008).

The importance of interacting with nature as described with biophilia has been emphasized and clarified, subsequently. Later on, in 2008 this importance of the interaction between humans and nature has been transferred to the interior spaces through the translation of biophilia to biophilic design to focus on the ways of bringing nature indoors and its benefits such as enhancing the productivity, creativity, perception and behavior (Browning et al., 2014; Kellert, 2015).

2.2 Biophilic Design

2.2.1 Biophilic Design Background

The term built environment can be described as the environment that differs from the natural environment that are spaces and places made by humans at various scale ranging according to the human activities of recreation, work and live. The school of thought of biophilia can be adopted in the design of the built environment through what is known as biophilic design. With the publication of a combination of articles in 2008 by authors of several fields on the subject following symposium of three days on

the topic, the term Biophilia design was coined; that is the theory, practice, and science of bringing life to building (Ojamaa, 2015).

Therefore, biophilic design can be explained as a methodology employed in designing the built environment that promotes the importance of sustaining, improving and reinstating valuable experience of nature. It also involves international moves to decode the comprehension of the deeply rooted human need for relation interaction with natural system with its procedures in the built environment (Kellert, Heerwagen and Mador, 2011). The issues facing biophilic design is to tackle the inadequacies of landscape practice and contemporary building by instituting a framework for the meeting up with the rewarding experience of nature in the built environment. Biophilic design aims to synthesize a conductive habitat for the users of space as a biological organism in the built environment of this modern-day which improves the user's wellbeing fitness and health.

2.2.2 Biophilic Design Principles

Kellert (2015) proposed fundamental conditions required for the positive biophilic design practice; the fruitful adaption of biophilic design requires a continuous sticking to specific fundamental principles. The principle denotes basic conditions for the successful practice of biophilic design. The basic conditions:

- Necessitate consistent and maintained contact with nature.
- Concentrate those aspects of human adjustments to the natural environment that over a period of evolution have improved peoples' wellbeing, health, and fitness.
- Promotes places and settings that encourage emotion attachment.

- Endorse successful connections between nature and people that promote an increased scope of a sense of relationship and accountability for the human and natural environment.
- Promote reciprocal reinforcement, interconnection, and integration of the architectural solution.

2.2.3 Biophilic Design Values

One of Stephen Kellert's (2005) strategies in the discourse of biophilia is clarifying the method by which individuals derive benefit and relate meaning to nature. This can be seen from a sequence of nine values together with affiliated benefits. By the clarification of this discourse, the significant relationship between human and nature are further divided in a way that provides better clarification and advantages of the relationship to nature in total. In addition, generates terminology and guidance to analyse, also evaluate the particular elements, characteristics, and principles, which limited the development as aspects of the discussion and implementation (Ojamaa, 2015).

Table 2: The values definitions and adaptive benefits of (adapted by the author from Ojamaa, 2015; Kellert, 2005).

VALUE	DEFINITION	ADAPTIVE BENEFITS
Aesthetic	Physical appeal and beauty	Inspiration, harmony, Physical security
Dominionistic	Mastery and physical control	Physical prowess, self-confidence, mastery skills
Humanistic	Emotional attachment to aspects of nature	Bonding, cooperation, companionship
Moralistic	Spiritual reverence and ethical concern	order, meaning, kinship
Naturalistic	Direct experience and exploration	Curiosity, discovery Security,
Negativistic	Fear and aversion	Security, protection, awe
Scientific	Systematic and empirical study	Knowledge, understanding, critical thinking skills
Symbolic	Nature in language and expressive thought	Communication, mental development
Utilitarian	Practical and material exploitation	Physical sustenance and security

2.2.4 Biophilic Design Goals

According to Kellert and Calabrese (2015), the goals of biophilia design are;

1- In natural systems overtime to maintain resilience, productivity, and functioning.
2- As a long term goal, biophilic design should be ecological health and maintainable natural community.
3- Another goal is to produce a worthy habitat for an individual as a living organism in the built environment as present modern-day that would improve an individual's physical and mental wellbeing.

Furthermore, Dr. Amjad Almusaed in his book (2010) "Biophilic and Bioclimatic Architecture: Analytical Therapy for the Next Generation of Passive Sustainable Architecture"; have stated that Biophilic architecture is among a ground break assessment in architecture, in which the combination of architectural theory, nature and life to create a dynamic habitable building part to meet the needs, challenge and also offer respect towards environment and people.

2.2.5 Biophilic Design Approaches

For the transfer of the theory of biophilia to its utilization in the built environment by means biophilic design possess numerous approaches, but do not have universally accepted strategies and definition of components of biophilic design or even proven approaches on how to achieve them (Ojamaa, 2015).

Biophilic design is described through the medium of interaction with nature. First one sees these interactions can be direct, indirect or symbolic. It can also be by means nature in the space, nature of the space, natural analogues which are further broken down into 14 pattern (Browning et al, 2014), while second one sees biophilic design

through three core elements, which are “Direct experience with nature”, “indirect experience with nature and “experience of space and place” which are also broken down to 24 design components (Kellert et al, 2015), whereas the third one sees biophilic design in term of 27 strategies (Wilson, 2006). The organization totally differ in how they are composed, how plane or complex they are, also what they are clarifying whether elements, goals, qualities, strategies, resultant interactions, even connection to their benefits. According to Ojamaa, 2015, these three approaches are the mostly cited in many studies, based on that, these three approaches of biophilic design are adopted in this study.

2.2.6 Biophilic Design Patterns & Benefits

Browning et al., (2014) categorized biophilic design into three classes which are:

1. Nature in the space (Pillar one)

Nature within the spatial quality deals with the explicit tangible sensorial interaction with nature or momentary natural existence in a particular place. It comprises of water, scents, plant life, air-flow or breezes, animals, sound and other features of nature. Simple instances are potted plants, water characteristics, flower beds, fountains, birds’ feeders, green walls, aquariums, butterflies, gardens, courtyards gardens, and vegetated roofs. On the other hand, direct sensorial interaction with nature in a space does not just mean closeness to one or more flower or plant pot, but the contact with the natural environment can be tangible from the availability of a thought-provoking view of nature or the utilization of sound, breezes, sound, water features, and plants. The adoption of these patterns during design, would produce a sensible direct interaction with elements of nature through a connection that is multisensory, movement and diverse.

2. Natural Analogues (Pillar two)

Natural Analogues deal with organic, inanimate and indirect stimulation of nature through furniture, ornamentation, décor, artwork, textiles in the built environment manifest through objects, patterns, colours, shapes, materials, and sequences. In natural analogue patterns, existence of a component with an indirect interaction to nature, which produces a hint to the brain, may evoke the similar sense of comfort as that of the natural environment (Browning et al., 2014).

Moreover, by mimicking the aesthetics details of nature with various manifestations like patterns, artwork, textiles, light, and organic shapes, one can exhilarate the biophilic human interaction (URL, 1). However, the analogues themselves possess the natural model, which are specifically tangible in their elements. To achieve analogue of nature with a very strong experience, the provision of adequate information should be co-ordinated in a stimulating manner (Browning et al., 2014).

3. Nature of the space (pillar three)

This pillar deals with the quality of the space organization. This comprises of individual inborn and cultured longing to be able to visualize further than the direct environment, their appeal with a little danger or even the unknown; concealed views and revealing moments; and often fearing inducing characteristics that are added to an element trusted with safety. In addition, the nature of the space pattern clarifies how one connects to the building, room even the space around the individual in an immense human level. There is an inborn longing to visualize outside the direct environment. The combination of these three pillars increases the impact in biophilic design experience strongly (Browning et al., 2014).

Fourteen Patterns of Biophilic Design

The previously explained three pillars, have in-depth explained through the following 14 patterns.

A-Pillar one:

Pattern one - Visual connection alongside nature (VCN):

Browning et al., 2014, describe this pattern to be the visualization of natural elements, natural processes, and living systems. The VCN data is extracted from feedbacks during the visualization to nature, which has indicated a reduction in stress, an increase in good emotional functioning, enhanced recalling rates and concentration, and also visual preference (Ryan et al, 2014). It has also been reported that lower heart and blood pressure have been achieved from visual connection with nature (Browning et. al., 2014; Van den Berg et. al., 2007); increased mutual attentiveness and improved attitude and general happiness (Biederman & Vessel, 2006; Barton & Pretty, 2010). It has also been reported that evidence of stress reduction from viewing images of nature and experience real nature by Grahn & Stigsdotter, 2010; Bloomer, 2008; Kahn et al., 2008). In addition, visual interaction with biodiversity has been said to have more benefits to the psychological aspects of a human than interaction to the quantity of land (Fuller et al., 2007). According to Kahn et al., (2008) visualization of natural scenes or images stimulates a bigger part of the visual cortex than that of non-natural images or scenes. They mention that these images trigger much more pleasure receptor in brain, which leads to an elongated fascination and speedup stress recovery.

The core aim of the VCN pattern is to create an environment that aids people to move that attention to relaxation. The benefits of the adoption would increase as the value of

the view and quantity of seen biodiversity both improve. Visual connection with nature can be achieved through various methods; they are:

- Video showing natural scenes
- Artwork showing natural scenes
- Plants & Green vertical walls indoor spaces or place
- Workspaces or places that are opening adjacent to a view to element of nature.

Figure 1: Work areas next to openings, green wall; (URL 2)

Figure 2: Work areas next to openings, indoors plants; (URL 3)

Figure 3: Indoors green wall; (URL 4)

Figure 4: Nature artwork; (URL 5)

Pattern Two - Non-Visual Connection with Nature (NVCN):

This pattern deals with olfactory, auditory and haptic stimuli that provoke intentional and good locus of nature, natural processes or living systems (Browning et al., 2014). Pattern two (NVCN) has gone forward from the study on the reducing with hormonal

stress; the influence through vibration with sound on cerebral efficiency and apparent increase on psychological wellbeing and peacefulness resulting from non-visual sensual connection and unthreatening nature (Ryan et. al., 2014). Hunter et, al., (2010) stated that the experiencing non-visual and visual stimulation concurrently alters location in the brain where the non-visual stimuli are deduced; However, if both stimulations are linked to nature, a bigger part of the brain is excited and the combination of psychological and physiological feedback is greater than when the two are in isolation (Hunter et al., 2010).

Relating olfactory perception, research concerning aromatherapy and post-anesthesia care showed that about 45% less morphine and about 56% lesser analgesics were used among patients who took part in the aromatherapy after surgery (Ryan et al., 2014). Li et, al., (2012) stated in their study that researches have shown that olfactory interaction with essential oils from trees and herbs has a good impact on the recovering process and to that of the human immune function collectively.

Concerning Auditory perception; Alvarsson et al; (2010) stress that sounds from nature, to be compared to that of urban noise, which permits the restoration of a physiological and psychological stressor. In addition, Jahncke et, al., (2011) stated that participators of specific study that listen to water body sound or watched a film with audios of river in the course of a post-task recovery period reported that they have more motivation and energy after the recovery duration in comparison to the participators who just listen to work place environment silence or noise.

Also concerning haptic sense; the deed of coming in contacting with real plant life and to that of synthetic plants has resulted in evoking relaxation made possible by an

adjustment in cognitive blood flow rates according to Koga & Iwasaki, (2013). Browning et al., (2014) argued that the above-stated instances of non-visual connection with nature have provided a reason to assert that there are more positive benefits of having contact with natural elements like water or raw materials.

The core aim of NVCN (Pattern two) is to create a space or place that utilizes scent, sound, touch and if even possible the sense of taste, in which these stimuli can be experienced independently, however, these experience can be increased if these senses are combined together which would compound the wellbeing and benefits which would aid in decreasing stress and increase a physiological and psychological stressor health of the individual.

NVCN pattern can be achieved through several methods which could be stimulated or through natural means, which are according to the three core types which are:

- Touch (Haptic): Water for reducing the temperature of space and handrails.
- Sound (Auditory): Human conversation, animal, music, weather, and water sounds.
- Smells (Olfactory): Smells from perfumes, smells form fragrant of plants and oil.

Figure 5: Birds sounds, Sound; (URL 6)

Figure 6: Natural material, Touch; (URL 7)

Figure 7: Fragrant flowers- Smell; (URL 8)

Pattern three - Non-Rhythmic Sensory Stimuli (NRSS):

Here the pattern three interactions with nature are still the result cannot be projected definitely (Browning et, al., 2014). However, elements with random movement but still steady are generating pattern three (NRSS) (May, 2017).

According to Vessel et, al., (2012) one of the cores and rational objectives for introducing NRSS (pattern three) in space or place is because of the connection eye betwixt focal relaxation and optical stress model. In addition, Browning et al, (2014) stated that further proof of the productivity influence of pattern three on patient sympathetic nervous system activity and systolic blood pressure.

Browning et al, (2014) stressed that refilling from modest concentrating and allowance of people's ability to focus on a task is promoted through the utilization of natural sensory stimuli, which is the main purpose of pattern three. Furthermore, the achievement of pattern three is made possible by making designs that have a brief connection to random or changeable motions, for instance, stimulation of natural tones with the variation of its time and also its quality; the adjustment of lighting elements through the entire day. Places or spaces that do not have a connection to elements that occur naturally can benefits pattern three.

Figure 8: Shadow movement; (URL 9)

Figure 9: Plants leaves and shadow movements; (URL 10)

Figure 10: Grass movement, insects buzz sounds, water falling; (URL 11)

Pattern four - Access to Thermal and Airflow Variability (ATAV):

The imitation of an environment of nature with the refinement that involves the adjustment of relative humidity, surface temperatures, air temperature and air movement over the skin provides the description of pattern four according to Browning et al (2014).

Ryan et al (2014) broadly stated that the risen dissatisfaction toward traditional method of thermal design, that have concentrated on it attempt to realize a much smaller goal for the span of unevenness in addition to studies that have quantify the impact of ventilation from natural means, with the resultant thermal inconsistency, the effect of natural motion, wellbeing, attention restoration theory, worker comfort, physiology, and productivity, have all lead to the ATAV pattern. Ryan et al (2014) stressed that boredom and inactivity can result from a non-variable and stimulating environment, in support Heerwagen (2006) stated that refined among varying temperatures light and sound in an environment have been accepted by individuals in addition to balanced intensities to sensory inconsistency. In addition to the argument, Wigo (2005) stated in his research that upon not having an adverse effect on brain activity, moderate adjustment of ventilation speed had led to the improvement in relation to capacity to connect to the memory of a brief span.

The purpose of pattern four (ATAV pattern) can be summarized as follows according to browning:

1. The creation of a built environment that promotes the allowance of occupants to perceive various sensory elements of thermal and airflow variability.
2. To provide the users of the space the ability to engineer thermal situation, whether through the allowance of users connected to changing ambient conditions in space or individual control.

Several methods that can be adopted in order to realize ATAV pattern (pattern four) are as follows:

1. Interior spaces with balconies
2. Mechanical ventilation that can be seen

3. Window that can be operated by the user.
4. Windows glazing accessibility (temperature)

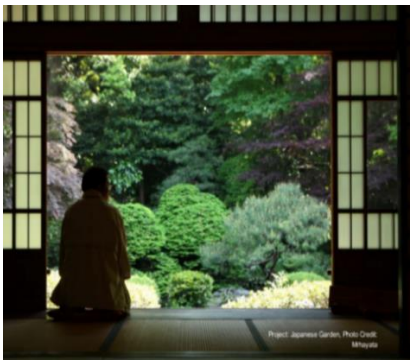


Figure 11: Manually openings with outdoor terrace; (URL 12)

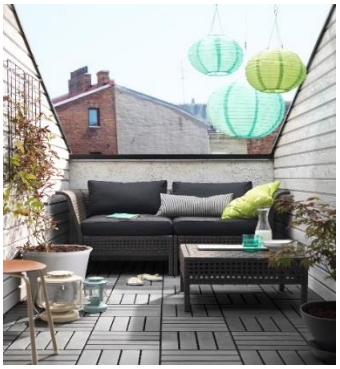


Figure 12: Indoor spaces with balconies; (URL 13)

Figure 13: Visible mechanical ventilation; (URL 14)

Pattern five - the presence of water (PW):

This pattern is concerned with condition that leads to the improvement of the experience of place through the senses of the eye, nose, ear, and skin that interact with water (Browning et al., 2014). According to Karmanov and Hamel (2008) in their study, enhanced adult attentive capacity has been linked visual connection of window to water or even green vegetation, then the visual connection of window to buildings or block wall, they went further to state that human's inborn fascination to setting of nature comprising of hints of water, shelter, and food, which has resulted in an immense relation to nature that might be viewed as an evolutionary beginning in human beings. Alvarsson et al. (2010) in their paper stated that interaction with water bodies or even water-related endeavours has shown to have improved the physiological and psychological wellbeing of the individual. Barton and Pretty (2010) in their analysis supported the above argument by stating that there are bigger benefits derived from the time spent around a water lake, or beach or any water body.

Man-made water features or natural water bodies like rivers, lakes, and streams can aid in realizing pattern five. In order words, good mood, optimal comprehension, recovery from cognitive tiredness as a result of the improved experience of a place where are benefits form focusing as a result of the improved experience of a place where the benefit from focusing on the vast-sensory aspects of water (Browning et, al., 2014).

Figure 14: Water presence, office complex- Rajasthan, India; (URL 15)

Figure 15: Indoors water presence, Khoo Teck Puat Hospital- Singapore; (URL 16)

Pattern Six - Dynamic and diffuse light (DDL):

This pattern is concerned with taking advantage of several amounts of light and shadow, which modifies at various periods to produce a condition that takes place in the natural environment.

A considerable length of time has been given to the research of daylight impact on psychological and physiological wellbeing in which early studies have reported the increase in productivity and sales in workspace and stores with much daylight class are higher. Furthermore, designs of light have long been utilized to control mood (Browning et al., 2014).

Kilic and Hasirci (2011) credited the contentment of individuals within an interior pace to the fasciation for daylight for being the main basis of natural light for the lighting of the interior space and a tool that has impacted occupants' behaviour and their perception that is employed by architecture. They went further to state that in particular daylight and the intensity of light possessed a huge effect on productivity going through literature and various chore engagements. In order words, the relevant productivity utilization of daylight particularly in spaces of continuous learning cannot be downplayed. The availability of daylight in the work environment has been credited also for contributing strongly towards the decreasing sense of the amount of work to be done and tiredness. However, activation of the sympathetic nerve is realized by utilization of daylight in the work environment which has aided in the enhancement of creative work performance (Sanchez, et al., 2018).

It aids in sustaining circadian system performance and upholding of concentration in a way that promotes good psychophysiological feedback and providing occupants with various choice of light that stimulate the eye (Browning et al., 2014).

The realization of DDL patterns can be done through the following ways according to Browning et al., 2014. They are;

1. Natural means, which comprises sunlight and firelights.
2. Artificial means, which comprises of light distribution. Individual user dimmer control, and ambient diffuse lighting.

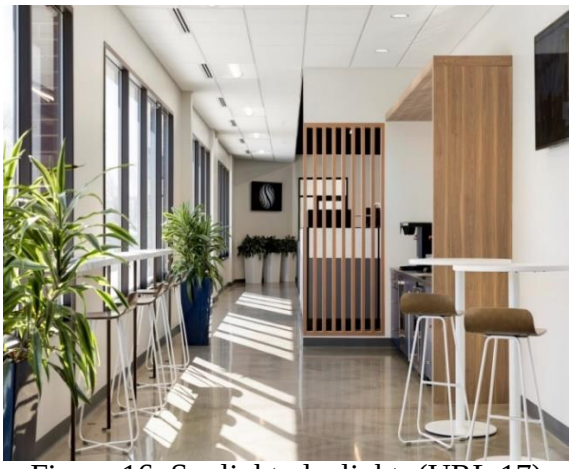


Figure 16: Sunlight, daylight; (URL 17)

Figure 17: Daylight, artificial light; (URL 18)

Figure 18: Natural light-scattering, Louvre- Abu Dhabi; (URL 19)

Figure 19: Artificial Fountain light, Louvre -Abu Dhabi; (URL 20)

Pattern seven - Connection with Natural System (CNS):

Due to the insufficient scientific documentary evidence of the health effects typically associated with exposure to systems of nature, similar to pattern six (presence of water) connection with natural systems is believed to positively improve health feedbacks, however, connection with natural system is concerned with increasing consciousness of natural phenomena, particularly seasonal and period variations that may be distinctive feature of a functional environment (Browning et al, 2014). To offer the capacity to visualize weather and seasonal variations with the behaviour of animals (Figure 22), it is important that the natural production of magnificent displays of nature

and integration of interaction with the subtle changes of the environment (Caraanen, 2016). Ideal environment management of the environment and increase in the understanding of natural characteristics is the aim of CNS patterns (Browning et al, 2014).

Figure 20: 4 seasons Coelhorst Mansion-Netherlands; (URL 21)

Figure 21: Animal behavior; (URL 22)

Figure 22: Weather changes; (URL 23)

B - Pillar two:

"*Look deep into nature, and then you will understand everything better"* Albert Einstein. (URL 24)

Pattern eight - Biomorphic forms pattern (BFP):

This pattern is concerned with mutually beneficial links that exist in nature with numerical, texture, contoured or patterned forms. Depending on the textures, contours and patterns which generates its inspiration from nature, which may occur in more artistic installations of architectural or structural form or minor application which are more abstractly embody natural form can be said to be Biomorphic form (Caraanen, 2016). Biomorphic patterns are generated from inspirations from natural geometries which are complicated, but comprehensible and ordered (Salingaros, 2012).

Although human brain identification of biomorphic patterns and forms as life's conceptual descriptions, still the brain understands that they are non-living forms. However, science has not articulated the explanation behind the perceptual affinity for natural and biomorphic forms (Vessel, 2012). In relation to the mediated adjustment in attention and increment in the ability to concentrate, biomorphic patterns and shapes development have resulted from studies concerning visual penchant and decreased stress level (Joye, 2007)

The production of a desirable viewable environment that leads to the reduction of stress, while it aids in promoting and improve brain function, while it aids in promoting and improve brain function. These, however, are the many intentions toward the utilization of biomorphic patterns and shapes, also to be able to interact with nature within the built environment through description element the in design.

By the means of natural shapes, curvilinear shapes and forms, fractal floor plan arrangement, spiral and with many geometric shapes BEP can be realized.

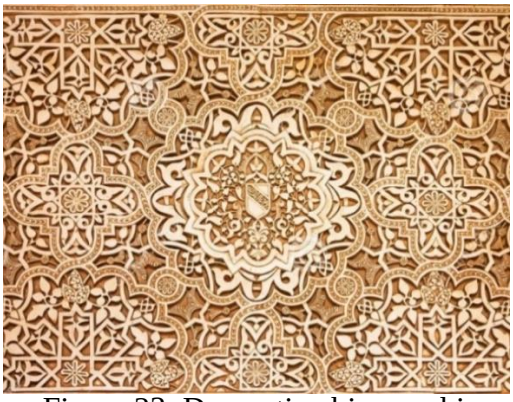


Figure 23: Decorative biomorphic form, Arabesque- Alhambra place, Granada, Spain; (URL 25)

Figure 24: Decorative biomorphic form, Arabesque- Umayyad Mosque, Damascus; (URL 26)

Figure 25: Architectural biomorphic form- mocarabes., Alhambra place- Granada, Spain; (URL 27)

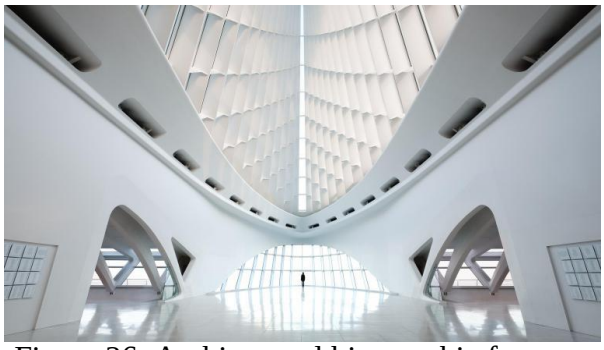


Figure 26: Architectural biomorphic form, The Milwaukee Art Museum- Milwaukee, US; (URL 28)

Figure 27: Fractal biomorphic pattern, Federation square atrium- Australia; (URL 29)

Figure 28: Fractal biomorphic pattern, Federation square atrium- Australia; (URL 30)

Figure 29: Fibonacci sequence biomorphic pattern- Vatican Museum, Italy; (URL 31)

Figure 30: Fibonacci sequence biomorphic pattern, Enlightenment; (URL 32)

Pattern Nine - Material Connection with Nature (MCN):

The production of a special sense of place that is unique to particular environment is realized by the process minimalizing of elements and materials from nature (browning et al., 2014) the specification and quantity of materials that are essential for an inherent quality and expectation for restoration validates the inadequate research in the academic world in respect to psychological benefits of material connection with nature, that has received much attention (Gills & Gatersleben, 2015).

The provision of restorative characteristics of wood and good health effect to users when is utilized in the interior of the built environment as a material has been established by some minor research conducted in this respect MCN (Burnard & Kutnar, 2015). Several physiological feedbacks from contrasting in wood ratio of interior space's walls are one the research's validation scholars have noticed that a space with considerable proportion of wood that is 45% exposure ratio which promotes psychological wellbeing (tangible improvement in pulse rate and reduction in diastolic blood pressure) whereas an exposure ratio of about 90% has been said to promote reduction in cognitive activities. In a place where, higher brain activities are required

it could be contra-productive and could be of greater restoration benefits in spaces like office, physician office or spa (Tsunetsugu, 2007).

Advancement and proficiency in creation are mental progress synonymous with the colour green. However green actually represent a specific variety of flourishes that engenders proficiency approach pursuit in ingenuity domains. Therefore, the promotion of growth and the imaginative result is realized by proficiency-approach pursuit (Lichtenfeld et al., 2012).

The integration of material of nature like wood in interior space could be either for functional purposes or artistic reasons. However, the core purpose of the MCN pattern to examine the various traits and concentrations of materials of nature the ideal optimistic brain or mental feedback (Browning et al., 2014).

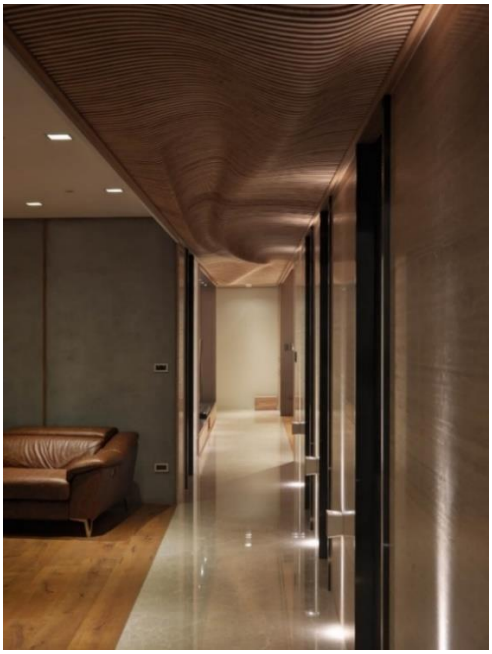


Figure 31: Interior design natural wood usage; (URL 33)

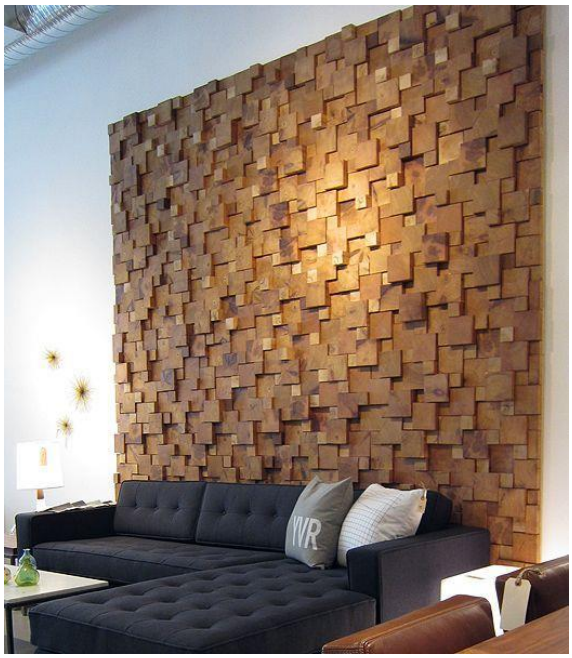


Figure 32: Interior design natural wood decorative wall mounted; (URL 34)

Pattern Ten - Complexity and Order (CO):

This pattern is concerned with adequate sensual details which confirm to spatial grading parallel to the ones found in the natural environment (Browning et al., 2014). The physical and mental stress feedback towards the intricacy of fractal in the natural environment, architecture, art, with the ability to produce the manifestation of patterns in addition to design movement in the natural environment (Joye, 2007). Accordingly, complexity and order are generated from studies on favourable views and fractal geometrical forms and patterns (Hagerhall et al., 2008; Taylor, 2006).

A visually productive environment that promotes optimal physical and mental feedback, through configuration with an articulated spatial hierarchy, produced from fractal and symmetrical geometries are the goal of complexity and order (Salingares, 2012).

Figure 33: Repeated & symmetrical exposed structure; (URL 35)

Figure 34: Repeated geometrical columns and fractal roof; (URL 36)

C- Pillar three:

Pattern Eleven - Prospect (P):

This pattern is concerned with unobstructed visualization of a long-range for the purpose of observation and preparation (Browning et al., 2014). Through the various

studies in architectural analysis, evolutionary psychological, spatial habit feedback, visual penchants have all lead to the generation of the prospect pattern, in which the physiological and psychological wellbeing could be reduction in fatigue, stress boredom irritation and being vulnerable sensually and increment of comfort (Wang and Taylor, 2006; Grahn and Stigsdotter, 2010; Ryan et al., 2014). Grahn and Stigsdotter (2010) stress that when an individual specific alone or find them in a new or an environment that is not known to the individual, prospect aid to decrease stress level and fear's feedback; in support to this argument Herzog and Bryce (2007) states that a better sense of alertness and relaxation is offered by a prospect of less than 30meters than that of the focal length more than 6 meters. Prospect is the capacity to visualize from a space to another space in populated urban spaces and indoor spaces. The prospect becomes stronger when there is room to visualize through several spaces and when there is not blurry identification of elements, therefore the application of the features of prospect is of limitless composition (Dosen & Ostwald, 2013).

The ability to comprehend and observe the outdoor spaces intensively is the goal of the prospect pattern. In other words, the prospect pattern can be realized by various approaches like views "partition height", "staircase landing", an "open floor plan" which possesses more length than 6meters (Browning et al., 2014).

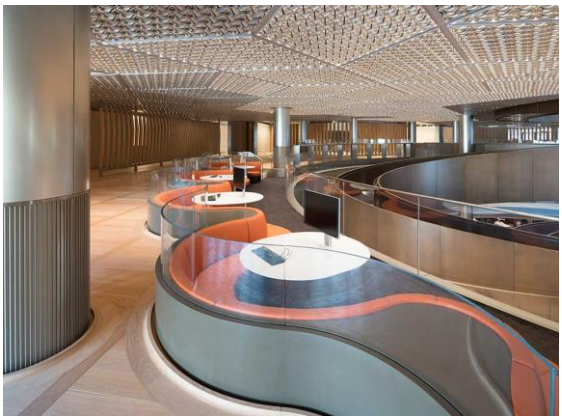


Figure 35: Figure Bloomberg London Offices, Open floor plan, partition height; (URL 37)

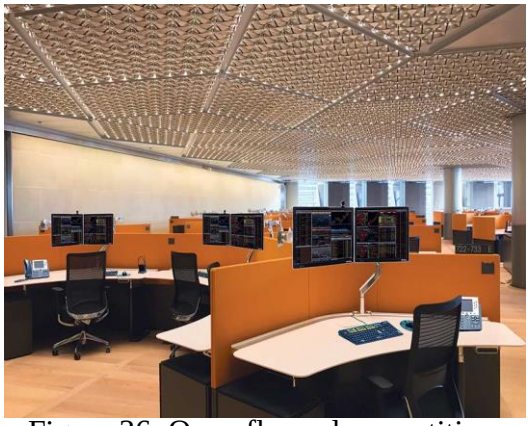


Figure 36: Open floor plan, partition height -Bloomberg London Offices; (URL 38)

Figure 37: Open floorplan; (URL 39)

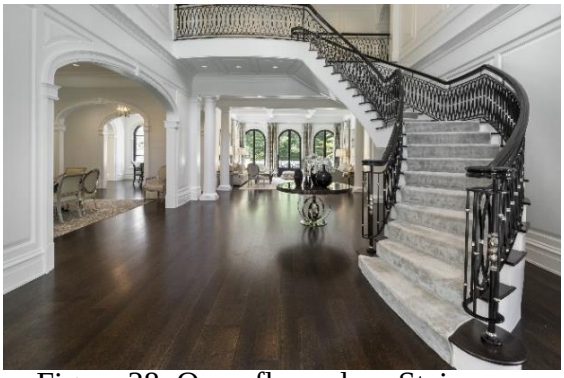


Figure 38: Open floor plan- Staircase landing ;(URL 40)

Pattern Twelve - Refuge (R):

This pattern is concerned with the provision of a place of detachment for the individual, which comprises of boundary shields for the individual back and above, away from the mainstream of action or environmental situation (Browning et al., 2014).

"*The ability to see without been seen"* Heerwigen &Gregory, 2008

Refuge and Prospect usually take place next to each other, even though there would be times when one, could be desired above the other. The Prospect-Refuge theory

provides clarification for the situation in which a specific view would be preferred, by which visual access (prospect) and enclosure (refuge) would be identified as vintage points (Caraanen, 2016). The prospect and refuge theory is generated from first the supposition that humans progressed from African Savannah when individuals have a penchant for vintage points or settlement that promotes observation and security like a cave or meadow and second researches been conducted in relation to human studies (Townsend and Barton, 2018).

Benefits of Refuge pattern as stated (Wang & Taylor, 2006; Grahn & Stigsdotter, 2010):

1- Decreasing irritation
2- Reduced blood pressure and heart rate
3- Essential for a restorative experience
4- Decreasing stress level.

Grahn & Stigsdotter, (2010) stated that the unification of natural prospect and refuge is so predominant at the verge of wood; this is so because of the provision of observation point and fortification against predators and weather condition, however, the health feedback is not that is more effective. When the two spatial phenomena meet it becomes a multifaceted response (Grahn & Stigsdotter, 2010).

With a thoughtful reduction of visual admittance to the refuge space and the provision of a small or larger portion of space that would be accessed with ease and also provide a space with the sense of security is the major goal of the refuge pattern (Browning et al., 2014).

According to Caraanen, (2016), the pattern can be realized through various approaches like

- Modular Refuge
- Window seats
- Booth sealing
- Reading nooks
- Gazebos
- Covered walkways & arcades.

Figure 39: Window seats; (URL 41)

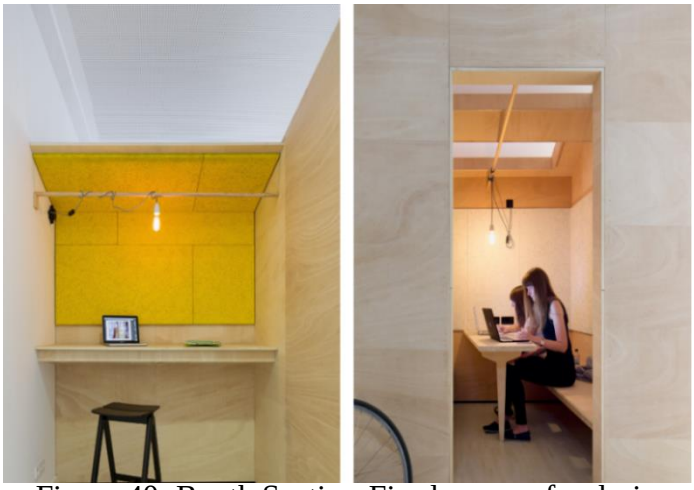


Figure 40: Booth Seating-Fjord agency for design & innovation- Berlin; (URL 42)

Figure 41: Reading Nook- Raheen Library at Australian Catholic University; (URL 43)

Pattern thirteen - Mystery (M):

The Mystery pattern is concerned with engendering the individual to go in-depth into an environment by impeding views of another stimulating device that provide assurance of more information. R.Kaplan & S.Kaplan (1989) asserted that individual requires two foundational things from their environment, which is comprehension and explanation, they also framed the Mystery pattern. Herzog and Bryce (2007) stress that these requirements are to take place beginning from an individual exact point, be able to promote a feeling of Mystery. Mystery pattern promotes immense feedback of pleasure, which occurs as a cognitive activity which resembles to occur that of anticipation, it has been guessed as one of the reasons listening to music is pleasurable because humans are always wondering what is hidden. The traits of mystery patterns are generated from studies on pleasurable feedbacks to anticipation events, sensed danger and visual penchant (Ryan et al 2014). The invitation of the user to engage in the exploration of the spaces, which would allow them to visualize moderately impeded elements, partly covering the boundaries and a part of the forward plane of the building, exterior space, would assist in creating a good mystery situation (Ikemi, 2005). However, Herzog and Bryce (2007) stated that an impeded view that has little prospect can result to a feedback that are not positive, while a greater prospect of moderately greater than or less than 6 meters to an increased depth of field of greater than or less than 30 meters would be better. This pattern of mystery can be realized by the following approach according to Caraanen, 2016:

- Winding pathways and corridors
- Curving edges
- Semi-transparent partitions.

Figure 42: Winding Corridor-One Jackson Square- USA; (URL 44)

Figure 43: Curving edges; (URL 45)

Pattern fourteen - Risk/Peril (R/P):

This pattern is concerned with having a dependable provision of safety and with a notable amount of threat. Risk /peril positive situation in a space can be lead to a pump of adrenaline, with notable risk, which might be moderately mischievous, but gives the sense of excitement and would want to explore more (Browning et al, 2014). However, resulting from reliable component of safety, the hazard element of danger is not harmful. Risk can be produced from biophilic feedback which could be a result of present and distant danger. The significant distinction among risk and peril in comparison to fear would be the extent of sensed danger with restraint (Kohno et al., 2013).

The extent to which an individual is exposed to risk/peril can affect to amount of department produce, which in turn affects to amount of dopamine produced, which in turn affects the individual's mood, that exposure of an individual to a risk/peril situation with a small-time can lead to just those of dopamine that promotes problem-solving, fight or fly feedback, motivation and memory, whereas exposure with a long period leads to overproduction of dopamine that leads to mood disorder and depression (Kohno et al., 2013).According to the specific user or available space, the risk/peril

condition would be determined for the various extent of risk that can be integrated into the design. To be able to evoke alertness and curiosity in addition to reviving memory are the major goals of this pattern (Browning et al., 2014).

Mystery pattern can be realized by several approaches according to Caraanen, (2016):

- Cantilevers (going under through water)
- Double height atrium
- Catwalk or balcony
- Resisting gravity (transparent floor)

Figure 44: Gravity - Los Angeles County Museum of Art; (URL 46

Figure 45: Transparent balcony floor; (URL 47)

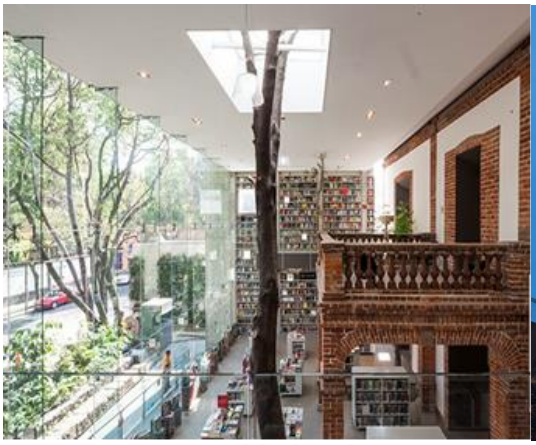


Figure 46: Double-height atrium, Balcony- Elena Garro Cultural Center; (URL 48)

Figure 47: Cantilever- Pennsylvania museum- USA; (URL 49)

Figure 48: Underwater restaurant- Maldives; (URL 50)

It could be observed from the literature review of the14 patterns of biophilic design that they are interconnected and interrelated; that is to say that in order to achieve realize one pattern it might require the application of other patterns, and also when identifying one pattern, one would be able to identify other patterns that would be present without intentional placing them there in that interior space.

The optimization of the function of the brain, improvement of psychophysiological performance is the descriptions of the 14 patterns objective which are shown in the table below; (Table 3).

Table 3: The 14 patterns of biophilic design alongside with the improvements of psychophysiological and brain functions (adapted by the author from Browning et al., 2014)

	14 PATTERNS	*	STRESS REDUCTION	COGNITIVE PERFORMANCE	EMOTION, MOOD & PREFERENCE
NATURE IN THE SPACE	Visual Connection with Nature	* * *	**Lowered blood pressure and heart rate** (Brown, Barton & Gladwell, 2013; van den Berg, Hartig, & Staats, 2007; Tsunetsugu & Miyazaki, 2005)	**Improved mental engagement/ attentiveness** (Biederman & Vessel, 2006)	**Positively impacted attitude and overall happiness** (Barton & Pretty, 2010)
	Non-Visual Connection with Nature	* *	**Reduced systolic blood pressure and stress hormones** (Park, Tsunetsugu, Kasetani et al., 2009; Hartig, Evans, Jamner et al., 2003; Orsega-Smith, Mowen, Payne et al., 2004; Ulrich, Simons, Losito et al., 1991)	**Positively impacted cognitive performance** (Mehta, Zhu & Cheema, 2012; Ljungberg, Neely, & Lundström, 2004)	**Perceived improvements in mental health and tranquility** (Li, Kobayashi, Inagaki et al., 2012; Jahncke, et al., 2011; Tsunetsugu, Park, & Miyazaki, 2010; Kim, Ren, & Fielding, 2007; Stigsdotter & Grahn, 2003)
	Non-Rhythmic Sensory Stimuli	* *	**Positively impacted heart rate, systolic blood pressure and sympathetic nervous system activity** (Li, 2009; Park et al, 2008; Kahn et al., 2008; Beauchamp, et al., 2003; Ulrich et al., 1991)	**Observed and quantified behavioral measures of attention and exploration** (Windhager et al., 2011)	
	Thermal & Airflow Variability	* *	**Positively impacted comfort, well-being and productivity** (Heerwagen, 2006; Tham & Willem, 2005; Wigö, 2005)	**Positively impacted concentration** (Hartig et al., 2003; Hartig et al., 1991; R. Kaplan & Kaplan, 1989)	**Improved perception of temporal and spatial pleasure (alliesthesia)** (Parkinson, de Dear & Candido, 2012; Zhang, Arens, Huizenga & Han, 2010; Arens, Zhang & Huizenga, 2006; Zhang, 2003; de Dear & Brager, 2002; Heschong, 1979)
	Presence of Water	* *	**Reduced stress, increased feelings of tranquility, lower heart rate and blood pressure** (Alvarsson, Wiens, & Nilsson, 2010; Pheasant, Fisher, Watts et al., 2010; Biederman & Vessel, 2006)	**Improved concentration and memory restoration** (Alvarsson et al., 2010; Biederman & Vessel, 2006) **Enhanced perception and psychological responsiveness** (Alvarsson et al., 2010; Hunter et al., 2010)	**Observed preferences and positive emotional responses** (Windhager, 2011; Barton & Pretty, 2010; White, Smith, Humphryes et al., 2010; Karmanov & Hamel, 2008; Biederman & Vessel, 2006; Heerwagen & Orians, 1993; Ruso & Atzwanger, 2003; Ulrich, 1983)
	Dynamic & Diffuse Light	* *	**Positively impacted circadian system functioning** (Figueiro, Brons, Plitnick et al., 2011; Beckett & Roden, 2009) **Increased visual comfort** (Elyezadi, 2012; Kim & Kim, 2007)		
	Connection with Natural Systems				**Enhanced positive health responses; Shifted perception of environment** (Kellert et al., 2008)
NATURAL ANALOGUES	Biomorphic Forms & Patterns	*			**Observed view preference** (Vessel, 2012; Joye, 2007)
	Material Connection with Nature			**Decreased diastolic blood pressure** (Tsunetsugu, Miyazaki & Sato, 2007) **Improved creative performance** (Lichtenfeld et al., 2012)	**Improved comfort** (Tsunetsugu, Miyazaki & Sato 2007)
	Complexity & Order	* *	**Positively impacted perceptual and physiological stress responses** (Salingaros, 2012; Joye, 2007; Taylor, 2006; S. Kaplan, 1988)		**Observed view preference** (Salingaros, 2012; Hägerhäll, Laike, Taylor et al., 2008; Hägerhäll, Purcella, & Taylor, 2004; Taylor, 2006)
NATURE OF THE SPACE	Prospect	* * *	**Reduced stress** (Grahn & Stigsdotter, 2010)	**Reduced boredom, irritation, fatigue** (Clearwater & Coss, 1991)	**Improved comfort and perceived safety** (Herzog & Bryce, 2007; Wang & Taylor, 2006; Petherick, 2000)
	Refuge	* * *		**Improved concentration, attention and perception of safety** (Grahn & Stigsdotter, 2010; Wang & Taylor, 2006; Petherick, 2000; Ulrich et al., 1993)	
	Mystery	* *			**Induced strong pleasure response** (Biederman, 2011; Salimpoor, Benovoy, Larcher et al., 2011; Ikemi, 2005; Blood & Zatorre, 2001)
	Risk/Peril	*			**Resulted in strong dopamine or pleasure responses** (Kohno et al., 2013; Wang & Tsien, 2011; Zald et al., 2008)

2.2.7 Biophilic Design Elements & Attributes

The project's context and limitations like legal regulations, socio-cultural factors, economic constraints, the size of the project, building type and its landscape would all affect the decision towards design application that would be adopted. Attributes and experience can be said to makeup design strategies, which are of various applications that refer to Biophilic design practice (Kellert, 2015).

The fundamental classes of Biophilic design structure are denoted by three experiences of nature, they are:

1. Direct experience of Nature:

   This experience of nature denotes a tangible interaction with natural elements in the built environment comprising of landscapes, animals, natural light, water and plants.

2. Indirect experience of nature:

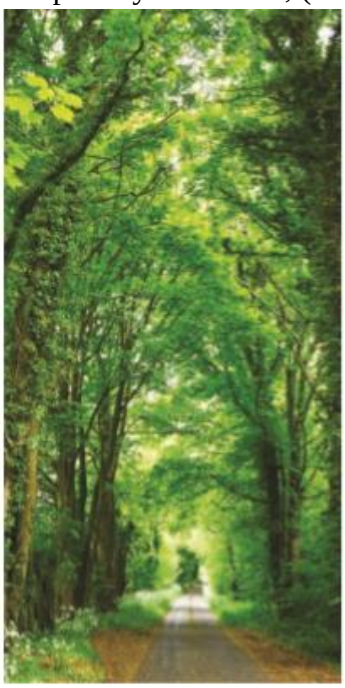
   This experience of nature denotes an interaction with the description of nature, interaction with patterns, or processes that are peculiar to nature. An example is a material from nature, like wood and stone images and artwork inspired by nature, even form and shapes that take place in nature.

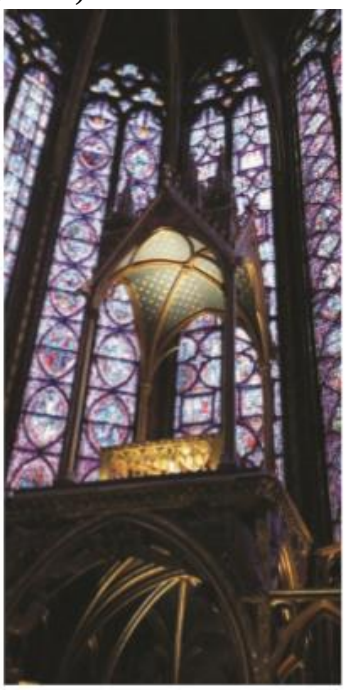
3. The experience of space and place:

   This experience of nature denotes the interaction with a spatial element that is distinctive to nature, which enhances the psychological wellbeing of human for instance prospect and refuge, way find complexity organization.

The basic categories of biophilic design which are represented in the three experiences of nature are broken down into 24 attributes, which are shown in the table below ;(Table 4);

Table 4: The three classes of experience and the 24 attributes for biophilic design, adapted by the author, (Kellert, 2015)





Direct Experience of Nature	Indirect Experience of Nature	Experience of Space and Place
• Light	• Images of nature	• Prospect and refuge
• Air	• Natural materials	• Organized complexity
• Water	• Natural colors	• Integration of parts to wholes
• Plants	• Simulating natural light and air	• Transitional spaces
• Animals	• Naturalistic shapes and forms	• Mobility and wayfinding
• Weather	• Evoking nature	• Cultural and ecological attachment to place
• Natural landscapes and ecosystems	• Information richness	
• Fire	• Age, change, and the patina of time	
	• Natural geometries	
	• Biomimicry	

2.2.8 Biophilic Design Strategies

The implementation of design adopts varying strategies that are concentrated in one of the frameworks developed for biophilic design strategies by Alex Wilson (2006). This framework is tackled from a generic point of view to a more particular point of view, which mentions design strategies whilst considering biophilic design from a larger to smaller scale such as landscape and site scale to the building's design to interior design scales (Ojamaa, 2015).

Table 5: General biophilic design strategies (adapted by the author from Ojamaa, 2015)

Biophilic been tackle at the initial design stage	Landscaping, spatial configuration, interior design, setting and architectural shapes and be easily realized when biophilic design strategies are thought of at the initial space.
Biophilic design with a specific focus on the building of elderly and children	Imbibe the consciousness and appreciation of nature in children and as in the elderly and the sick which promotes healing, through visualization of natural views.
The education of natural features in the building	People can comprehend and appreciation of signage and boards about natural elements.
Exploring ways to introduce biophilic design in a building.	Biophilic design can be integrated into a new building to a greater extent than the existing building, in which so many of the strategies can be employed.
The provision of the feeling of mystery in the design of landscape	The complexes of nature can be appreciated by user exploring and observing various parts of the building, it is critical for places design for children
Aid in the dissemination of the appreciation of biophilic design	The dissemination of the essence of biophilic design to the design would with much focus on some sector of the market like health care and education
Promote connection to a place	Assisting users of a space to connect to a place through historical, cultural ecological and visual mean, providing that strong sense of connection which enable them to protect the space.

Table 6: Landscape design biophilic design strategies (adapted by the author from Ojamaa, 2015)

Provision of open space around the building	The essence of open planted nature space around the building cannot be downgraded also space that increases with nature
Preservation of native landscape and existing tree	Protection of native landscape and tree all through the executing of a building project could be cost-efficient, even when developing a new landscape it is important to sustain the existing one.
Provision of aesthetic and plants of natural context around the building	So many windows should have an outlook on natural elements like plants' water bodies and the landscape sound surrounding the house should design efficiently.
Pathways across the landscaped and natural area should be constructed	The pathway can provide a connection between smaller communicates with bigger communities' pathways that can be constructed for walkthrough pack and also restore the native landscape.
Several of the native plants can be utilized in the replacement of hard landscape	The replacement of impervious surfaces with vegetation, to allow rainwater to filtrate through the ground would help the environment and also be aesthetical pleasing.
On the building, exterior walls that are living should be provided	One of the objectives of living walls is to bring the building come to nature, with vine climbing the exterior and saving energy.

Table 7: Building biophilic design strategies (adapted by the author from Ojamaa, 2015)

Provision of visual connection to nature (Natural views)	Windows should be at various points of the house that would provide the occupants the visual access to natural elements.
Reduce the point of transition between the outdoor and indoor (Connect interior to exterior)	Where possible there should be an extension of working and living space to the connecting outdoor spaces like courtyard, gazebos, balconies, and terraces. And also the creation of spaces that attract users.
Daylight should be provided in the high amount (Daylight)	Obstruction of sightline and visual access to natural elements that interfere.
Windows that can be open should be installed (Operable windows)	Occupants should be provided with windows that are operated able and provide interaction for natural elements like temperature and smell.

Provision of green roofs (Green roofs)	Provision of vegetation on the roof with a gentle slope, with a physical and visual connection to the roof
Integration of vegetation in atria and planting in the interior (Interior landscape)	The notion behind atria and plant beds is to integrate nature in the interior space. Atria has been established to bring physical and mental benefits to the occupants.
Integration of living walls and systems for water and air (Water & Interior landscape)	Water bodies can give both visual and acoustic advantages, taking the occupants' mind to waterfall or spring rain.
Provision of sense of complexity and order in the building design (Complexity)	Introduction of intricacy and variation gives a unique relationship of natural pattern that is critical to biophilic design
Consideration of refuge and spaciousness in projects design (Refuge and spaciousness)	Different ceiling height produce space that copies the outdoor and also provision of space of refuge for the sense of security
Introduction of organic forms in the project (Organic forms)	Integration of organic forms to copy what is in the exterior space

Table 8: Interior design & biophilic design strategies (adapted by the author from Ojamaa, 2015)

Potted plant serving as decoration (Potted plant)	Connection to nature in the interior space as he achieved by the introduction of potted plants in interior design.
Introduction of natural art and natural materials in the building (Natural materials & images of nature)	Places where the view of nature is not a present natural material and artwork or image of nature can be employed to evoke biophilic respond.
Configuration of space for promotion visual access to nature (Configure interior spaces next to openings)	The work area should be oriented towards natural light and interior garden and other natural features
As part, interior design interpretation should be provided	The utilization of signage and descriptive elements to provide clarification biophilic elements and functions, in order for them to be understood properly.

Since this study focuses on the biophilic design in the interior spaces of public libraries, two groups of biophilic design strategies (building design & interior design) will be considered for the study framework generating.

2.2.9 Chapter Conclusion

It can be observed in this chapter that in the transfer of the theory of biophilia to its practical use biophilic design, many approaches have been employed, but for this thesis, the delimitation is within the utilization of the 14 patterns (Browning et, al., 2014), elements and attributes (Kellert, 2015), biophilic design strategies (Wilson, 2006). However, the 14 patterns are of critical importance to this thesis due to how elaborate and comprehensive it is.

Chapter 3

THE NECESSITY OF BIOPHILIC DESIGN EMPLOYMENT IN PUBLIC LIBRARIES

3.1 Public Libraries

The focus of this section of the thesis would be on the public library. However, before discussing public libraries, it would be critical to know what a library is, its types, and its importance. Therefore, this section would first of all discuss the definition of a library, then types of libraries (in which public libraries would be looked into in detail), which would lead to the section on the consideration of what future libraries would be focused on, the last part of this section would be on the importance of libraries.

3.2 Libraries

3.2.1 Definition

From the Etymologies of Bishop of Seville, bibliotheca, which is the most used word for library in lain is seen as a "vastly important conduit for classical antiquity into the medieval world". As one of the terminal bases of medieval scholarship and the project of antiquity oblation encyclopaedic, this was formulated in the early years of the seventh century (König, 2013). With the origin of writing in the fertile crescent of southwest Asia, when a span of Nile in Africa to Mesopotamia in which the initial libraries surfaced about 5000 years ago (Renfrew, 2008). According to Krause (2007) library can be defined as a building that contains categorized books, journals, institutional documents, manuscripts, maps, newspapers, magazines and other sources

of knowledge. The library is a very critical building in the university campus and educational institutions. Furthermore, library buildings have been of great sources of knowledge as it houses various form and types of knowledge of whatever field that might be the subject in question, to every one of various age groups, income level, at every location and of every ethnic group and physical ability. The knowledge from the library is required to work, for everyday living and to govern a particular place.

In addition to the above, the library can be seen as a knowledge reservoir that would be utilized later. The documentation of human knowledge of several types that have been stored through various forms or means, which is not only stored in written form but with aid of technology, several media have been employed; for instance, the utilization of electronic multi-media (URL 51). Libraries are of various types which are Academic libraries, special libraries, national libraries, and public libraries.

3.2.2 Types of Libraries

1- Academic libraries:

According to Curzon and Quinonez (2009) stated that libraries found in the institution of higher learning are known as an academic library which provides two corresponding functions where are;

- Sustenance of the institution's curriculum.
- Sustenance of the various studies in the institution.

2- Special libraries:

Bilawar (2013) stated that a special library provides support for a particular set of people and concerned with specific research focus or a combination of research focus, which might outspread to cover a specific user group. This library might provide

service for a unique profession or research group, in which their knowledge might require a special activity for instance, military, law, medical, engineering libraries.

3- National Libraries:

Defined the national library as a place set up by the government to be a nation's well-known storehouse of knowledge. Materials are hardly borrowed from the national library, then a public library. The materials that are contained in the library are exceptional and of immense value. The major functions of the national library are the collection and preservation of literacy material critical to the nation whether national or international. The user group of this library is the nation itself (URL 52).

4- Public Libraries:

On a whole library is the main center for the information and enlightenment in which its fundamental objective is the propagation of knowledge, with the provision of reference materials to its users. Presently library is not just a tangible place of enlightenment, but a place of interaction, linking up, a place of education, either as a group or an individual, in most cases the freedom or right to information and other materials which are relevant. Therefore, it is now vital to draw people into the library by making it attain a greater level of interior quality.

Furthermore, McCabe and Kennedy (2003) stated that any person can use the public library. However, new library buildings are designed like bookstores and may little refreshment, which engenders users to stay longer, in addition, spaces for galleries, performing art, meeting, and seminar are becoming programs which are provided by the libraries.

Another one stated that a public library is set up, financed and sustained by local, regional or national administration that is belonging to the community which is of various forms. Access to knowledge and information is without bias no matter the age, gender, economic status, educational level, language, religious affiliations and even physically challenged; it also provides sources of imaginative works that can be perceived through various means (Sufar et, al., 2012).

Nowadays, libraries' design is a significant concern due to changing conditions of time and renewed expectations of the users. This due to the primary functions of the library which are provision and storage of knowledge can be gotten now from so many places that are not libraries; therefore, the libraries have to be adapted to meet the needs of the changing time and needs of the users. This would be discussed in the next section.

3.2.3 Future libraries design considerations

Libraries of the future as a matter of importance should be able to provide several functions and programs for its host community and the society at large (Sufar et, al., 2012). The optimization of the design of these future libraries depends on the users' satisfaction, which is greater impacted by the tangible indoor environment. Latimer (2007) stressed that the needs of users of the 21st century have evolved, in which the spaces have to efficiently design, and aesthetically pleasing. Furthermore, having the needs of the users of the public library should be a core consideration of the design as stressed by Juhnevica and Udre (2010). This argument is buttressed by Eigenbrodt, (2009) by stressing that with the user's needs at the core, it would become a place sustained learning and educational interaction. McCabe and Kennedy (2003) stated that libraries have to be functional and up-to-date with the utilization of technology that assists the host society. Anandasivam and Cheong (2008) stated that the whole sense must be considered through good music, pleasing smell, optimal lighting,

furniture that are complacent, with images on the vertical plane, in addition to anything that would make space pleasant to its users. Users can be provided with various space zoning considerations, like space for gathering and space for individuals.

3.2.4 Importance of public libraries

1- Libraries have been a place that attracted people of various backgrounds that is an inclusive place, with the ability to reinvest in civic space that might have lost its essence (Worpole, 2004).

2- Public libraries of these days is not just a place of enlightenment and knowledge seeking, but now a place for social interaction, execution of assignments, provision of a space for social and educational events (Worpole, 2004).

3- Physical public libraries also assist in the propagation of reading culture in the society through socialization, communication in a comfortable interior space, thereby engendering the acquisition of knowledge (Sufar et al., 2012).

4- Sufar et al., (2012) stated that a public library is a critical civic asset. With the new approach of rejuvenation of the exterior and interior spaces, for socialization, knowledge gaining, communication.

Project for public spaces founder also an architect, in the person of Fred Kent stated since people do not have to go the library for knowledge, but they will visit the library if it is a "*desirable place*". The design and development of a public library should be evolutionary to the needs of the users with inspiring designs and concepts. Library design does not depend on the aesthetic of the exterior envelope, but a functional and inspiring physical interior environment that would require so many considerations. These considerations comprise space organization and interior atmospheres like good light, appropriate materials, comfortable furniture, and finishes.

In addition to the above stated significant concerns yet the role of nature is inadequately considered. As in so many researches which have focused on the essence of interior introduction of nature such as hospital, care homes, private estate, and shopping malls there is no adequate studies that have focused on the integration of nature into public libraries, which has prompted the research question of this study: ‘How biophilic design can be integrated into the public library’s interior spaces?’.

Chapter 4

EVALUATION OF BIOPHILIC DESIGN EMPLOYMENT IN PUBLIC LIBRARIES

Introduction

The literature review chapter has provided intensive theoretical information on the main domain (biophilic design), this information covered the origin, principles, goals, values, most popular approaches, prominence, and the benefits on the occupants of interior spaces as well. Consequently, by using the qualitative research method, this chapter argued in order to explore the role of biophilic design in interior spaces with specific reference to public libraries to assess the essential study question: How biophilic design can be integrated into the public library's interior spaces? This chapter comprised of four main sections, the first section briefly explains the method used for evaluation, the second section clarifies the main research delimitations, third section explains the data collection method, and finally the data evaluation criteria of the selected study cases.

4.1 Methodology of the Research

A qualitative exploratory research method is used through this study's investigation. Accordingly, it will be used to explore the *biophilic design* in detail through the literature review to identify the biophilic design from various aspects, accordingly, conclude the essential key terms in relation to interior spaces where the main focus is the *public library*, consequently to achieve the aim of the study by answering the

research question to which extent that ‘the biophilic design’ utilized in the study cases of public library.

4.2 Research Delimitations

Biophilic design is a major aspect of this study. Biophilic design is a comprehensive topic and can be related to different aspects such as urban, landscape, internal spaces, as well as external spaces, thereby, this study focuses on the biophilic design in terms of interior spaces, and how can biophilic design integrated into the interior spaces. Biophilic design considered as a fresh subject and yet there is no unified agreeable information, accordingly, this study’s investigation based on most popular three approaches of biophilic design (Ojamaa, 2015), 14 patterns (W. Browning et al., 2014), elements & attributes (S. Kellert, 2015), and strategies (A. Wilson, 2006). Since these three approaches have been clarified in chapter 2, therefore, the method of analysis, evaluation, and exploring the study cases is the main focus of this chapter.

Public libraries need to be modified, developed, and adapted in order to meet the recent & upcoming new requirements. According to IFLA “International Federation of Library Associations and Institutions”, public libraries are one of the most important hosts of society lifelong local knowledge education, therefore, the future of lifelong education processes need to be developed & improved through allowing the public libraries playing that role. And since there is a scarcity of studies carried out on the libraries in relation to biophilic design, the public library is the second aspect of the study, this study focuses on the influences of bringing biophilic design into the public library.

4.3 Data Collection

Several sources & materials were used in the study, these sources & materials divided into two sections, the first section is directly related to the main study domains (biophilic design, public libraries), while the second section is the indirectly related materials from different fields such as medicine, psychology, and physiology as well. Data were collected from several knowledge sources such as books, articles, journals, published theses, and websites.

While the public library is one of the delimitations of the study, five cases of public libraries are used in the study; these five public libraries are used for the study evaluation because they are the only winners of the IFLA "International Federation of Library Associations and Institutions" public library world competition. Interior & exterior 3D views, floor plans, and the required information of these five cases were collected from architectural websites and from the same public libraries websites as well.

4.4 Data Analysis

Based on what was clarified & noticed in chapter 2, biophilic design patterns are somehow related to each other, accordingly, the study cases' analysis has been done in terms of the used strategies and attributes, and at the end of each case study, an evaluation has been reflected on the study framework.

Based on what stated in the review of literature, the study framework generated from the most popular three biophilic design approaches (Ojamaa, 2015), 14 patterns, elements & attributes, and strategies. The framework has developed & generated to produce more valuable and accurate data evaluation from three different stands of

view. These three approaches were clarified extensively in chapter 2. Due to the inclusivity of the 14 patterns approach, it was considered as the main aspect of the framework, whereas the other two approaches' elements were accordingly categorized based on the similarities between them in terms of the 14 patterns (Table 9).

Table 9: Study framework

		Patterns of Biophilic Design (*W. Browning et al., 2014*)													
		Nature in the Space							Natural Analogues			Nature of the Space			
		1. Visual Connection with Nature. **(VCN)**	2. Non-visual Connection with Nature. **(NVCN)**	3. Non-rhythmic Sensory Stimuli. **(NRSS)**	4. Access to Thermal & Airflow Variability. **(ATAV)**	5. Presence of Water. **(PW)**	6. Dynamic & Diffuse Light. **(DDL)**	7. Connection with Natural Systems. **(CNS)**	8. Biomorphic Forms & Patterns. **(BFP)**	9. Material Connection with Nature. **(MCN)**	10. Complexity & Order. **(CO)**	11. Prospect **(P)**	12. Refuge **(R)**	13. Mystery **(M)**	14. Risk/ Peril. **(R/P)**
Matching with 14 patterns literature															
Elements And Attributes To Biophilic Design (S. Kellert, 2015)	Direct Experience of Nature	Plants Weather Water Animals	Animals Water		Air Weather	Water	Light Fire	Natural landscape & systems							
	Indirect Experience of Nature	Images of nature			Simulating natural air	Images of nature	Simulating natural light	Age, change, and the patina of time (weather)	Neutral colors Naturalistic shapes & forms Evoking nature Biomimicry Natural geometries	Natural materials	Information richness Biomimicry			Biomimicry	
	Experience of Space and Place										Organized complexity	Prospect Transitional spaces Mobility and wayfinding	Refuge		
Biophilic Design Strategies (A. Wilson, 2006)	Building Design	Natural views Green roofs Interior landscape	Water		Connect interior to exterior Operable windows	Water	Daylight	Connect interior to exterior Natural views Green roofs	Organic forms		Complexity	Spaciousness	Refuge		
	Interior Design	Potted plants Nature views Configure interior spaces next to openings						Configure interior spaces next to openings		Natural materials Nature artwork					

Adapted by the author based on Browning et, al (2014), Kellert et al (2015), & A. Wilson (2006) approaches.

Selection of the cases for evaluation

As explained previously, the used public libraries cases in the study are the IFLA public library competition winners (Table 10). IFLA established in 1927, Scotland. IFLA is an independent global organization of the library, library users, and knowledge services as well. IFLA arranges an annual competition for the best public library in the world according to their specific assessment criteria standards. These criteria based on six main elements (flexibility, learning spaces, sustainability, domestic culture & surroundings contacting, architectural character, and digitization).

Table 10: List of the IFLA public library competition winners including general information.

Library name	**location**	**Year of construction completion**	**Year of award-winning**	**Designer**	**Built-up area**
Oodi Helsinki Central Library	Helsingfors, Finland	2018	2019	ALA Architects	17250 m2
School 7	Den Helder, Netherlands	2016	2018	Van Veen Architects	3000 m2
Dokk1	Aarhus, Denmark	2015	2016	Schmidt Hammer Lassen Architects	35600 m2
Kista Library	Stockholm, Sweden	2014	2015	Wester+Elsner Architects	2400 m2
Craigieburn Library	Craigieburn, Australia	2012	2014	Francis-Jones Morehen Thorp	4640 m2

4.5 Evaluation of the selected cases

4.5.1 Case study no.1: Oodi Helsinki Central Library

Figure 49: Oodi Helsinki Central Library; (URL 53)

A. Spatial and Functional Organization

This library can be considered a good example of modern multi-function public libraries buildings due to the combination between the conventional library functions and public social center within the same three floors building, and this is what distinguishes this library from the majority of other public libraries. This library contains three floors plus the basement; the basement used for technical & mechanical equipment. Ground floor seems more public spaces & functions such as multi-function spaces for different types of activities & events, cafe-restaurant, movie theater, and a huge entrance lobby as well. Moreover, the continuity of the outside plaza flooring into the ground floor reflects the concept of connection between the outdoors &

indoors spaces, and to provide an appearance that the ground floor is more a public space with public facilities as well (Figure 50).

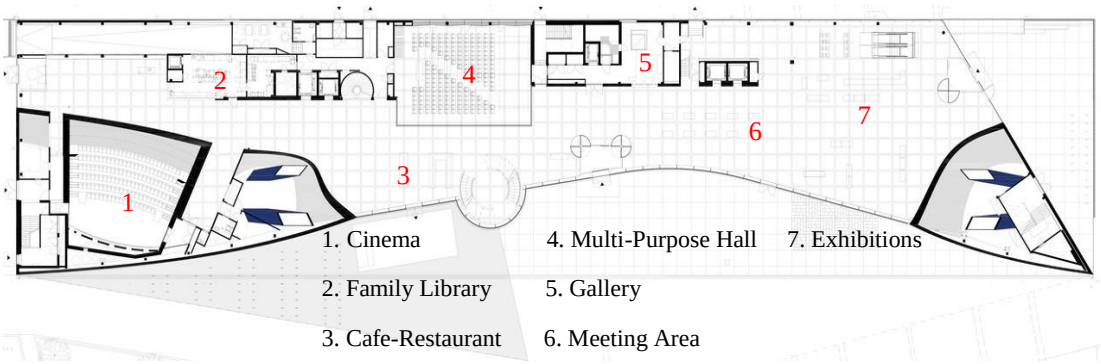


Figure 50: Library ground floor plan; (URL 54)

The first floor provided more different flexible types of spaces for public activities & creativity such as conference hall, game room, music gallery, and design creation spaces, the flexibility can be seen through that these spaces are offering same facilities for different numbers of users whether for individual person or families and it suits both the quiet and also various noisy activities (Figure 51)

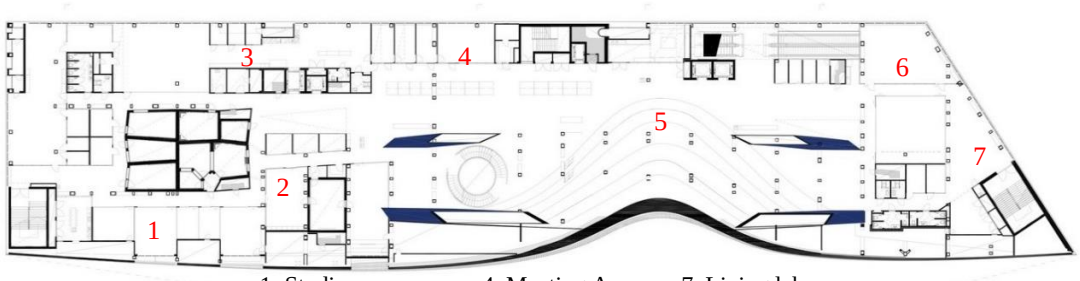
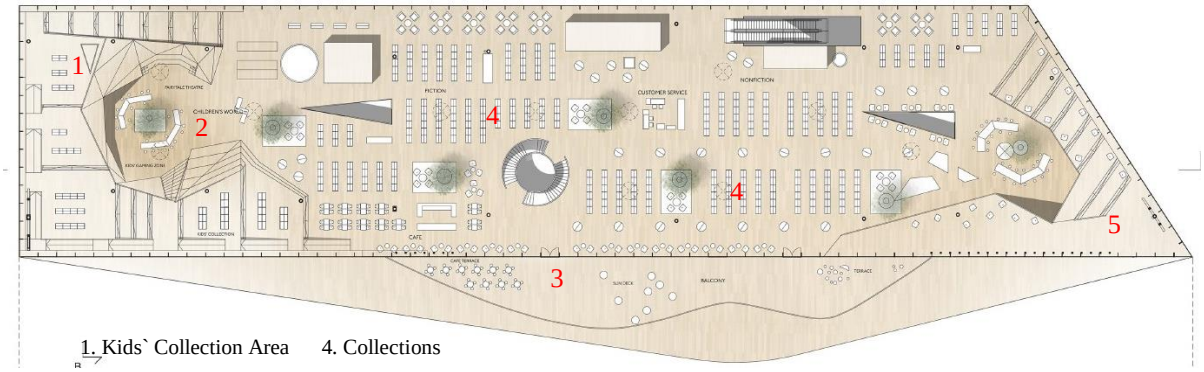


Figure 51: Library first floor plan; (URL 55)

While the ground & first floors are more for public social activities and events. The second floor is a harmonious open floor space where the library's main facilities are provided for the public and for different ages as well (Figure 52).



1. Kids` Collection Area
2. Kids` Area
3. Balcony
4. Collections
5. The Peak

Figure 52: Library second floor plan; (URL 56)

B. Biophilic design employment evaluation

The upper (second) floor of the library building, where are the library's main facilities located. As can be observed and based on the theoretical background of the literature (Page 17-18), many methods were used to integrate & simulate the nature and natural systems indoors. *VCN* pattern has achieved through several methods such as using *living olive trees* in different nine positions, and these trees considered as the only living systems that have been physically integrated into the library building (Figure 53).

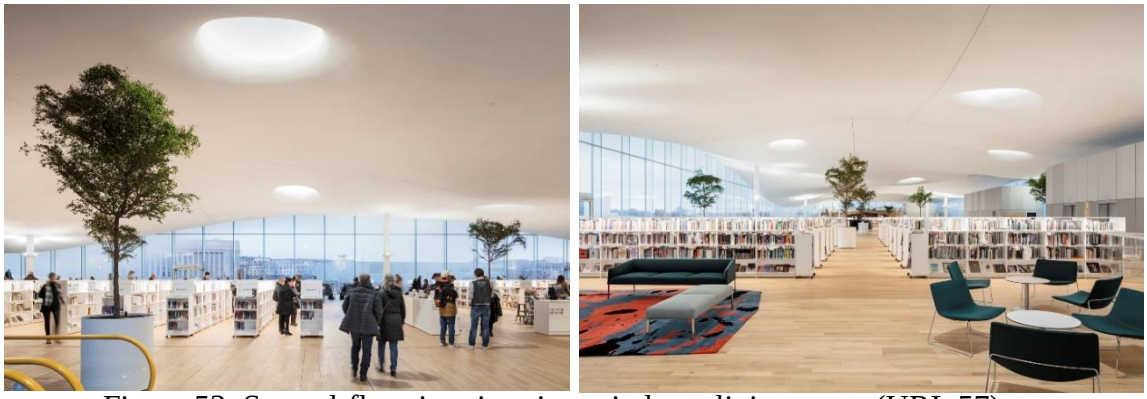


Figure 53: Second-floor interior views, indoors living trees; (URL 57)

Natural wood besides glass and white concrete are the main materials used in this library, it almost can be seen everywhere. Spruce wood has been used for the ground floor ceiling and white concrete for the flooring patterns, regarding the second floor the oak wood has been used for the different flooring levels and wavy white concrete for the ceiling. Using *natural materials* especially *natural wood* is the essential method to achieve *MCN* pattern (Figure 54,55). Moreover, *natural wood* usage, *outdoors* & *weather different sounds*, besides the *olive trees* are achieving the *non-visual connection with nature* pattern.

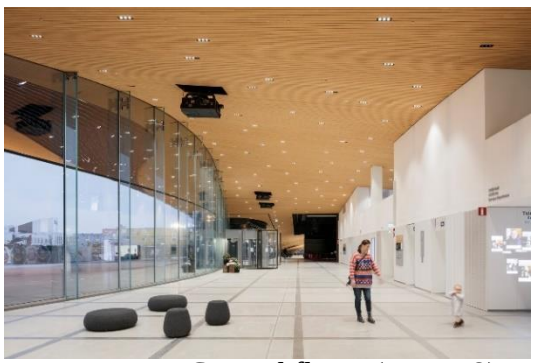


Figure 54: Ground floor; (URL 58)

Figure 55: Second floor; (URL 59)

Moreover, many utilized methods have accomplished *visual connection with nature* (VCN) pattern through using *fully glazed elevations* which mainly used for the main façade (west façade) on ground & second floors and for all facades for the second floor

beside the circular roof skylights in the second floor, majority of these methods are intersecting with *CNS* pattern such as the *natural views*, providing *seating areas next to the openings* which allow the library` occupants to *experience the outside weather*, and providing the ability for occupants to *communicate & interact with outdoor natural systems & environments*, furthermore, the library *cantilevered balcony* is providing strong *connection between indoors & outdoors* spaces and that is achieving *CNS* pattern too (Figure 56).

On the other hand, through these two openings elements, the *fully glazed elevations & skylights* two more patterns have accomplished, *DDL* pattern via the considerable *natural light* access. Also, these two openings elements are providing to the library users to observe the outdoors & natural elements movements which accordingly reflect *NRSS* pattern.

Figure 56: Glazed facades & round skylights; (URL 60)

A considerable public balcony was created above the building entrance canopy; this balcony provides the ability for the occupants to meet each other while watching the city. Through this balcony, *ATAV* pattern has accomplished by allowing the library's occupants to experience different natural elements such as *connecting interior to exterior*, *airflow*, and *changeable weather humidity & temperature* (Figure 57).

Figure 57: Library public balcony; (URL 61)

The *white wavy ceiling* punctuated by smooth edges of round skylights is one of the interior design elements which distinguishes the second floor, this *white wavy ceiling* reflects *BFP* pattern since it can be considered a *naturalistic form* and reflects natural elements movements such as grass or water waving, and painted with a *neutral color* (*white color*) as well (Figure 58).

Figure 58: White wavy ceiling punctuated by smooth edges of round skylights; (URL 62)

Based on the theoretical background in chapter 2 (Page 33), creating a nourishing & attractive visual space view is one of the objectives of biophilic design patterns. The *symmetrical and repeated diagonal columns* located on the first floor are achieving

this objective by providing an attractive visually interior space which might be considered as one of the *CO* pattern methods (Figure 59).

Figure 59: First-floor diagonal columns; (URL 63)

Creating an interior wide sight view for the occupants is one of the themes of integrating & simulating nature indoors. A huge *open floor plan* which is mainly used in the ground & second floors, as well as *medium books cabinets height* (around 170 cm), were used to accomplish the *Prospect* pattern in the library (Figure 60,61).

Figure 60: Library cabinets height; (URL 64)

Figure 61: Open second-floor plan; (URL 65)

According to what has been stated in *R/P* pattern in chapter 2 (Page 39-41), enhancing enjoyment responses, issue resolving skills, nosiness, and memory

refreshing are the main advantages of experiencing a controllable threat, therefore, creating a controllable threat tools in the library would be a valuable addition to the users' experience. Based on the *gravity resistant* two methods of risk design used in the library building are, firstly the second floor *cantilevered balcony* which provides access for the balcony users to experience the high height *controllable threat* (Figure 62). Secondly, the wooden design of the kids' area which might be confirmed the *R/P* pattern due to the accessibility to the different angled wooden slopes (Figure 63).

Figure 62: Cantilevered library balcony; (URL 66)

Figure 63: Kids collection area; (URL 67)

With reference to the theoretical part of the *Refuge* pattern (Page 35-37), reducing stress, restoration, and more benefits can be achieved through creating a readily accessible and safe space with limited visible sight within the same refuge area. Accordingly, the used *curved cave* reading area might be achieved this theme (Figure 64).

Figure 64: Curved refuge reading area; (URL 68)

Below table reflects the biophilic design employment in case study no.1, (Table 11)

Table 11: Oodi Helsinki Public Library Evaluation

		Patterns of Biophilic Design (*W. Browning et al., 2014*)													
		Nature in the Space							Natural Analogues			Nature of the Space			
		1. Visual Connection with Nature. **(VCN)**	2. Non-visual Connection with Nature. **(NVCN)**	3. Non-rhythmic Sensory Stimuli. **(NRSS)**	4. Access to Thermal & Airflow Variability. **(ATAV)**	5. Presence of Water. **(PW)**	6. Dynamic & Diffuse Light. **(DDL)**	7. Connection with Natural Systems. **(CNS)**	8. Biomorphic Forms & Patterns. **(BFP)**	9. Material Connection with Nature. **(MCN)**	10. Complexity & Order. **(CO)**	11. Prospect **(P)**	12. Refuge **(R)**	13. Mystery **(M)**	14. Risk/ Peril. **(R/P)**
Matching with 14 patterns literature			Weather sounds	Natural elements movements											Cantilevered balcony
Elements And Attributes To Biophilic Design (*S. Kellert, 2015*)	Direct Experience of Nature	Plants Weather Water Animals	Animals Water		Air Weather	Water	Light Fire	Natural landscape & systems							
	Indirect Experience of Nature	Images of nature			Simulating natural air	Images of nature	Simulating natural light	Age, change, and the patina of time (weather)	Neutral colors Naturalistic shapes & forms Evoking nature Biomimicry Natural geometries	Natural materials	Information richness Biomimicry			Biomimicry	
	Experience of Space and Place										Organized complexity	Prospect Transitional spaces Mobility and wayfinding	Refuge		
Biophilic Design Strategies (*A. Wilson, 2006*)	Building Design	Natural views Green roofs Interior landscape	Water		Connect interior to exterior Operable windows	Water	Daylight	Connect interior to exterior Natural views Green roofs	Organic forms		Complexity	Spaciousness	Refuge		
	Interior Design	Potted plants Nature views Configure interior spaces next to openings						Configure interior spaces next to openings		Natural materials Nature artwork					

Adapted by the author based on Browning et, al (2014), Kellert et al (2015), & A. Wilson (2006) approaches.

4.5.2 Case study no.2: KopGroep Bibliotheken (School 7)

Figure 65: School 7 exterior view; (URL 69)

A. Spatial and Functional Organization

The original design of School 7 building was prepared in 1903 by architect Kastelijn, and in 1905 school 7 building construction was completed. Since that time this building mainly has used for two main purposes, school & film house. In 2012 the real estate association of Den Helder bought the building and had adapted & renewed the building to be the new school 7 public library as it is today (Figure 66).


Figure 66: School 7 original building; (URL 70)

This building is considered a successful result of combining modernity and authenticity due to the conservation of the old building in addition to the additional building of the library which has been built around the characteristic school 7 (Figure 67).

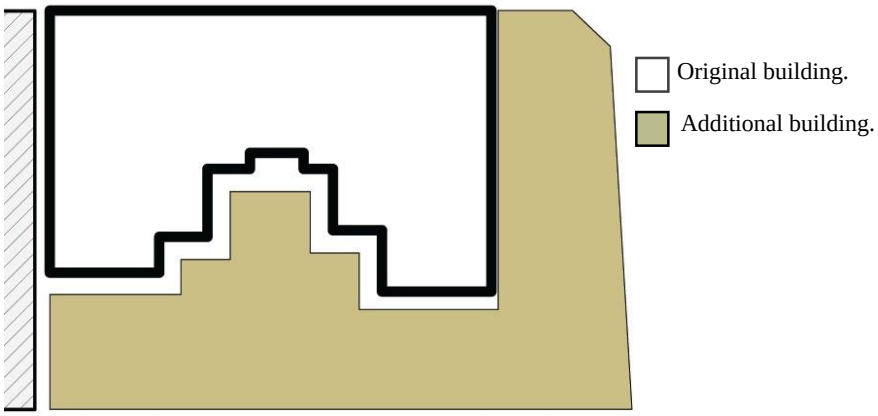


Figure 67: Schematic Plan of Original & additional building (URL 71)

Through reviewing plans & views, it can be considered that the library design has designed & adapted in a more intimate and active style. There are many different types of areas for sitting, reading, and working that were provided in various locations in between the cabinets. Moreover, it can be seen that the building restoration has maintained almost all the original school building structure including main halls, corridors, classrooms, and toilets walls, these different maintained interior spaces were modified and used in a way to meet the public library requirements. On the other hand, several visible bridges & staircases were constructed during the building restoration to connect the original and additional building floors to each other (Figure 68,69).

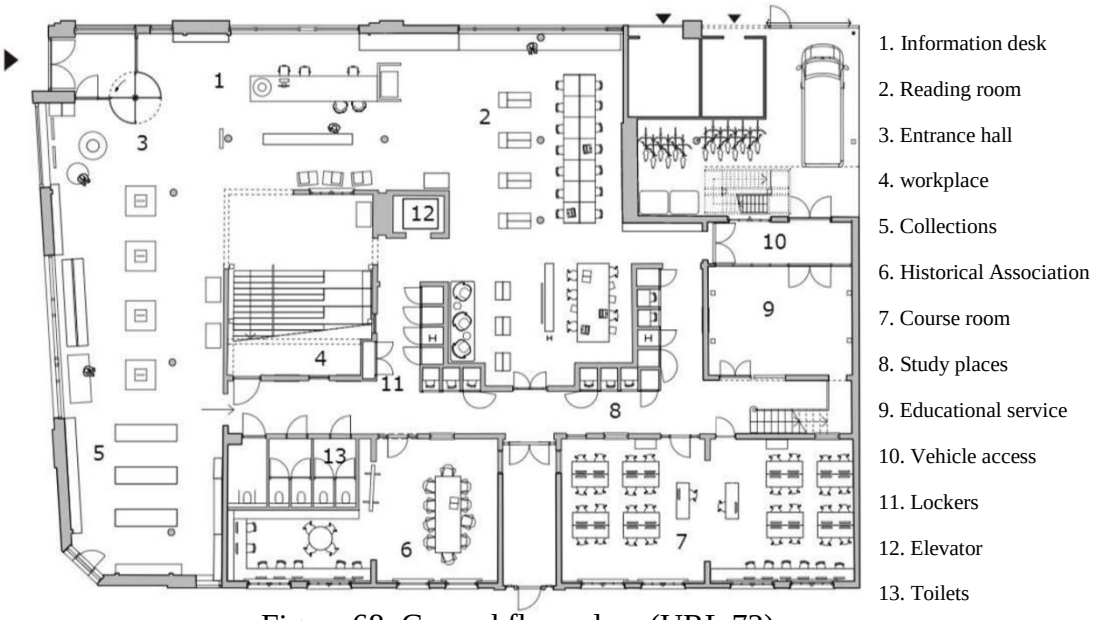


Figure 68: Ground floor plan; (URL 72)

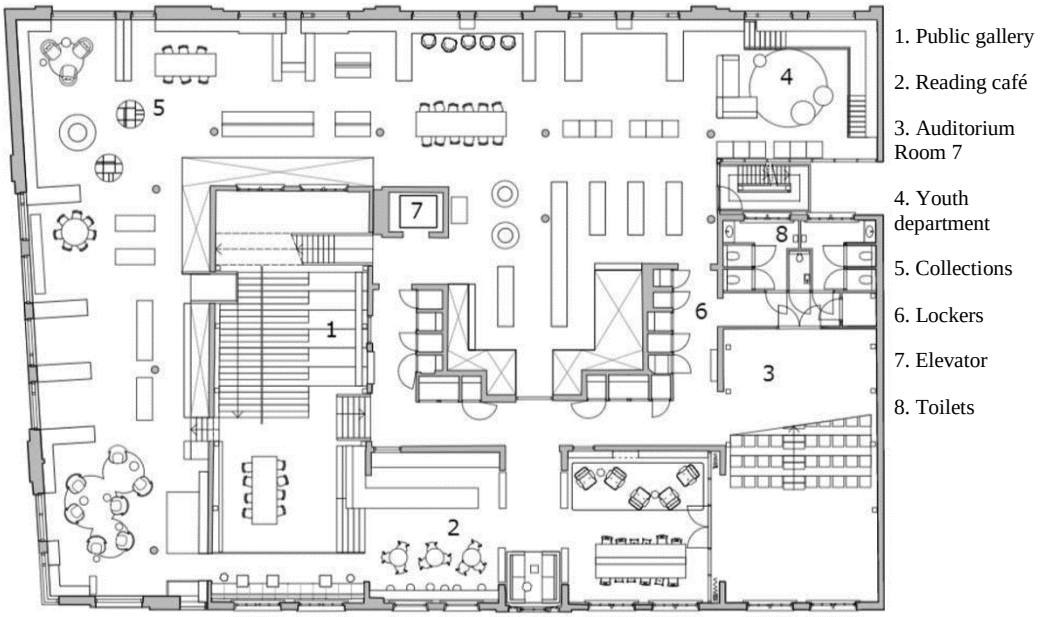


Figure 69: First-floor plan; (URL 73)

B. Biophilic design employment evaluation

Openings are an essential element in all building types, creating openings providing several benefits for the interior space's occupants. In this library, *tall openings* were provided in the majority of the facades. Through these openings, several biophilic design patterns were accomplished such as *VCN* & *CNS* patterns through providing

seating seats next to the outside weather & *natural systems views* which allow the library' occupants to *interact with natural landscape elements, weather, and weathering sounds* which achieving *NVCN* pattern as well, moreover, experiencing the *unpredictable outside weather & natural elements movements* reflect *NRSS* pattern (Figure 70).

Also, through these openings different patterns were simulated such as *dynamic & diffuse light* pattern since there is no doubt that the openings are one of the most preferred methods of providing *natural light* indoors, furthermore, feeling *natural temperature* via these openings is the only method can be considered as a simulation of *ATAV* pattern (Figure 70).

Figure 70: Openings, daylight access, natural views; (URL 74)

MCN pattern has obviously achieved by using the natural wood, *natural wood* is one of the main materials that was used in the library interior design, natural wood covers the majority of the public library furniture & elements such as books cabinets, the building's pitched roof, main library staircase, parquet flooring for some spaces, reading disks, and coffee tables as well (Figure 71). Moreover, using the *white color*

for the majority of the library wall painting is the only method reflecting the *BFP* pattern.

Figure 71: Natural material, wood; (URL 75)

As it has stated in chapter 2 (Page 33), one of the aims of biophilic design is to enhance human wellbeing & health through creating a good environment using different ways such as creating a nourishing & attractive visual space view, creating spaces & forms using a thoughtful repetitive symmetrical of geometries to create distinguished geometrical forms, volumes, and patterns is one of the concerned method. In school 7, two examples can be considered as *CO* pattern, the first one is the *parquet flooring pattern* in the reading cafe area (Figure 72).

The second example is the five staircases in addition to the small cantilevered terrace within the same volume, these five staircases are visible to each other within the same space with different locations & directions, it might reflect the idea behind the complexity and order through the viewer' first impression of the view, as well as, it reflects the idea behind the *Mystery* too (Figure 73).

Figure 72: Parquet pattern in reading café; (URL 76)

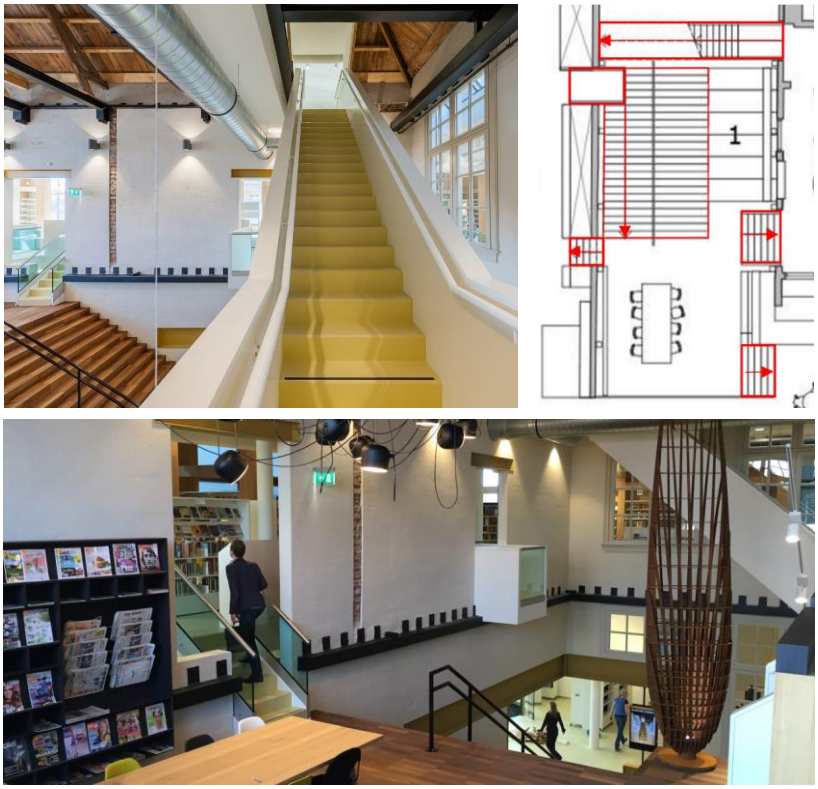


Figure 73: Two different views of the staircases & blow up detail plan; (URL 77)

Due to the conservation target during the building renovation, the majority of the old building walls kept as it is, therefore, these walls have prevented the merging between the old & new buildings of school 7 to create an open floor plan concept. Even though in some places of the library still meet the P*rospect* pattern concept in a limited way, it can be seen on the ground floor entrance lobby (Figure 74) & in the main corridors of the first-floor reading areas (Figure 75).

Figure 74: Ground floor entrance lobby & reading area; (URL 78)

Figure 75: First-floor areas; (URL 79)

On the other hand, because of the building conservation method, two different concepts of biophilic design were accomplished, conserving & converting the old building's toilets to reading nooks has achieved the *Refuge* pattern concept through providing a kind of *tiny protective studying* places for the library occupants (Figure 76).

Figure 76: Ground floor reading nooks & blow up detail plan; (URL 80)

Moreover, conserving the original building walls and materials might be enhancing the *CNS* pattern concept by allowing the library's users to feel and experience the *age* & *time changing* by the interaction with the old original materials such as the walls brick & old buildings wooden windows.

Figure 77: Original building materials, walls bricks & wooden windows; (URL 81)

Below table reflects the biophilic design employment in case study no.2, (Table 12)

Table 12: School 7 Public Library Evaluation

		Patterns of Biophilic Design (*W. Browning et al., 2014*)													
		Nature in the Space							Natural Analogues			Nature of the Space			
		1. Visual Connection with Nature. **(VCN)**	2. Non-visual Connection with Nature. **(NVCN)**	3. Non-rhythmic Sensory Stimuli. **(NRSS)**	4. Access to Thermal & Airflow Variability. **(ATAV)**	5. Presence of Water. **(PW)**	6. Dynamic & Diffuse Light. **(DDL)**	7. Connection with Natural Systems. **(CNS)**	8. Biomorphic Forms & Patterns. **(BFP)**	9. Material Connection with Nature. **(MCN)**	10. Complexity & Order. **(CO)**	11. Prospect **(P)**	12. Refuge **(R)**	13. Mystery **(M)**	14. Risk/ Peril. **(R/P)**
Matching with 14 patterns literature			Weather sounds	Natural elements movements	Temperature through glazing									Staircases	
Elements And Attributes To Biophilic Design (*S. Kellert, 2015*)	Direct Experience of Nature	Plants Weather Water Animals	Animals Water		Air Weather	Water	Light Fire	Natural landscape & systems							
	Indirect Experience of Nature	Images of nature			Simulating natural air	Images of nature	Simulating natural light	Age, change, and the patina of time (weather)	Neutral colors Naturalistic shapes & forms Evoking nature Natural geometries Biomimicry	Natural materials	Information richness Biomimicry			Biomimicry	
	Experience of Space and Place										Organized complexity	Prospect Transitional spaces Mobility and wayfinding	Refuge		
Biophilic Design Strategies (*A. Wilson, 2006*)	Building Design	Natural views Green roofs Interior landscape	Water		Connect interior to exterior Operable windows	Water	Daylight	Connect interior to exterior Natural views Green roofs	Organic forms		Complexity	Spaciousness	Refuge		
	Interior Design	Potted plants Nature views Configure interior spaces next to openings						Configure interior spaces next to openings		Natural materials Nature artwork					

Adapted by the author based on Browning et, al (2014), Kellert et al (2015), & A. Wilson (2006) approaches.

4.5.3 Case no.3: Dokk1 public library

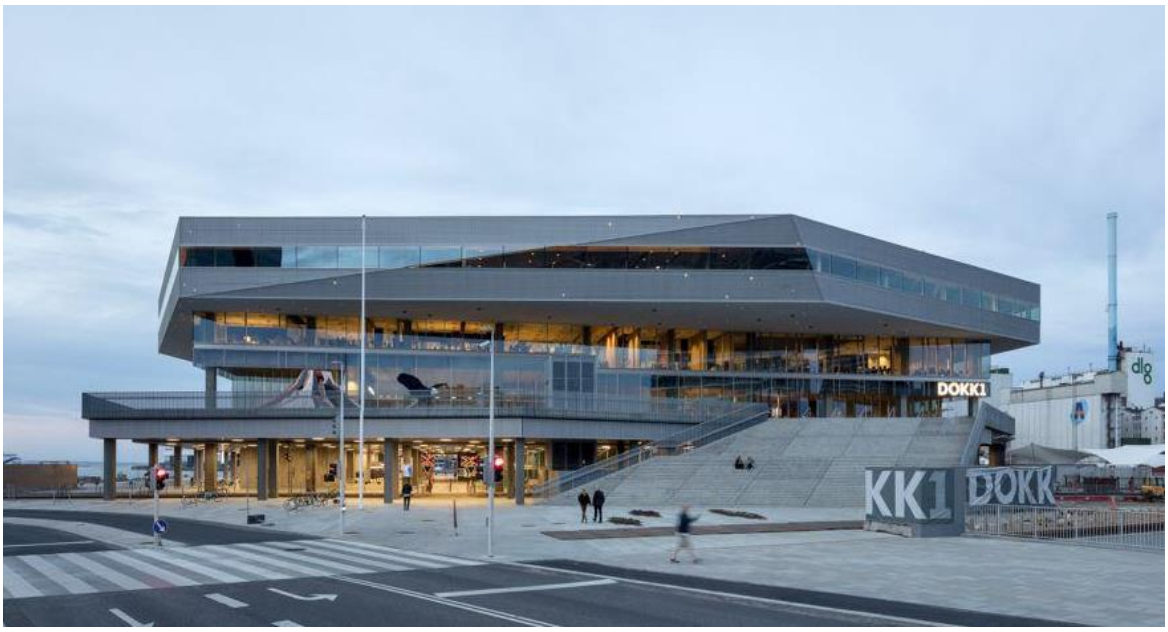
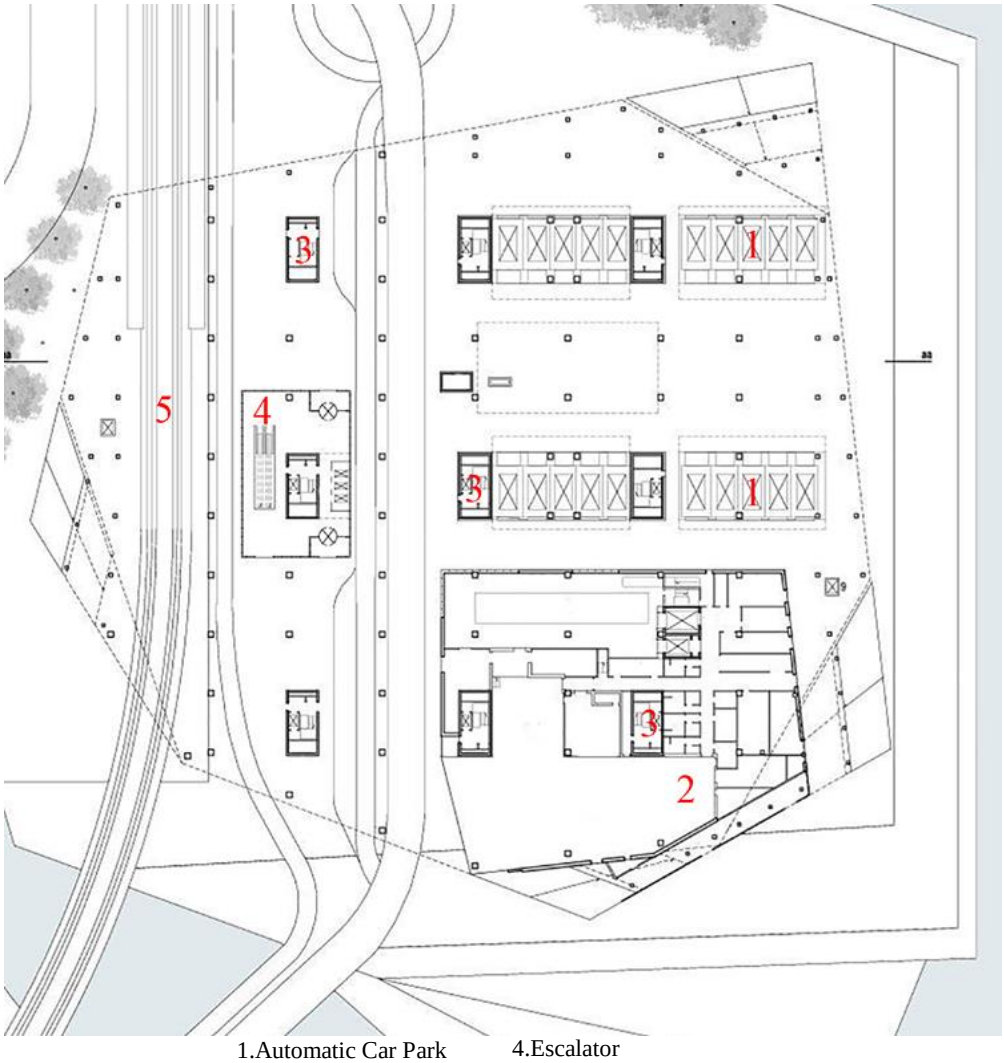


Figure 78: Dokk1 public library; (URL 82)

A. Spatial and Functional Organization

Dokk1 library building can be seen as the building of a ribbed layers with panoramic glassed facades. The panoramic glassed facades allowing the building's occupants to view the surrounded forest, sea, seaport, and city life. Dokk1 is considered a social center and the building of a multicultural purpose, it includes the public library which provides various several educational services and tools for the public for different ages, it also provides municipal services for citizens, and leased working spaces areas.

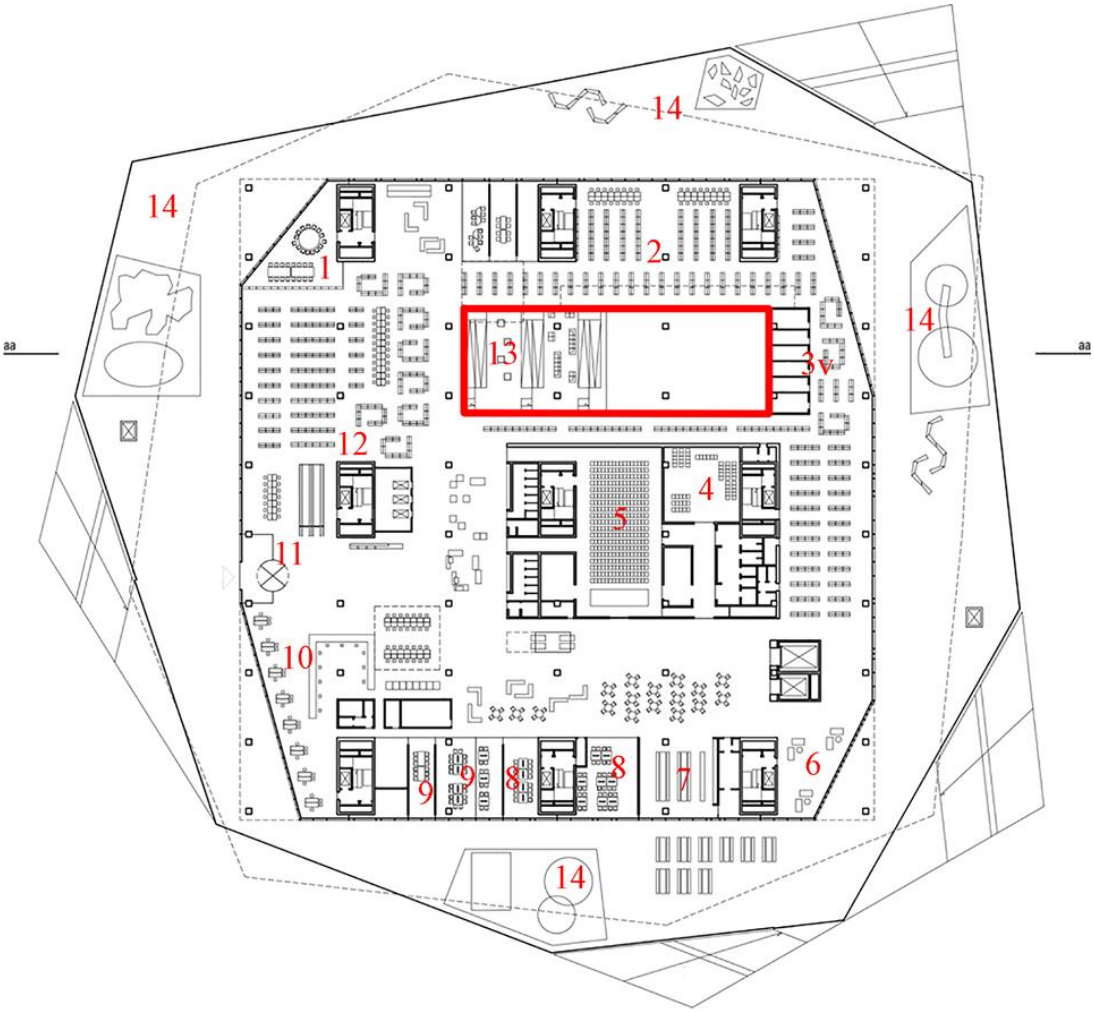
Dokk1 is a large public library building, it consists of four floors. The ground floor is used mainly for transportation means whether between the building floors by the staircases, escalator & elevators as well as for serving traffic accessibility to the library auto park.



1.Automatic Car Park
2.Goods-in
3.Lift and staircase
4.Escalator
5.Light Railway

Figure 79: Dokk1 ground floor plan; (URL 83)

Main public library` facilities in addition to other public services are located on the first and second floors were both are more likely open floor plans, and both floors are opened to each other by a wide concrete slope, this slope is divided into five different floor levels, each one has different public activity function: readings areas, interacting activities, events, children games, and exhibitions.



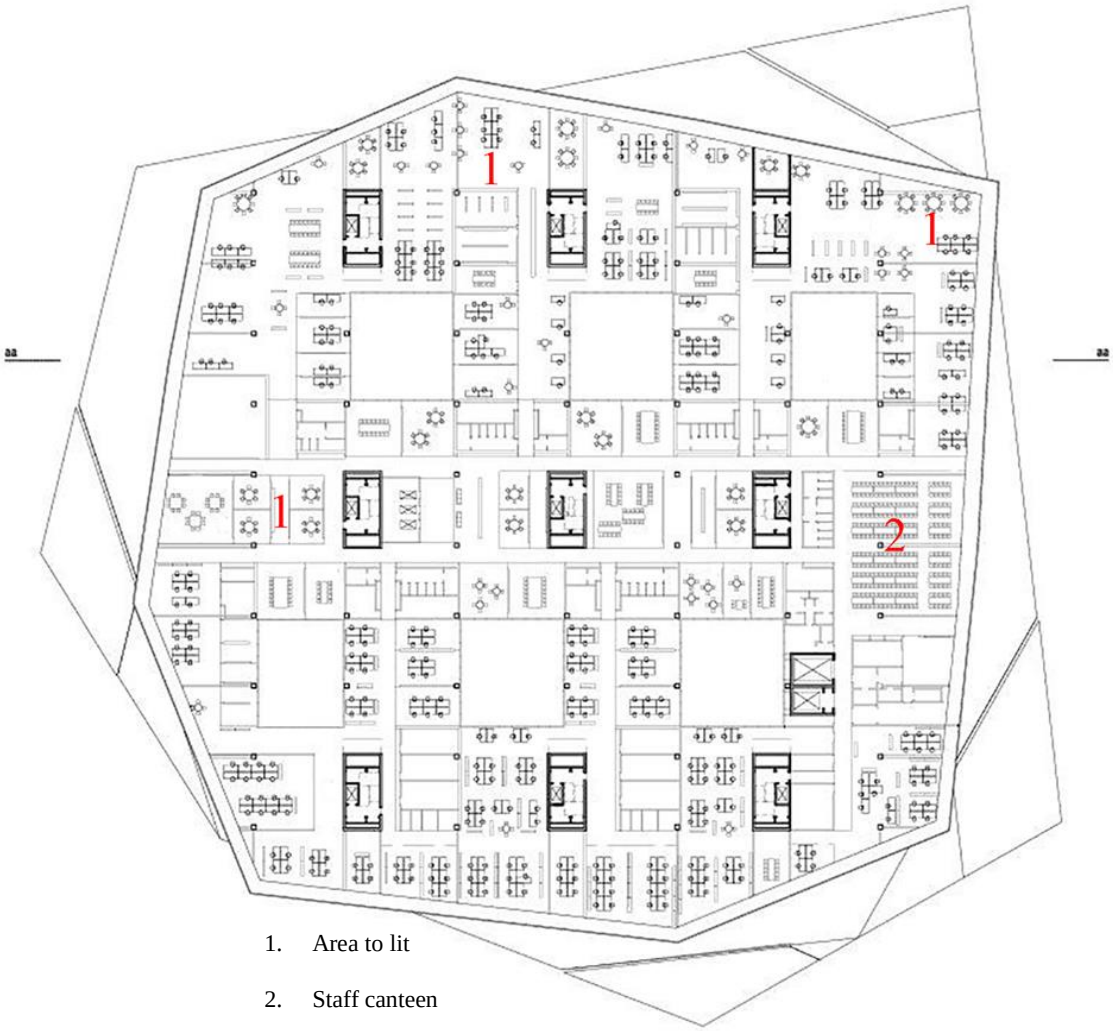
1.Reading Room	6.Setting Area	11.Main Entrance
2.Non-fiction collection	7.Cafe	12.Fiction collection
3.Study Rooms	8.Meeting room	13.The Ramp
4.Large Event hall	9.Teaching Rooms	14.The Playground
5.Small Event Hall	10.Citizens` Services	

Figure 80: Dokk1 First floor plan; (URL 84)

1.The Alley
2.The Gong
3.Eating Areas
4.Nursing Room
5.The Stage
6.The Family Lounge
7.Children's Lab
8.The Box
9.0-3 years
10.Gaming Street
11.Tweens Lab
12.Makerspace
13.Municipality offices

Figure 81: Dokk1 second-floor plan; (URL 85)

Whereas the third floor mainly contains different workspaces for rent, renting these multi-purpose spaces whether for working, studying and reading on the upper floor is providing the ability for the public to have a personal space within a public building to do their works while enjoying the panoramic glassed views.



1. Area to lit
2. Staff canteen

Figure 82: Dokk1 Third floor plan; (URL 86)

B. Biophilic design employment evaluation

As can be observed, Dokk1 building is designed with a *fully glassed elevations* and many *considerable skylights*, through these two important design elements numerous biophilic design patterns have achieved; several patterns have accomplished through different aspects such as providing *seating seats next to the full openings* which allowing the occupants to *view* & *interact* with the *weather*, surrounding *natural elements* life such as the near forest and that reflect *VCN* & *CNS* patterns. The existence of the *seawater* next to the library simulated *presence of water* pattern as

well. It also provides huge natural light access and that reverberates *DDL* pattern. On the other hand, *NRSS* pattern is achieved through the ability to view the *unpredictable outside movements* through these two elements. Moreover, *NVCN* pattern achieved through the outside *weathering sounds* including *sea waves sounds* (Figure 83).

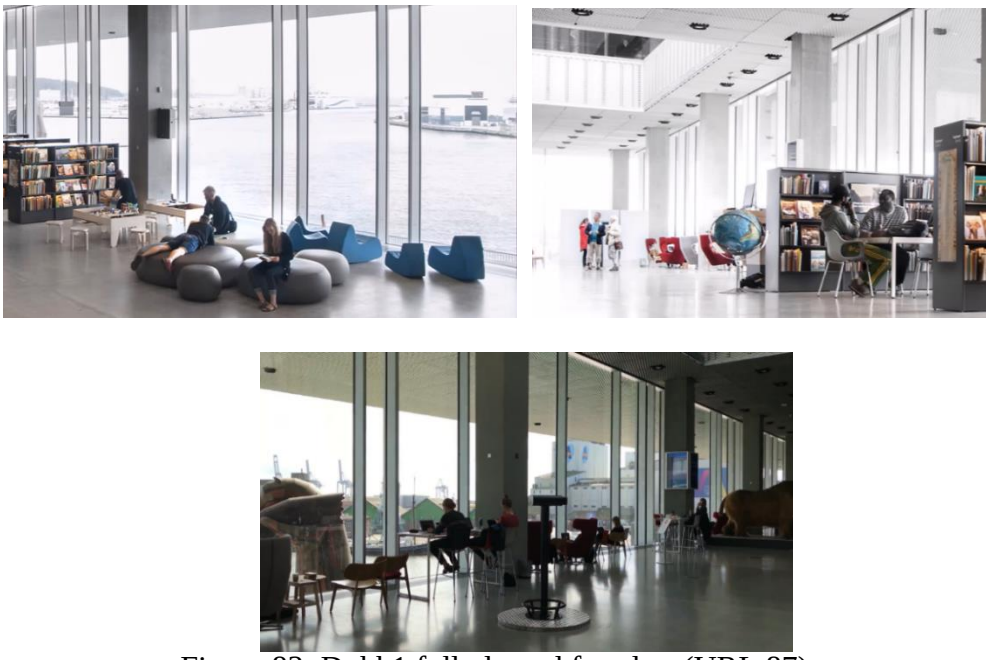


Figure 83: Dokk1 full glassed facades; (URL 87)

Figure 84: Dokk1 skylights; (URL 88)

The first-floor large balcony contains the children playground (as shown on the first-floor plan, Figure 85) is a proper design element that *connects interior spaces to the exterior* and that confirmed *CNS* & *ATAV* patterns; this considerable balcony increases the building value by providing easy access for outside to *interact with natural systems* such as the *airflow*, and *weather temperature & humidity* changes which confirmed *ATAV* pattern (Figure 85).

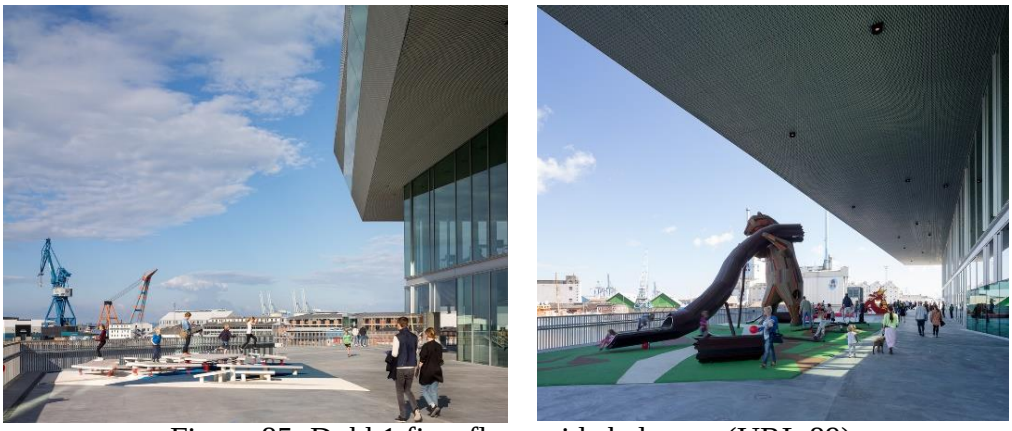
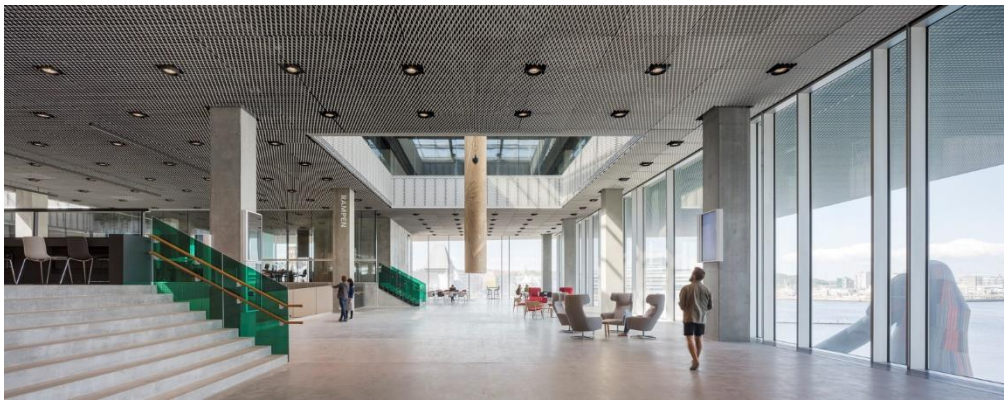


Figure 85: Dokk1 first-floor wide balcony; (URL 89)

Dokk1 building offers several types of *open floor areas*, especially on the first and second floors, the ramp used, which connects the first floor to the second floor and the *height skylights cavity* are also contributing to enlarge these open-floor areas. These methods offering the users the ability to discover different interior spaces from the same point of view and accordingly that confirmed the *Prospect* pattern (Figure 86).

Figure 86: The ramp platforms open area; (URL 90)



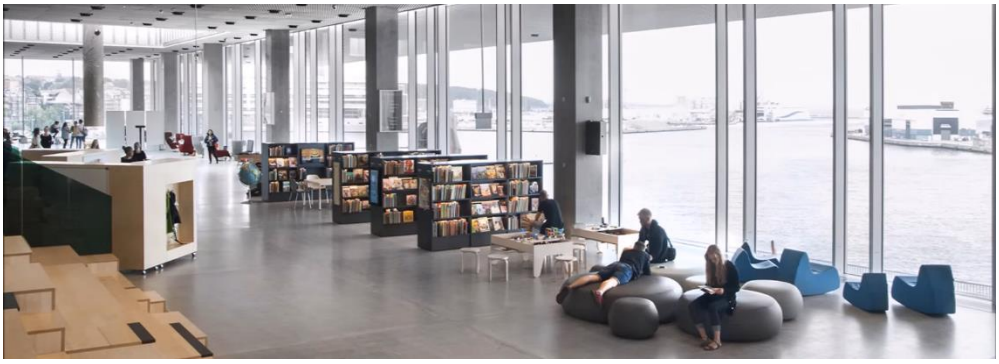


Figure 87: Reading & setting open areas; (URL 91)

In terms of *MCN* pattern, *natural wood* has used in Dokk1 in a limited way while the robust materials were covering the majority of the building. Natural wood was used in specific furniture such as some seating areas, and as walls covering (Figure 88).

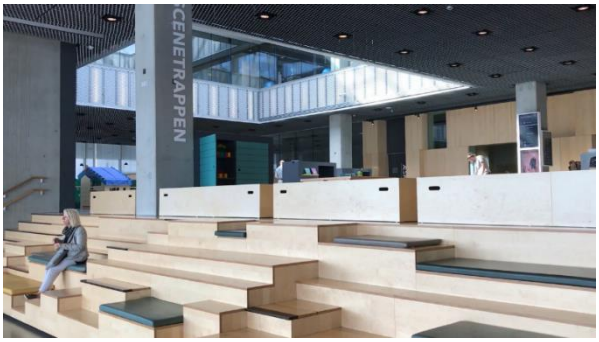


Figure 88: Natural wood usage; (URL 92)

On the other hand, providing *separate small study rooms* (as shown in the first-floor plan, point no.3, Figure 80), as well as the rentable small work areas on the third floor within a huge open floor area building such as Dokk1, responds the concept of the *Refuge* pattern.

Below table reflects the biophilic design employment in case study no.3, (Table 13)

Table 13: Dokk1 Public Library Evaluation

		Patterns of Biophilic Design (*W. Browning et al., 2014*)													
		Nature in the Space							Natural Analogues			Nature of the Space			
		1. Visual Connection with Nature. **(VCN)**	2. Non-visual Connection with Nature. **(NVCN)**	3. Non-rhythmic Sensory Stimuli. **(NRSS)**	4. Access to Thermal & Airflow Variability. **(ATAV)**	5. Presence of Water. **(PW)**	6. Dynamic & Diffuse Light. **(DDL)**	7. Connection with Natural Systems. **(CNS)**	8. Biomorphic Forms & Patterns. **(BFP)**	9. Material Connection with Nature. **(MCN)**	10. Complexity & Order. **(CO)**	11. Prospect **(P)**	12. Refuge **(R)**	13. Mystery **(M)**	14. Risk/ Peril. **(R/P)**
Matching with 14 patterns literature			Weather sounds	Natural elements movements											
Elements And Attributes To Biophilic Design (*S. Kellert, 2015*)	Direct Experience of Nature	Plants Weather Water Animals	Animals Water		Air Weather	Water	Light Fire	Natural landscape & systems							
	Indirect Experience of Nature	Images of nature			Simulating natural air	Images of nature	Simulating natural light	Age, change, and the patina of time (weather)	Neutral colors Naturalistic shapes & forms Evoking nature Natural geometries Biomimicry	Natural materials	Information richness Biomimicry			Biomimicry	
	Experience of Space and Place										Organized complexity	Prospect Transitional spaces Mobility and wayfinding	Refuge		
Biophilic Design Strategies (*A. Wilson, 2006*)	Building Design	Natural views Green roofs Interior landscape	Water		Connect interior to exterior Operable windows	Water	Daylight	Connect interior to exterior Natural views Green roofs	Organic forms		Complexity	Spaciousness	Refuge		
	Interior Design	Potted plants Nature views Configure interior spaces next to openings						Configure interior spaces next to openings		Natural materials Nature artwork					

Adapted by the author based on Browning et, al (2014), Kellert et al (2015), & A. Wilson (2006) approaches.

4.5.4 Case no.4: Kista public library

Figure 89: Kista Shopping mall- Kista public library; (URL 93)

A. Spatial and Functional Organization

Kista public library is the smallest library among the five winners of IFLA award, it is also restricted within the second floor of the city mall building; it is designed as an open floor area with the minimum requirements of internal walls. The open floor area contains different opened zones functions such as reading, learning, digital, setting, and children creation zones.

These various zones were provided to meet different activities & needs such as the computer area, 40-person capacity stage, and 50-person capacity lecture hall. The learning zone provides 20 rooms with different interior designs for each to meet the users' need, three rooms are available for free while the other seventeen are for rent. Moreover, this library provides a special space for children, this space includes the

colorful reading & games areas, and the black box which is a sound-proof movie watching room.

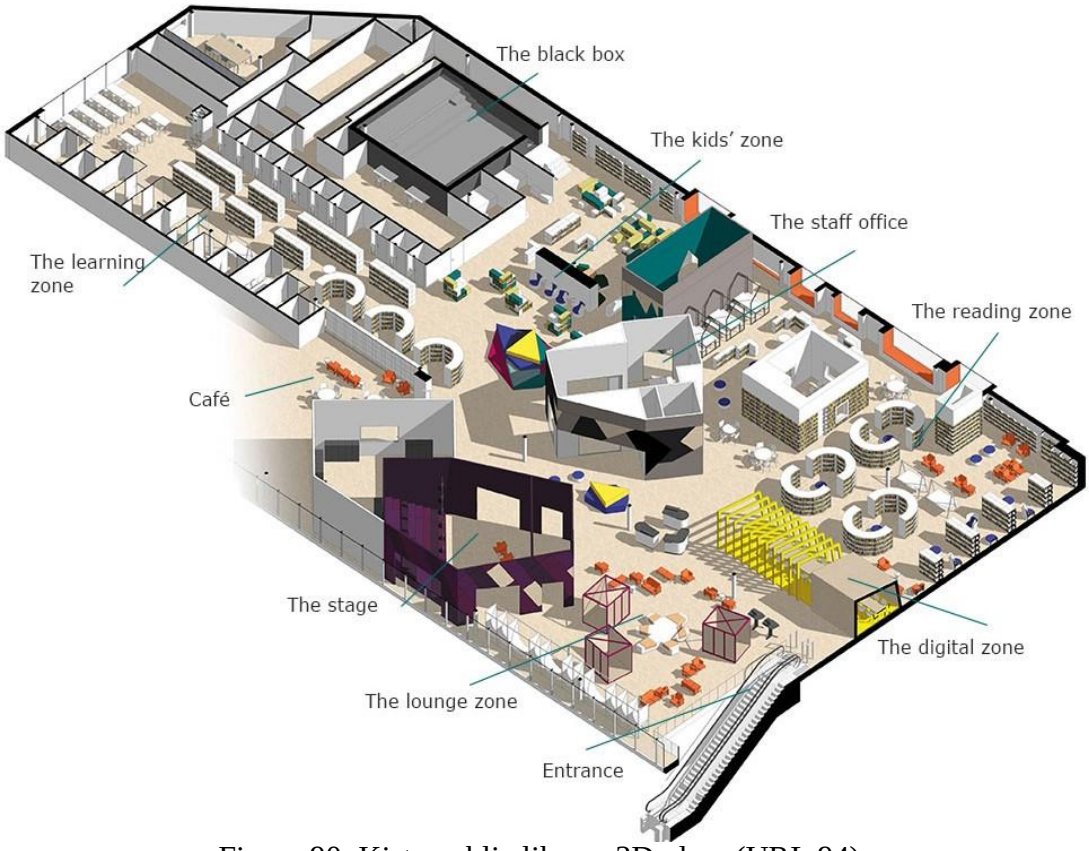


Figure 90: Kista public library 3D plan; (URL 94)

B. Biophilic design employment evaluation

Although Kista library is restricted on the second floor of the city mall building, it has achieved some of the biophilic design methods. A large skylight and limited openings in specific areas were used in the library, through these two elements; several of the biophilic design methods were limitedly accomplished. The *skylight* and the *limited openings* are considered as the only source of the *natural light* for the library and that accomplished the *DDL* pattern. Moreover, the skylight & openings have achieved *VCN* & *CNS* patterns through providing *seating areas next to the openings* which allow the users to watch the *natural views*, *interact with landscapes & natural systems* and

weather proprieties such as the weathering sounds which achieved *NVCN* pattern too. On the other hand, *non-rhythmic sensory stimuli* pattern has achieved through viewing the outside *unpredictable movements* (Figure 91, 92).

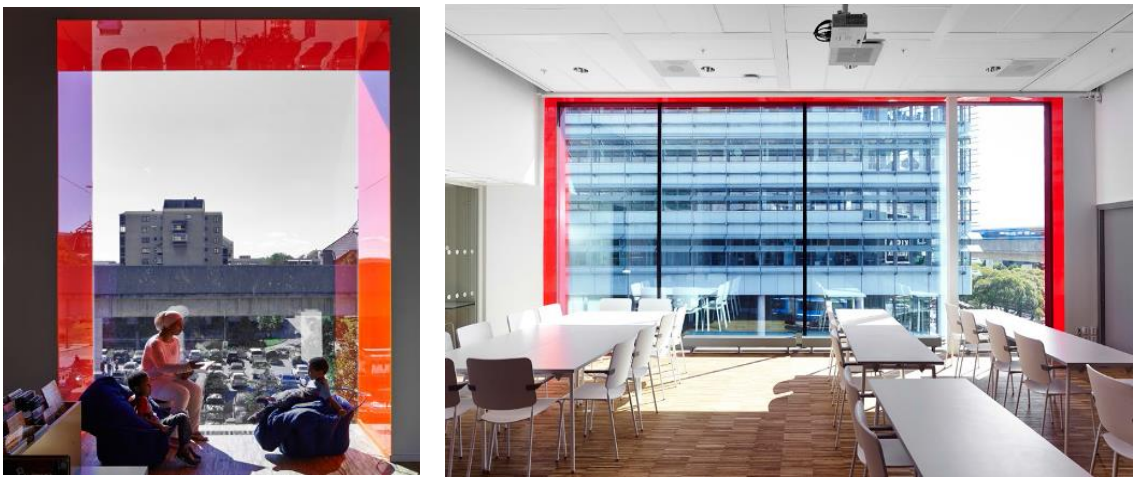


Figure 91: Library openings; (URL 95)

Figure 92: The large skylight; (URL 96)

Prospect pattern has been accomplished limitedly in the entrance looby & main reading zone due to the limited library area with various facilities (Figure 95). Providing different *tiny and sheltered reading areas* such as the *bay window seats*, *hanging chairs*, and *small rentable study rooms* are enhancing the protection feeling

within the wide-open public floor which reflects the idea behind the *Refuge* pattern (Figure 93,94).

Figure 93: Bay window seats, hanging chairs; (URL 97)

Figure 94: Rentable small study rooms; (URL 98)

In terms of *MCN* pattern, *natural wood* used in the majority of the library design and furniture, it was used for the book cabinets, chairs, tables as well as for the entire library flooring parquet (Figure 95). Furthermore, using the *white color* for the majority of the internal library walls and ceilings is the only simulated method of the *BFP* pattern.

On the other hand, and based on what has remarked in the literature review (Page 33), the *visible mechanical* types of equipment in between the false ceilings such as the different sizes of pipes, wires, and the AC 4-way cassettes might reverberate the idea of the *CO* pattern, moreover, *ATAV* pattern has accomplished through two different aspects, first one is the visibility of these types of equipment which may boost the active & refreshing feelings especially it shows the *fresh air mechanism*, the second is the accessible weather *temperature* through the library skylights and openings (Figure 96).

Figure 95: Natural material, wood; (URL 99)

Figure 96: Visible mechanical equipment; (URL 100)

Below reflects the biophilic design employment in case study no.4, (Table 14)

Table 14: Kista Public Library Evaluation

		Patterns of Biophilic Design (*W. Browning et al., 2014*)													
		Nature in the Space							Natural Analogues			Nature of the Space			
		1. Visual Connection with Nature. **(VCN)**	2. Non-visual Connection with Nature. **(NVCN)**	3. Non-rhythmic Sensory Stimuli. **(NRSS)**	4. Access to Thermal & Airflow Variability. **(ATAV)**	5. Presence of Water. **(PW)**	6. Dynamic & Diffuse Light. **(DDL)**	7. Connection with Natural Systems. **(CNS)**	8. Biomorphic Forms & Patterns. **(BFP)**	9. Material Connection with Nature. **(MCN)**	10. Complexity & Order. **(CO)**	11. Prospect **(P)**	12. Refuge **(R)**	13. Mystery **(M)**	14. Risk/ Peril. **(R/P)**
Matching with 14 patterns literature			Weather sounds	Natural elements movements	Temperature through glazing										
Elements And Attributes To Biophilic Design (*S. Kellert, 2015*)	Direct Experience of Nature	Plants Weather Water Animals	Animals Water		Air Weather	Water	Light Fire	Natural landscape & systems							
	Indirect Experience of Nature	Images of nature			Simulating natural air	Images of nature	Simulating natural light	Age, change, and the patina of time (weather)	Neutral colors Naturalistic shapes & forms Evoking nature Natural geometries Biomimicry	Natural materials	Information richness Biomimicry			Biomimicry	
	Experience of Space and Place										Organized complexity	Prospect Transitional spaces Mobility and wayfinding	Refuge		
Biophilic Design Strategies (*A. Wilson, 2006*)	Building Design	Natural views Green roofs Interior landscape	Water		Connect interior to exterior Operable windows	Water	Daylight	Connect interior to exterior Natural views Green roofs	Organic forms		Complexity	Spaciousness	Refuge		
	Interior Design	Potted plants Nature views Configure interior spaces next to openings						Configure interior spaces next to openings		Natural materials Nature artwork					

Adapted by the author based on Browning et, al (2014), Kellert et al (2015), & A. Wilson (2006) approaches.

4.5.5 Case study no.5: Craigieburn public library

Figure 97: Craigieburn public library; (URL 105)

A. Spatial and Functional Organization

Craigieburn library building consists of two floors, it is designed as overlapping pavilions. Each pavilion has a different size and height as well. In front of each pavilion from the northern side, there is a directional louvered roof that connects between the building and the landscape as well as it protects the full glassed facades from the high sun rays' temperature. Many public events used to be done such as bazaar and music functions under these louvered sunshades.

All library facilities are connected to each other through the T shape entrance main lobby. Double height volume is provided on the northern side of the main reading area. Craigieburn Library provides spaces for different functions/facilities along with the

basic library main services such as public art hall, computer teaching room, childcare area, meetings room, and large events hall.

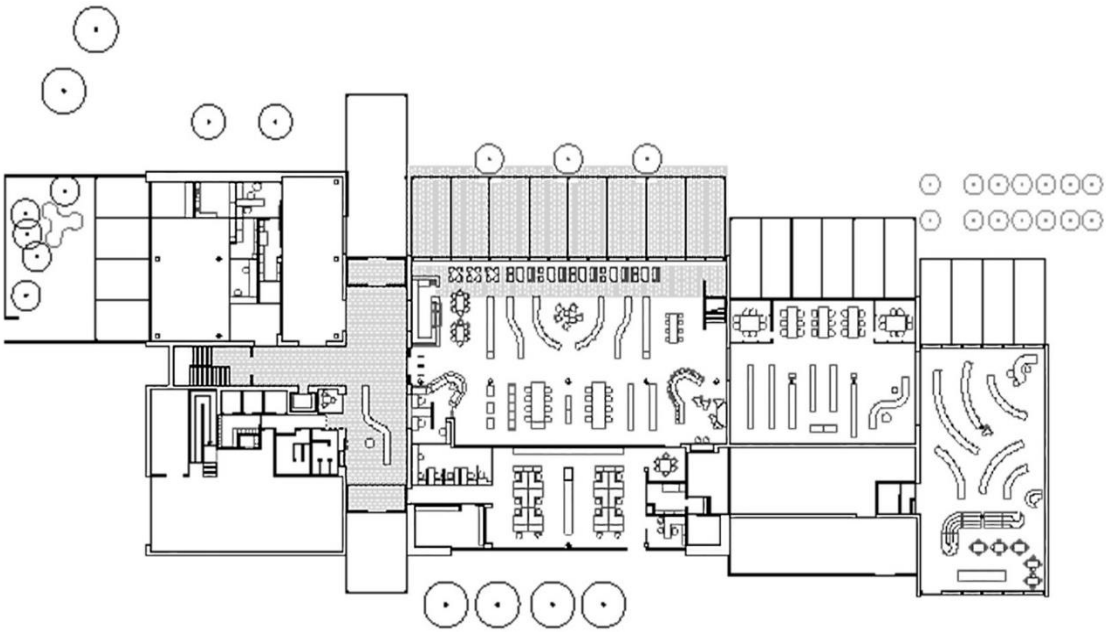


Figure 98: Library building ground floor; (URL 106)

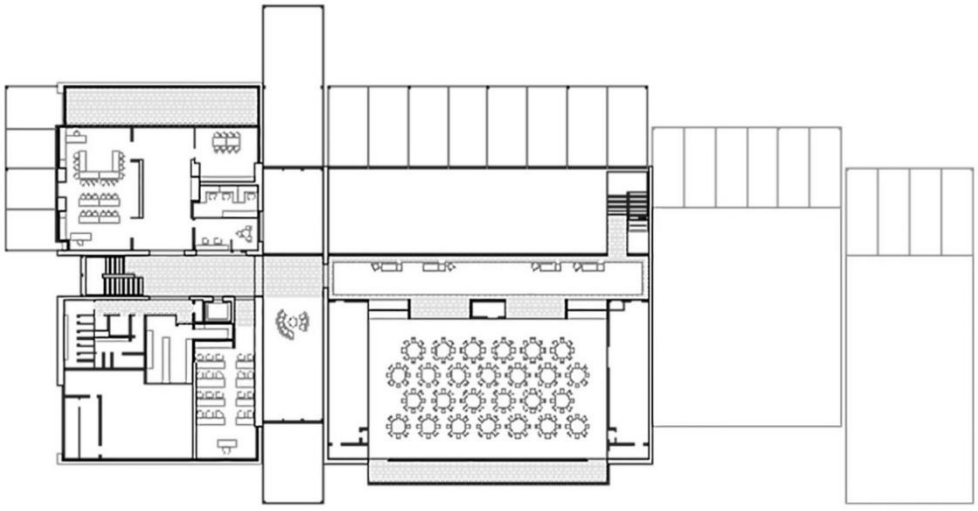


Figure 99: Library building first floor; (URL 107)

B. Biophilic design employment evaluation

Since the library constructed from an intersected overlapping pavilions, the *open floor plan* pattern method has achieved limitedly within the main three reading halls,

moreover, using clear glassed partitions in the first-floor corridor & for the closed studying rooms in the ground-floor enlarges the viewer's focal length distance which support the *Prospect* pattern concept (Figure 100, 101). On the other hand, natural materials have been used variously, *natural sandstone* used for the majority of the internal walls and the roofs as well, and the *natural wood* used mainly for the book cabinets and that achieved the *MCN* pattern. In terms of *BFP* pattern, the limited usage of white color can be considered the only simulated used method (Figure100, 101).

Figure 100: Northern reading area, first-floor transparent partition; (URL 108)

Figure 101: Closed reading rooms, transparent partitions; (URL 109)

Multiple methods have been used to enhance the connection between interior and exterior; it can be seen from different aspects such as the preferred natural materials,

and full windows. Moreover, the continuity of the flooring pavement & the wooden louvered gazebo in parallel from the outside landscape area until the interior northern linear seating area is also improving the connection idea (Figure 102, 103).

In addition to the liner louvered *skylight* (Figure 102, 103), the *double-height windows* on the northern side are obviously the main considered tool in the library to connect between the interior and exterior. Through this strong connection, several patterns have accomplished such as the *DDL* pattern by the *natural light* huge access. *VCN* & *CNS* patterns has achieved through *providing liner seating area next to the glazed elevation*, the *natural wide views* which allow the users to interact with the *weather* changing.

On the other hand, *NVCN* pattern achieved by the *outdoors* & *weathering sounds*. *NRSS* pattern has achieved through viewing the *outdoors natural elements movements* besides the *changeable movements of the sun shades* above the liner reading area which affected by the gazebo` slots (Figure 103). The employment of *ATAV* pattern observed through the accessible *outdoors temperature* through the glazed facades.

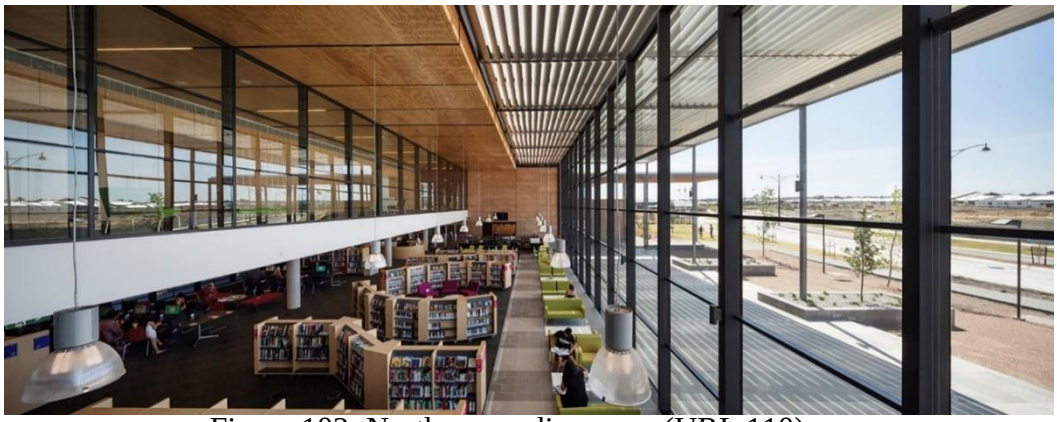


Figure 102: Northern reading area; (URL 110)

Figure 103: Northern reading area, Sun rays' movement through the louvered canopy; (URL 111)

Below table reflects the biophilic design employment in case study no.5, (Table 15)

Table 15: Craigieburn Public Library Evaluation

		Patterns of Biophilic Design (*W. Browning et al., 2014*)													
		Nature in the Space							Natural Analogues			Nature of the Space			
		1. Visual Connection with Nature. **(VCN)**	2. Non-visual Connection with Nature. **(NVCN)**	3. Non-rhythmic Sensory Stimuli. **(NRSS)**	4. Access to Thermal & Airflow Variability. **(ATAV)**	5. Presence of Water. **(PW)**	6. Dynamic & Diffuse Light. **(DDL)**	7. Connection with Natural Systems. **(CNS)**	8. Biomorphic Forms & Patterns. **(BFP)**	9. Material Connection with Nature. **(MCN)**	10. Complexity & Order. **(CO)**	11. Prospect **(P)**	12. Refuge **(R)**	13. Mystery **(M)**	14. Risk/ Peril. **(R/P)**
Matching with 14 patterns literature			Weather sounds	Natural elements movements	Temperature through glazing										
Elements And Attributes To Biophilic Design (*S. Kellert, 2015*)	Direct Experience of Nature	Plants Weather Water Animals	Animals Water		Air Weather	Water	Light Fire	Natural landscape & systems							
	Indirect Experience of Nature	Images of nature			Simulating natural air	Images of nature	Simulating natural light	Age, change, and the patina of time (weather)	Neutral colors Naturalistic shapes & forms Evoking nature Natural geometries Biomimicry	Natural materials	Information richness Biomimicry			Biomimicry	
	Experience of Space and Place										Organized complexity	Prospect Transitional spaces Mobility and wayfinding	Refuge		
Biophilic Design Strategies (*A. Wilson, 2006*)	Building Design	Natural views Green roofs Interior landscape	Water		Connect interior to exterior Operable windows	Water	Daylight	Connect interior to exterior Natural views Green roofs	Organic forms		Complexity	Spaciousness	Refuge		
	Interior Design	Potted plants Nature views Configure interior spaces next to openings						Configure interior spaces next to openings		Natural materials Nature artwork					

Adapted by the author based on Browning et, al (2014), Kellert et al (2015), & A. Wilson (2006) approaches.

4.5.6 Chapter Conclusion

Through this chapter, an evaluation has been made for the selected study's five cases, these five cases were selected because they are the only winners (till now) of the yearly IFLA competition as the best public library in the world. The evaluation of thesis has been done in terms of the biophilic design utilization in these public libraries separately according to the generated framework, the study's framework is created after reviewing the literature of most three common biophilic design approaches, each one of these three approaches has different method of producing the biophilic design and thus they were categorized according to the similarities between them parallel with the 14 pattern approach. Accordingly, an evaluative framework has been provided after each case of the study showing the biophilic design investment status for the next chapter results concluding.

After delving into exploring the biophilic design integration into the five study cases' interior spaces, it has been observed that each one of these public libraries has been dealt with biophilic design by utilizing different patterns' concepts. Some of the patterns were achieved in all cases through offering particular concepts such as *natural light & natural views, open floor plans,* and *providing closed tiny reading spaces,* whereas there are other several concepts that scarcely used such as the *presence of water*, *potted plants*, and using *naturalistic forms & shapes.* Moreover, there are other concepts that which not seen at all such as *green roofs* and *natural artworks.* In the next chapter, the results of these cases investigation would be openly discussed, summarized, and evaluated.

Chapter 5

DISCUSSION OF THE FINDINGS

5.1 Introduction

In chapter four, a thorough exploration analysis has been completed on the five selected study' cases, these five cases are the only winners of the IFLA “International Federation of Library Associations and Institutions” yearly competition for the best public library of the year around the world. They were selected in accordance with the aim of this study in order to respond the research question: ‘How biophilic design can be integrated into the public library’s interior spaces?’ This explorative analytical approach has been utilized separately for each case based on the procreated study framework, in the prior chapter; following each case an evaluative framework has been provided that summarizes the exploration analysis. In this chapter, a discussion of the entire analysis would be summarized and clarified in order to produce a comprehensive evaluation of the biophilic design overall utilization techniques in the interior spaces of the selected cases.

The framework has been created by combining & classifying three of biophilic design approaches, these approaches were selected due to their realized popularity (Ojamaa, 2015), each one of these approaches is presenting the subject from a different point of view. Consequently, the combining and classification process was done based on the similarities between the three approaches. And that process has been done in terms of

the 14 patterns approach; since it has been realized that it's the most comprehensive approach.

5.2 Criteria Clarifications

As a result of the combining & classification process of the framework (Table 9, page 59), and referring to the evaluated five study cases frameworks (Tables 7, 8, 9, 10 &11) that have been mentioned among the previous chapter, in line with the next figure (Figure 104, page 107), below are the two points that have been observed and need to be clarified prior to moving to the findings of the study:

Through the evaluation of the framework of the study cases, it can be observed that the concepts that have been achieved are reflected in two ways:

1) First, the concept that was achieved and reflected on the units of the attributes and strategies approaches, see Figure 108, region no. A-1.
2) While secondly the concepts are achieved and reflected in the pattern while not reflecting at the units of the attributes and strategies, but are realized in the pattern that was mentioned in the literature review. Accordingly, based on the section of the prior point, the concepts that have been achieved through the patterns concepts derived from its literature, these derived concepts were mentioned and clarified in the yellow row below the 14 patterns row in each case evaluative framework, see Figure 108, region no. A-2.

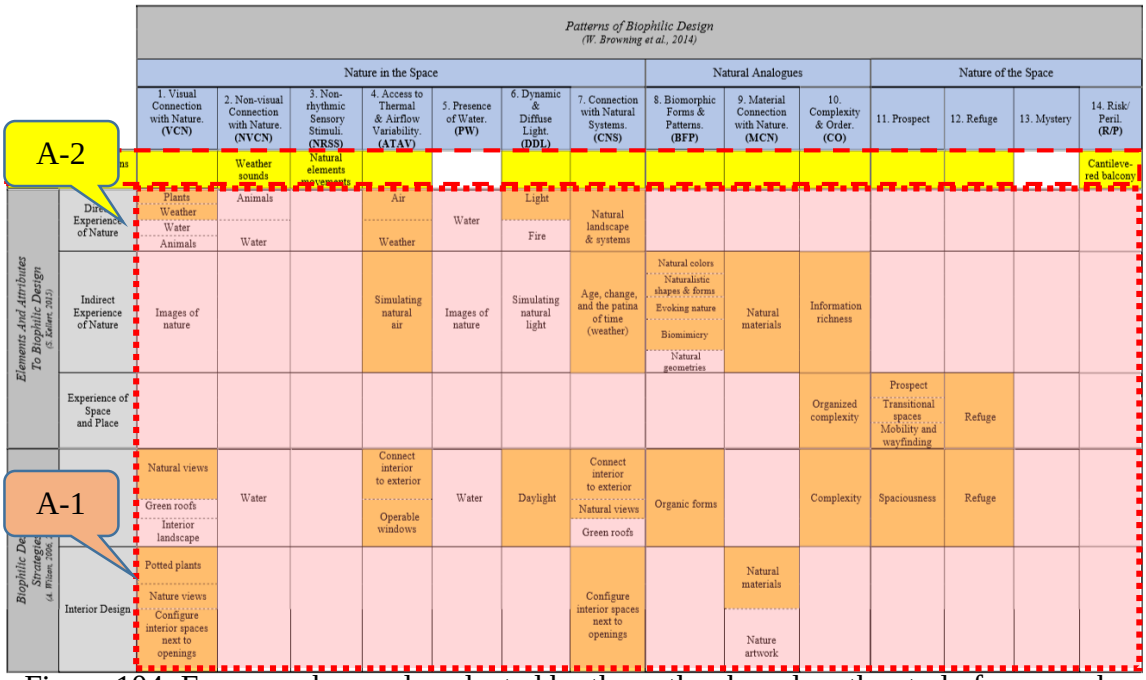


Figure 104: Framework sample, adapted by the author based on the study framework.

Below are the two summarized study cases evaluation, first table (Table 16) is based on achieving the three biophilic design approaches concepts. While the second summarized table (Table 17) is concerned with the 14 patterns and its concepts (attributes & strategies) usage. These two summarized tables show an evaluative analysis that summarizing the five cases' evaluative frameworks that would be employed to clarify the executed biophilic design into the public libraries' interior spaces.

Table 16: Summarized study cases evaluation, based on achieving the three biophilic design approaches concepts.

	1. Visual Connection with Nature. **(VCN)**	2. Non-visual Connection with Nature. **(NVCN)**	3. Non-rhythmic Sensory Stimuli. **(NRSS)**	4. Access to Thermal & Airflow Variability. **(ATAV)**	5. Presence of Water. **(PW)**	6. Dynamic & Diffuse Light. **(DDL)**	7. Connection with Natural Systems. **(CNS)**	8. Biomorphic Forms & Patterns. **(BFP)**	9. Material Connection with Nature. **(MCN)**	10. Complexity & Order. **(CO)**	11. Prospect **(P)**	12. Refuge **(R)**	13. Mystery **(M)**	14. Risk/ Peril. **(R/P)**
Case no.1 Oodi Helsinki Library		Weather sounds	Natural elements movements											Cantileve-red balcony
Case no.2 School 7 Library		Weather sounds	Natural elements movements	Temperature through glazing									Staircases	
Case no.3 Dokk1 Library			Natural elements movements											
Case no.4 Kista Library		Weather sounds	Natural elements movements	Temperature through glazing										
Case no.5 Craigieburn Library		Weather sounds	Natural elements movements	Temperature through glazing										

Adapted by the author based on Browning et, al (2014), Kellert et al (2015), & A. Wilson (2006) approaches

Key elements

Achieved according to all of the three approaches.

Achieved based on only the “14 patterns approach” database

Not applicable

Table 17: Summarized study cases evaluation, based on the biophilic design patterns usage.

	1. Visual Connection with Nature. (VCN)	2. Non-visual Connection with Nature. (NVCN)	3. Non-rhythmic Sensory Stimuli. (NRSS)	4. Access to Thermal & Airflow Variability. (ATAV)	5. Presence of Water. (PW)	6. Dynamic & Diffuse Light. (DDL)	7. Connection with Natural Systems. (CNS)	8. Biomorphic Forms & Patterns. (BFP)	9. Material Connection with Nature. (MCN)	10. Complexity & Order. (CO)	11. Prospect	12. Refuge	13. Mystery	14. Risk/ Peril. (R/P)
Case no.1 Oodi Helsinki Library														
Case no.2 School 7 Library														
Case no.3 Dokk1 Library														
Case no.4 Kista Library														
Case no.5 Craigieburn Library														

Adapted by the author based on Browning et, al (2014), Kellert et al (2015), & A. Wilson (2006) approaches

The commonly seen patterns.

Patterns that have been achieved by a minimum number of concepts.

Rarely achieved patterns.

5.3 Findings

Based on the previously mentioned evaluative frameworks of the five study cases as well as, the summarized study cases evaluation tables (Table 16, 17), this study finding is based on the observability of the framework patterns, the findings would be produced into two sections as the first section is based on the patterns usage in the study cases aspects, while the second sections based on achieving a number of patterns by using some specific interior design elements.

A- Patterns usage three aspects:

1- The commonly seen patterns.

2- Patterns that have been achieved by a minimum number of concepts.

3- Rarely used patterns.

1) The commonly seen patterns:

Through reviewing the exploration evaluations of the libraries, it was observed that there are nine patterns (patterns no. 1, 2, 3, 4, 6, 7, 9, 11 & 12) that were seen in all of the study cases as these nine patterns have been accomplished through achieving a different number of that patterns' concepts. For instance, the second pattern *visual connection*

with nature (VCN) has been achieved in all study cases by reflecting the pattern's main *concept* of *unpredictable natural movements*, whereas the third pattern *non-rhythmic sensory stimuli* (NRSS) has been also achieved through the pattern's main concept of *weather hearable sounds.* Moreover, *material connection with nature* pattern (MCN) has been achieved in all cases by using *natural materials* such as *natural wood* in all cases, in addition to the natural sandstone in the Craigieburn public library.

Regarding the first pattern *visual connection with nature* (VCN), it has been observed in all study cases, that each case is reflecting a different number of concepts. For instance, the School 7, Kista, and Craigieburn public libraries have achieved this pattern with the lowest number of concepts comparing to the other two, in these three cases the *weather contacting, natural views, and providing seating area next to the openings* are the utilized concepts. Whereas, the Dokk1 public library has achieved the same previously mentioned concepts in addition to *viewing the water* and that has been achieved due to the building is located next to the sea. As for the last public library (Oodi building), it can be observed the highest number of concepts were utilized, in which all first pattern concepts except *water viewing, animal presence, green roofs, and interior landscape.*

Concerning the fourth pattern *access to thermal & airflow variability* (ATAV), Oodi and Dokk1 public libraries have achieved the pattern using all the pattern concepts, while the other public libraries have reflected only one concept which is the *natural temperature accessibility* into the interior spaces.

With regard to the *dynamic & diffuse light* pattern (DDL), all public libraries have considered that they have achieved the *natural light* & *light* distribution concepts while all of them ignored the other two concepts: *firelight* & *simulating the natural light.*

In terms of the *connection with natural systems* pattern (CNS), it is considered that the Oodi & Dokk1 public libraries buildings have utilized all pattern concepts except the *concept of the green roof,* whereas the other three public libraries have utilized all pattern concepts except the *green roofs* & *connecting interior to exterior.*

With reference to the *prospect* pattern (P), all these pattern concepts have detected in all cases buildings with different proportions; due to the differences in the designs and areas. On the other hand, the *refuge* pattern has been achieved in all cases except the Craigieburn public library, it has been accomplished by utilizing different concepts such as *tiny closed study rooms,* and *window bay seating*.

2) Patterns that have been achieved by a minimum number of concepts:

This aspect clarifies the *biomorphic forms & patterns* pattern (BFP), that has been achieved in four out of five cases by utilizing only one simplified concept through using neutral colors (white color), whereas Oodi public library has achieved this pattern by using the *wavy white ceiling* in the second floor, and this has element reflected all pattern concepts except the *natural geometries.*

3) Rarely used patterns:

This aspect focuses on those patterns which can be considered as rarely used in the study cases, these patterns are *presence of water* (PW), *complexity & order* (CO), *mystery* (M), and *risk/ peril* (R/P) patterns. *Presence of water* pattern has been seen in the Dokk1 public library only; and that due to its location near to the sea. Whereas the other four public libraries were totally ignoring this pattern.

On the other hand, *complexity & order* (CO) pattern has been observed only in Oodi and School 7 buildings, while it is fully ignored in the other three cases. Moreover, in terms of *mystery* pattern (M), which it has been detected only in School 7 building, however, the other cases wholly neglecting this pattern. While *risk/ peril* pattern (R/P), it was considered that this pattern was seen only in Oddi public library building, and

it has been achieved through the accessibility to the second floor *cantilevered balcony*, nevertheless, the other cases completely were neglected this pattern.

Biophilic design patterns are simply the translation of the ways of integration & simulation nature various aspects into the interior spaces in order to enhance the humans' health & well-being, the integration & simulation of these patterns and its concepts (attributes & strategies) can be accomplished with various methods and scales to suit the building function and meet its occupants needs as well. For instance, the presence of water pattern can be achieved through using vertical wall water feature, medium fountain size, or even through using artwork of natural water images. Consequently, the reason behind the *rarely used patterns* in the study cases basically might be the unawareness of the importance of using these patterns into public libraries' interior spaces, or/ and it might be the inability of how to use these patterns in a way to suit the public libraries' interior spaces functions.

B- Achieving a number of patterns by using specific interior design elements:

After reviewing the exploring evaluation of the study cases, it realized that through utilizing some interior / architectural elements, several of patterns and almost full of one pattern concepts were achieved; these elements with interrelation to the patterns were observed as stated in the following:

- Through using one or all of the (glazed facades, skylights, not operable openings) several patterns were achieved, which are *visual connection with nature* (VCN), *non-visual connection with nature* (NVCN), *non-rhythmic sensory stimuli* (NRSS), and *dynamic & diffuse light* (DDL) patterns have been achieved.

- Through using balconies, or/and operable windows all *access to thermal & airflow variability* pattern (ATAV) concepts were directly achieved.

5.4 Chapter Conclusion

After delving into the discussion of the findings of study cases, it would be observed that the biophilic design has been adapted into the public libraries through diversified techniques and methods; however, through these integrations of techniques & methods, several biophilic design patterns & concepts have been accomplished. The accomplishment of these patterns & concepts has been realized in different proportions in each case; due to the differences among the cases' buildings specification such as the floor area, floors number, location, and the method of utilization of some architectural design elements such as openings which could be normal windows or fully glazed facades.

On the other hand, three main categories were recognized in terms of the biophilic design patterns achievement, in the study cases; firstly, the commonly employed patterns, this category which consists of nine patterns clarifies that these patterns were achieved in overall study cases by using the majority number of its concepts with varying number concepts in each case. Moreover, there are concepts that are totally ignored within these nine patterns (*fire, animals, green roofs, interior landscape & nature artworks*). The second category are those patterns that have been achieved by a minimum number of concepts, and only applicable to the *biomorphic forms & patterns* pattern (BFP) which were seen in four out of five cases, which utilized only the neutral *colors* concept and ignored the rest (*naturalistic shapes & forms, evoking nature, natural geometries, biomimicry & organic forms*); Whereas the third category specifics the four patterns that are scarcely applied in the cases of study.

Moreover, it was derived from the discussion of the findings that there are various concepts (attributes & strategies) of six patterns which could be simply achieved through the existence of operable openings such as balconies, and operable windows, in which that would be enhanced & positively affect the public libraries occupants' behavior, productivity, and perception through various methods such as providing them *natural light, natural views, weather changing views,* and allowing them to *feel and experience the natural weather humidity and temperature* (Fuller et al, 2007; browning et al, 2014; Ryan et al, 2014).

Chapter 6

CONCLUSION

6.1 Conclusion

The adoption of biophilic design in public libraries as a contrast from other movements' human-nature relationship approach in architecture is critical, as biophilic design focuses on the positive feedback from humans' interaction with nature than just benefitting nature. Besides, the integration of biophilic design in the interior spaces of public libraries will assist in the realization of the needs of the users. However, to achieve this it would be vital to evaluate the varying approaches adopted for the integration of biophilic design in public libraries' interior spaces.

The basic research problem of this study was based on an inquiry; that is what are the various approaches of biophilic design that can be integrated into the interior spaces of a public library which is a learning space. The thesis took the approach of qualitative exploration of biophilic design in public libraries by specially selecting public libraries that have won the IFLA "International Federation of Library Associations and Institutions" awards from around the world annually. Furthermore, as stated earlier several approaches were adopted and evaluated, to mention the integration from various schools of thought. Therefore, the main focus here is to highlight various biophilic design approaches that can be achieved in public libraries' interior spaces.

During the course of the thesis, it became imperative to generate a theoretical base of biophilic design from various approaches that have been described in numerous studies and from other fields of specialization outside architecture. This theoretical foundation also assisted in the discovering of the most popular approach to biophilic design which is the 14 patterns by Browning et, al (2014). Other approaches that were essential to the formation of the theoretical base of the study are elements and attributes to a biophilic design by Kellert (2015) and biophilic design strategies by Wilson (2006). With these approaches, a framework was created that became critical towards evaluating the extent to which biophilic design was utilized in the study cases. Therefore, this provided answers to the research question which is "how biophilic design can be integrated into the public library, interior spaces?

The primary focus of the thesis is learning spaces specifically the interior of public libraries that won the IFLA awards, that involve biophilic design as different from another movement's human-nature relationship in architecture. However, three-level of analyses were employed to achieve the aim of this study; the first level of the analysis is the literature review of critical terms of the study, in which biophilic design and public library's literature from numerous sources were evaluated intensively and a framework was produced which became vital in the analysis of the study cases. The second level of the analysis involved the evaluation of the distinctive selected cases with the aid of the framework mentioned above and other architectural communication materials that were available. The final level of the analysis involved the discussion of the findings after filling and evaluation of the framework for each study case.

The results of the various analyses conducted in the thesis showed that the various patterns of biophilic design are interrelated, and in the process of trying to realize one

of the patterns one might end up achieving other patterns in addition to the initial pattern. It can also be observed that patterns of biophilic design are also closely related to the approaches of elements and attributes of biophilic design, with biophilic design strategies.

The discussion of the findings was divided into two parts; the first part was subdivided into three sections, in which the first part focuses on commonly seen patterns with framework of the analyses of various cases, where pattern number 1, 2, 3, 4, 6,7, 9, 11, & 12 are patterns that are commonly utilized with the study cases. The second section of the first of the part involves the pattern that has been achieved by the minimum number of concepts, an example is pattern 8 (*biomorphic forms and patterns*) which is seen in 4 out of 5 libraries, by which materials of neutral color (white color) are utilized. The three-section is the rarely used patterns, in which pattern 5 (*presence of water*), pattern 10 (*complexity and order*), pattern 13 (*mystery*) and pattern 14 (*risk and peril*) are patterns that were rarely employed in the study cases evaluated. The second part of the findings in The discussion of that several patterns were achieved through employment of opening and balconies of interior spaces.

As mentioned earlier, the core problem of this thesis is that it is imperative to fill the huge research gap, where there is no research on the evaluation of integration of biophilic design techniques in the interior spaces of the public library, with several studies focusing on other interior spaces and in the benefits of biophilic design. By the help of evaluative framework generated in the study in conjunction with other relevant architectural communication materials, interior spaces of other public libraries can be evaluated for the planning, design, and implementation.

Moreover, and based on the theoretical background of biophilic design as well as the achieved biophilic design patterns in the study cases that have been discussed and clarified in the findings chapter; various benefits and advantages can be observed that positively affecting the study cases' learning spaces through improving its quality from various aspects to enhance health, wellbeing, productivity, creativity, and behavior as well.

6.2 Implication for Further Study

As stated above, the delimitation of the study is within boundaries of an interior space of public libraries. The public library's interior space is just an example within the learning spaces, it would be critical if other interior spaces are selected and evaluated, in which more approaches of biophilic designs that were not discussed in this thesis would be discussed in addition to the framework generated in this thesis. In addition, more research would be required to evaluate the tangible application of the value of biophilic design. Also, this thesis can be used as a foundation for forwarding studies, which would contribute to the body of knowledge in the discourse of biophilic design.

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