CONTRIBUTION OF THE BIOPHILIC DESIGN APPROACH TO THE UN SUSTAINABLE DEVELOPMENT GOALS

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ABSTRACT

In the last decade, biophilic design under the concept of creating strong connections between nature and manmade environments have spread significantly. Because of the rapidly increasing environmental crises and climate change phenomena globally. Consequently, biophilic design has become associated with sustainable applications, the question this research discusses is if this approach contributes to achieve the aspects of sustainability, under the umbrella of the UN Sustainable Development Goals (SDGs). This study will investigate biophilic approach contribution to sustainable design through defining aspects of nature that most influence human satisfaction of built environment. Aligned with the European Commission (2015) series actions titled "nature-based solutions" that are inspired by nature systems. During the COVID-19 lockdown, humans had minimal interaction with nature, and access to green public spaces, at the same time, an increasing interest to integrate nature in design, reducing humans impact on nature were recognized in the contemporary built environment. The study adopts William Browning's (2014) "14 Patterns of Biophilic Design" framework, that lays out a series of tools experiencing science and nature contribution for promising opportunities creating sustainable built environment design applications. In addition to identifying and analysing the current practices for biophilic design in the built environment and its' impacts on nature and human wellbeing. The results conduct design strategies, and guidelines that integrate biophilic approach as a base, within the 14 patterns framework for better practices creating innovative and responsible built environment.
Keywords: integration, biophilic design, sustainable built environment, nature-based solutions.

1 INTRODUCTION

The link of "nature" and human settlements has a deep history. The fabulous Hanging Garden of Babylon is thought to have been a brilliant construction in classical antiquity that was adjacent to the water source and filled with a rich diversity of trees, shrubs, and grapevines in terraced gardens. In modern architecture, architects discover living with nature through a wider range of approaches. For example, Leberecht Migge planned the installation of edible gardens. Apartments with private gardens were included in Le Corbusier's conceptual project, Immeubles villas [1]. Biophilic design (BD) can reduce stress, enhance creativity and clarity of thought, improve our well-being, and expedite healing; as the world population continues to urbanize, these qualities are ever more important. Theorists, research scientists, and design practitioners have been working for decades to define aspects of nature that most affect our satisfaction with the built environment. Several publications studied different approaches to biophilic design. The air approach by Browning et al. [2], Gou et al. [3] and Kellert [4] suggests to increase natural ventilation using operable windows, vents, narrower structures, etc. and simulate natural air and ventilation through operable windows, vents, airshafts, porches, clerestories, HVAC systems, etc. The water approach by Browning et al. [2] and Kellert [4] suggests building waterscapes such as fountains, constructed wetlands, ponds, water walls, rainwater spouts, aquaria, etc. and access to natural water features such as waterfalls, rivers, streams, oceans, etc. The light approach by Browning et al. [2] and Kellert [4] suggest bringing in natural light via glass walls, clerestories, skylights, atria, reflective colours/materials, etc. and mimic the spectral and ambient qualities of natural light,

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such as by arranging multiple low-glare electric light sources, ambient diffused lighting on walls/ ceiling, and daylight preserving window treatments. The plants approach by Chang and Chen [5] suggest bringing vegetation indoors by potting plants and indoor green walls and incorporate plants into buildings by using green roofs, green walls and facades, large atria with park-like settings, green pockets, etc. Another approach by Schweitzer et al. [7] suggests to create spaces to accommodate animals, such as ponds, aquariums, etc. and wild animal-friendly living areas to attract animals like nest boxes, gardens, green roofs/walls, etc. Additionally, Browning et al. [2] and Fei et al. [6] mention an approach involving landscapes in the sites such as constructed wetlands, grasslands, prairies, forests, and other habitats, interior landscapes in atria, courtyards, entry areas, hallways, etc. Also providing window views of natural landscapes like forests, seascapes, and water motifs. The study adopts William Browning's (2014) "14 Patterns of Biophilic Design" framework shown in Fig. 2, that lays out a series of tools experiencing science and nature contribution for promising opportunities creating sustainable built environment design applications. These patterns are comprehensive and include all the elements of nature that are encouraged by the many publications that has been reviewed.

Figure 1: The Sustainable Development Goals (SDGs) or global goals shown are a collection of 17 interlinked global goals designed to be a "blueprint to achieve a better and more sustainable future for all" [9].

According to European Commission (2015), nature-based solutions aim to help societies address a variety of environmental, social, and economic challenges in sustainable ways. They are actions inspired by, supported by or copied from nature. Nature-based solutions use the features and complex system processes of nature, such as its ability to store carbon and regulate water flows, in order to achieve desired outcomes, such as reduced disaster risk and an environment that improves human well-being and socially inclusive green growth [8].

2 OBJECTIVES AND METHODOLOGY

This paper is a step towards implementing sustainable biophilic design, and it aims to identify the sustainability strengths and weaknesses of BD patterns. It presents a review of projects, with the goal of identifying its biophilic features and their sustainable impacts. This study

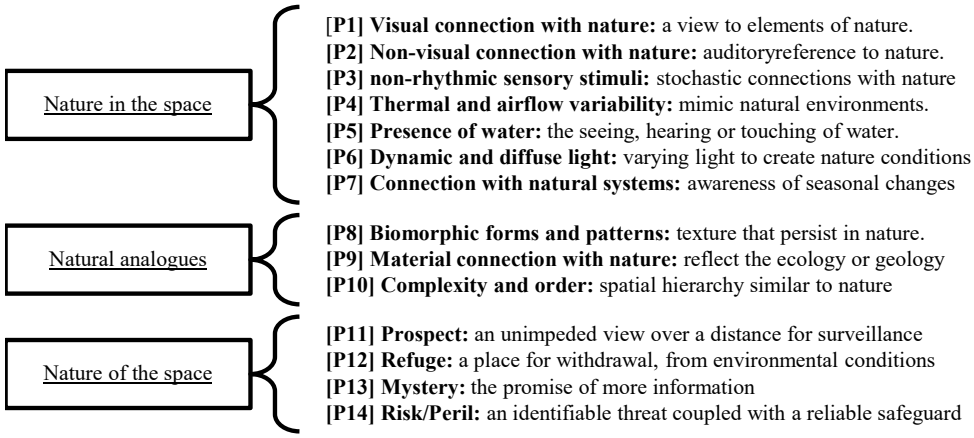

Figure 2: The biophilic design patterns within three categories based on nature relationship [10].

also reveals the potential sustainable benefits of adopting BD and the existing challenges that must be overcome, ultimately paving the way for the enhancement of human nature connection within sustainable built environments. In addition to conduct design strategies, and guidelines that integrate biophilic approach as a base, within the 14 patterns framework for better practices creating innovative and responsible built environment.

2.1 Methodology

The research methodology structured to analyse selected case studies represents current practices for BD projects in relation to SDGs achievements, with certain criteria included identification, screening, and eligibility, as shown in Fig. 3.

2.2 Case studies selection criteria

Based on the study limitation to analyse the BD case studies, there are three steps for considering the selected current practices for BD, started by identification, followed by screening and ending with eligibility as follows:

2.2.1 Step 1: Identification

The keywords used for the search were “biophilic”, “biophilic design”, “biophilic architecture”, “biophilic patterns”. The design concept was the first exclusion criterion. The fields included were architecture, interior design and furniture. Fields such as products, manufacturing, biology, and land conservative were not relevant subject areas for this study and were therefore excluded.

2.2.2 Step 2: Screening

In the second phase, all of the cases were reviewed to refine the selection list, and the second exclusion criteria was used to further narrow the selection of cases for eligibility is claiming to be “sustainable” or “green”. This is a crucial exclusion point because each project would be judged to see if the biophilic patterns or features are sustainable or just claiming to be green two biophilic design.

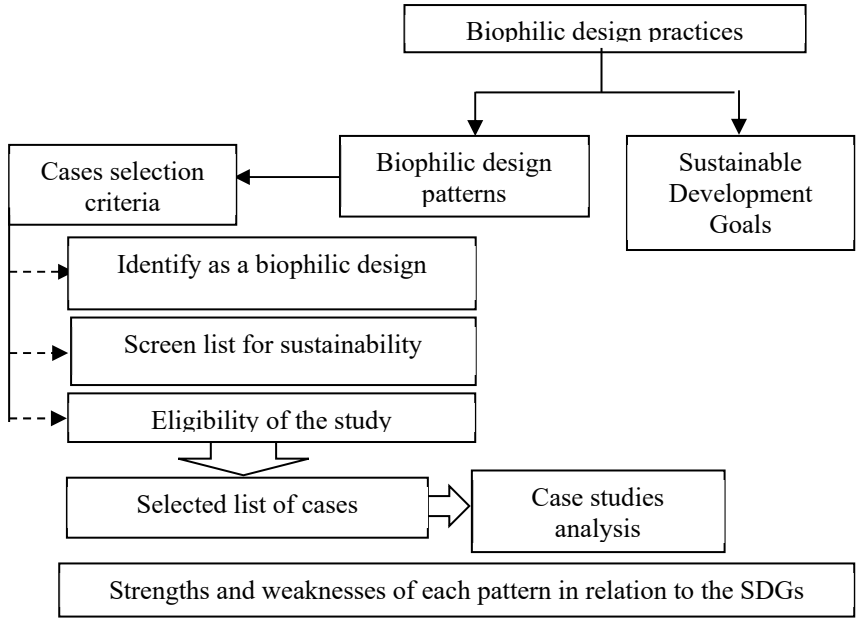

Figure 3: Research methodology chart.

2.2.3 Step 3: Eligibility

The goal of the third step was to filter the remaining cases to identify the projects with the highest potential for this study. All the documents were filtered according to two points. The two filtering criteria used to assess their potential applicability to the scope of the study were: focus on the Realistic projects not educational or competition and focus on 500 m^2 or more. By the end of this phase, each project taken under consideration is or has by biophilic patterns, claiming to be sustainable, realistic, completed and is 500 m^2 or more.

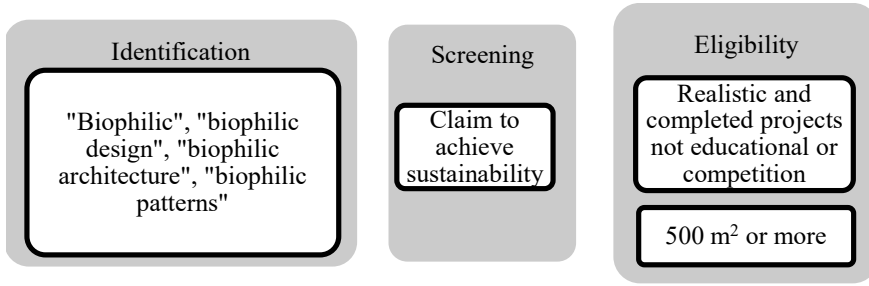

Figure 4: Selection criteria for BD case studies.

3 SUSTAINABLE DEVELOPMENT GOALS EVALUATION GUIDELINES

Investigating the eligibility of some biophilic design to have sustainable impact and contribute two sustainable aspects requires to set some guidelines and answer question “does the built environment meets any of these aspects?” in this case UN Sustainable Development

Goals SDGs are the guidelines for contributing to achieve the aspects of sustainability. Under the umbrella of sustainability, the 17 SDG cover a broad spectrum of causes like social issues so we will focus in this study on the environmental and design issues thus we will only choose eight goals shown in Fig. 5 out of the 17 to realize if these case studies will achieve any of them.

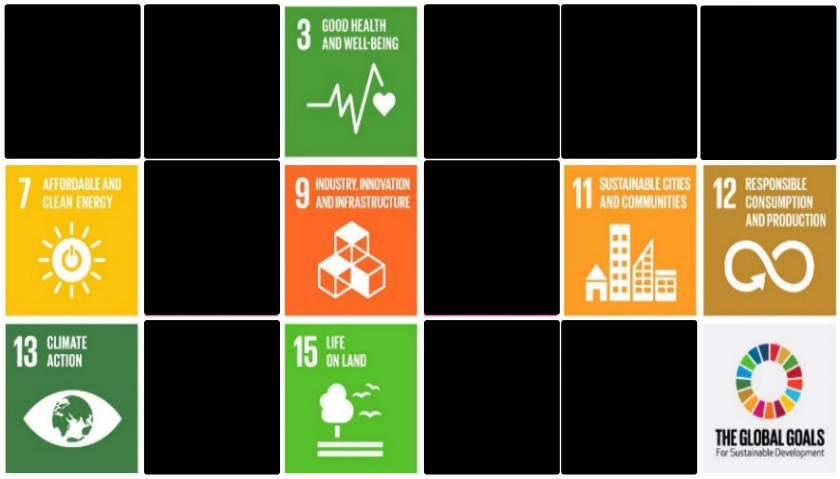

Figure 5: Study limitation to selected SDGs realized within the BD case studies selected.

4 BIOPHILIC DESIGN SELECTED CASE STUDIES ANALYSIS

4.1 Greenacre Park

Designed by Sasaki, Dawson, DeMay and Associates, in New York, USA. Within an area of 6,000 ft^2 (557 m^2), and completed in 1971.

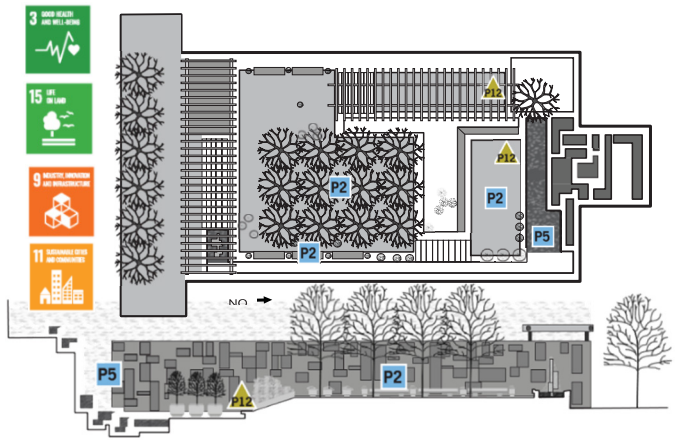

Figure 6: Greenacre Park layout and section drawing showing the BD patterns application and SDGs application [10].

4.1.1 Greenacre Park's strengths

The case presents with several biophilic features that achieve sustainable UN Sustainable Developments Goals. Abundant trees, shrubs, smell and texture of stone natural material contribute to the productivity of individuals and their mental health thus creating better community and more efficient environment to live and work in. The high-density spots of the plants help mimic the actual experience of being in nature in addition to the waterbodies contribution to visualizing and hearing the experience of being inside a forest or simply a greenery outdoor environment (**[P1] [P2] [P9] → SDG 3**). Rustling ivy on the west wall and tree canopy above, and birds contribute to sustainability of the surrounding living creatures and their flourish will help to not only maintain the creature but also to maintain the environment that we all coexist in it. The incorporation of this feature is highly advanced approach to help humans embrace the nature in the environment rather than eliminating nature to create a solitary environment (**[P3] [P7] → SDG 15**). Cool air wafts up from the water features, shading provided by trees, movable furniture ensures preferred conditions that reduce reliance on active systems. This feature is considered a passive approach to create thermal comfort and reduce use energy consumption. In addition, the comfortable environment with adequate ventilation and easy access layout promotes health, wellbeing, and stress-free zone (**[P4] → SDG 11**). Light filters in through tree canopy; lower, upper, and middle levels experience different amounts of infiltration contribute to an aesthetic indoor experience. Such application motivates the human mind and stimulate the sensors specially in artistic spaces allowing innovation and the attraction to observe the changes in light and the depth of the details of the natural materials and design (**[P6] [P12] [P13] → SDG 9**).

4.1.2 Greenacre Park's weaknesses

Although water bodies are encouraged in the space to provide cooling and connection to nature but a 25 ft tall waterfall cascades down the north wall is extremely consuming to the environment. The water source has not been established that it comes from renewable source, or it has been recycled such as using greywater and the flow of the waterfall is not stated to be energized by a renewable source which make it a weak and opposite to sustainability and conservation of resources. In addition, having a stone sculpture can be considered over the top, this addition to the space can waste of natural materials that are precious to our environment and must be used sustainably **[P5]**. Elevating the park above the street level must be for technical purpose and for a specific function; either for the structural integrity or for the safety of conditions such as rain but creating this elevation just for the purpose of aesthetics or biophilic design is considered an extra construction cost, time, materials, and energy **[P11]**.

4.2 Glumac's Shanghai office

Designed by Glumac, Gensler, Shimizu, GIGA, Terrapin Bright Green, in Shanghai, China. Within an area of 10,000 ft^2 (929 m^2), and completed on 2014.

4.2.1 Glumac's Shanghai office's strengths

Indoor plantings, garden views and partially obscured view of plants at the end of the long hallway. All these patterns help physical and mental health of a human being because existing in nature is calming thus it reduces stress. Integrating nature in and to the built environment can minimize anxiety, overthinking and pressure which effects both happiness and

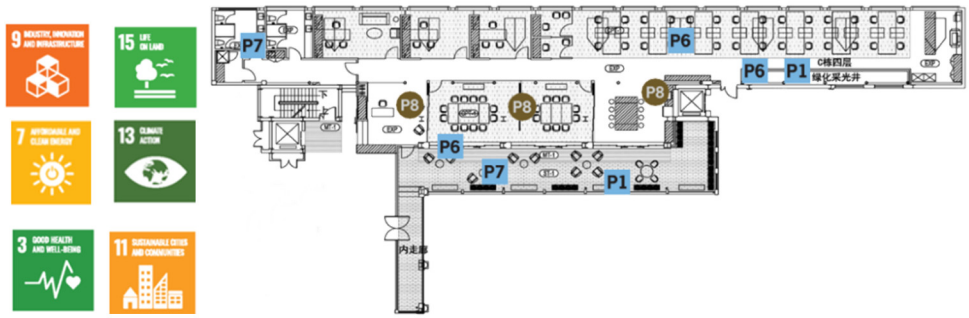

Figure 7: Glumac's Shanghai office plan drawing showing the BD patterns application and SDGs applied [10].

productivity of the individual (**[P1] [P13] → SDG 3)**. The pleasant odour of indoor plants, the sounds of the birds that inhabit the garden courtyard encourage the flourish of the natural environment that surrounds the built environment. This connects the outdoor to the indoor and create movement energy in the space and minimize the impact of the built environment on the surrounding (**[P2] → SDG 15)**. Fully operational windows throughout the space, and doors to the patio which can be propped open provides fresh air and daylight creating natural ventilation and natural illumination in the space thus reducing the need for energy consuming active systems such as HVAC and artificial lights. Open office plan and an elevated long-distance view from the patio added resilience to the space and to the building making it more comfortable and durable increasing the space life span and making it adaptable to multiple functions (**[P4] [P11] → SDG 11)**. A light well and large windows flood the space with daylight; adjustable transparency of the glass wall provide variability resilience of the functions and the buildings spaces because well lighted spaces can be used for anything and does not rely on lighting equipment's to achieve the desired illumination for different tasks that the space is intended. Open office plan and an elevated long-distance view from the patio contribute to the possibility of retrofitting the building and upgrading its potential overtime (**[P6] [P11] → SDG 9**). Reclaimed wood reception desk and bistro table, unpainted strawboard columns and cabinets and reclaimed Chinese gray bricks reduces greenhouse gases by reusing products without processing them which is a more responsible and sustainable method than recycling which requires processing thus contributes to climate change (**[P9]→ SDG 13**).

4.2.2 Glumac's Shanghai office's weaknesses

A light well and large windows flood the space with daylight; adjustable transparency of the glass wall and individual task lighting provide variability and control. This approach might make a lot of thermal bridges which compromises the thermal comfort it needs careful considerations and calculations. The cost is also a place of question since and advanced technology like this might be too expensive if it is not made from recycled materials **[P6]**.

4.3 Kickstarter Offices

Designed by Team Ole Sondresen Architect, in New York, USA Within an area of 29,000 ft^2, and completed in 2014.

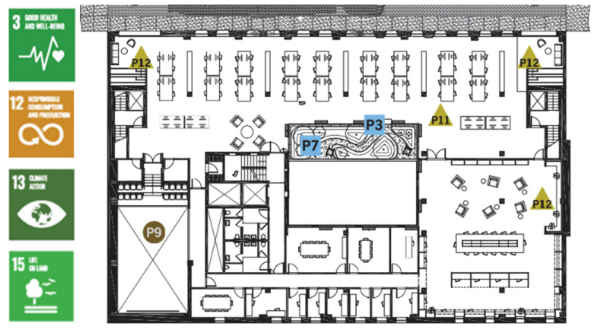

Figure 8: Kickstarter office plan drawing showing the BD patterns application and SDGs applied [10].

4.3.1 Kickstarter Offices' strengths

The views to the outdoors from all three floors and every work desk provides a sense of connection to the surrounding environment. Especially if the surrounding environment is green and have features such as moving grasses, edible berries, edible garden plots. Such an environment will assist in mental health of the workers (**[P1] [P2] → SDG 3**). Moving grasses, edible berries, edible garden plots represent a small scaled urban farming. The products of these edible garden slots are very important, and it provide a deeper link to the nature through taste sense. This quality is considered sustainable consumption because it does not depend on mass manufacturing and encourages the increase of functional planting (**[P2] → SDG**). The use of native landscaping sets the stage for non-rhythmic sensory stimuli, with occupants on each floor with direct view of native landscaping. In addition, it encourages the growth of local plants and making sure that the ecosystem remains for other creatures to be sustained for longer periods. The central courtyard and green roof's native landscaping rainwater capture and retention in the courtyard saves resources such as water and provides natural irrigation. The use of green roof is known to prevent heat island effect and creates a protection for the interior-built environment from outdoor conditions (**[P3] [P5] [P7] → SDG 15**). The operable windows in the office, natural light from the courtyard, sunroom, and exterior refurbished windows provides natural ventilation and natural illumination to the space thus reducing use of active system and the consumption of energy. Minimizing the use of active systems and relying on renewable energy such as wind and sun minimize the greenhouse gases and contribute to preventing climate change. Interior doors, desks and seating are made of salvaged or local materials, which extends the life cycle of used materials and saves energy of production, manufacturing and transporting new materials (**[P4] [P6] [P9] → SDG 13**).

4.3.2 Kickstarter Offices' weaknesses

The operable windows and open courtyard are appreciated but can cause indoor heat fluctuation due to thermal bridges. Such element is wanted but several factors must be considered like cost, recycled materials, amount of privacy and thermal comfort because too much use of light thermal mass such as glass leads to a weak envelope thus uncomfortable indoor condition. The point/aim of open spaces and windows is to allow naturally functional spaces but these spaces still must be controlled from the indoor **[P4] [P7]**.

4.4 Östra Hospital

A hospital in Göteborg, Sweden, designed by Team White Architects. Within an area of 193,750 ft^2 (18,000 m^2), and completed in 2006, the hospital considered one of the BD prototypes.

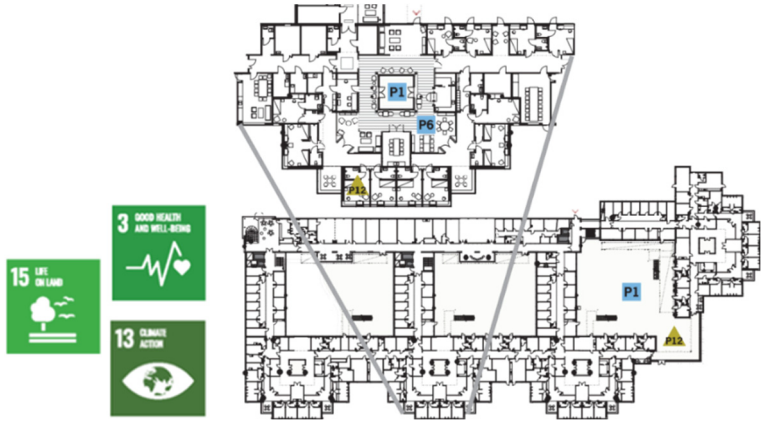

Figure 9: Östra Hospital plan drawing showing the BD patterns application and SDGs applied [10].

4.4.1 Östra Hospital's strengths

Patient rooms have views to the central gardens; light courts are planted with low vegetation providing a sense of connection to the surrounding environment and natural filtration/renewal of air indoors. Especially if the surrounding environment is green and have feature such as courtyards with edible plants. Such an environment will assist in mental health of the occupants (**[P1] [P2] → SDG 3**). Operable windows allow for responsible use of resources because it utilizes renewable energy such as sun and wind reducing the need to use artificial lighting and HVAC (**[P2] → SDG 12**). operable sunshades and windows light courts introduces natural light into the indoors does thus would you think the need for artificial lighting that consume energy (**[P4] [P6] → SDG 13**). Garden courtyards encourage biodiversity and create home for surrounding creatures that may lose the part of their palms to the built environment. In addition, it connects the natural environment to the built space (**[P3] [P7] → SDG 15**).

4.4.2 Östra Hospital weaknesses

Use of natural materials gives a nice addition to the interior but using non-recycled or non-reclaimed materials such as natural stone and wood increase the consumption of trees and invasion of forests and compromise the ecosystem thus compromising the creatures and the different natural components of the surrounding **[P9]**.

4.5 Parkroyal on Pickering Hotel

Designed by Team WOHA, in Singapore City, Singapore. Within an area of 12,121 ft^2 (1,126 m^2), and completed in 2013.

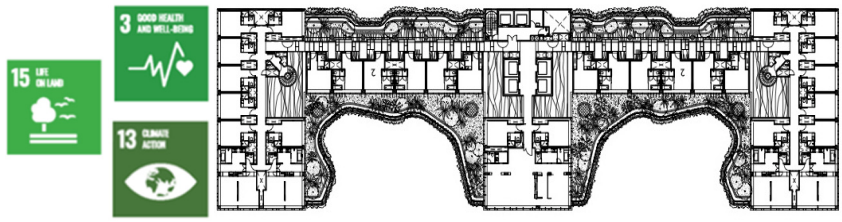

Figure 10: Parkroyal on Pickering plan drawing showing the BD patterns application and SDGs applied [10].

4.5.1 Parkroyal on Pickering's strengths

Views of Hong Lim Park or the sky-gardens are accessible from nearly every guest room; abundant indoor plantings and water features. Odours from indoor plants; sounds of birds and insects attracted by native plants. All these qualities create an interactive environment for the patients to break the norms and the boredom of staying in a hospital and gives a sense of calming and relaxation promoting health and healing (**[P1] [P2] → SDG 3**). Water features both inside and outside, light reflected off the water, natural light indoors and translucent curtains in guestrooms provides thermal comfort and sufficient lighting inside the interior space. Relying on such renewable resources to provide thermal comfort and to provide illumination reduce or eliminate active systems use thus minimizing the amount of greenhouse gases that cause climate change (**[P4] [P6] → SDG 13**). Planted sky-gardens attracts birds and other creatures which promotes biodiversity and sustainability of the natural life around the built environment. Also, it protects certain species and types of animals from migrating or dying by creating a sanctuary inside this space (**[P3] [P7] → SDG 15**).

4.5.2 Parkroyal on Pickering's weaknesses

Abundant water features incorporated into sky-gardens, lobby, passageways, infinity pool must be used in a responsible matter by recycling grey water, otherwise it considered a waste of water, and energy **[P5]**. Unfinished stone-walls, polished granite walls, and unpainted wood surfaces should be recycled reclaimed or reused because such precious components of nature are necessary to sustain the natural environment rather than be integrated into the built environment just for an aesthetic reason **[P9]**.

5 CONCLUSION

This paper identified and analyzed several projects that present many of the 14 biophilic patterns in terms of connection and relation to the nature-based solutions, that most influence human satisfaction of built environment. Where the research study investigated the biophilic approach contribution to achieve the aspects of sustainability, under the umbrella of the UN sustainable Development Goals SDG's. The patterns represented in each case have similarities to theoretical identification for biophilic approach, but the application showed clearly, how far they achieve some of the UN SDG's. It showed as well, how far application of some BD patterns could affect some sustainability aspects negatively, where decision here should compromise strengths against weaknesses. For instance, patterns use natural resources, as pattern number five "presence of water" is important as a wellbeing factor but can be a waste of precious resources like with huge energy operated, waterfall that also does not use recycled water for more efficiency. In such case, it puts a strain on natural resources in contradiction with SDG number 12 "responsible consumption and production". In such

cases research recommend more sustainable tools for application and using clean resources like PV operated fountain that relies on grey water. The author believes that most biophilic patterns serve a sustainable purpose achieving many SDGs, increasing human satisfaction of built environment, connecting them more with nature. For advancement of the biophilic design approach, corresponding sustainable goals should be assigned for each pattern application, assuring that the patterns are not only satisfactory for human wellbeing but also responsible with mindfulness of their effect on earth resources.

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