The initial study on implementation of vertical greenery in Malaysia

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Abstract: Mass urbanization and rapid global population growth lead to the occurrence of dense urban areas. For buildings located in densely built urban areas, there are minimum horizontal green spaces. One practical idea to increase the presence of green is to plant upwards when horizontal space is a constraint. This research is done for the case in Malaysia as Malaysia have yet to emerge in vertical greenery implementation for buildings. The aim of this research is to determine the significances of implementing vertical greenery. The second aim is to identify the barriers to the implementation of vertical greenery and the final aim is to provide practical approaches as well as recommendations to increase the adoption of vertical greenery in Malaysia. The methodology of this research is qualitative method whereby interviews are conducted. Vertical greenery is introduced to provide environmental, economic and social benefits. For environmental issues, the temperature can be reduced and energy efficiency can be improved. Economically, vertical greenery can assist in energy savings and improve acoustic insulation. As for the social impacts, the presence of vertical greenery provides pleasing and better environment for the community. With these three aspects, sustainability can be achieved. The main barrier to the implementation of vertical greenery is due to the high cost of construction. The government should place more emphasis on implementing vertical greenery as it is considered as a promising solution to bring significances.

1. Introduction

One of the ancient Seven Wonders of the World, known as Hanging Gardens of Babylon is the pioneer for the concept of vertical greenery [1]. Although the application of climbing plants along the facade of a building is not an unfamiliar trend, the purpose and the systems of the usage of vertical greenery has evolved. As stated by [2], historically, the usages of green walls were for ornamental or horticultural. However, in this modernized era, other passive techniques of vertical greenery are used to improve their sustainability [3].

In modernized era, high density urban spaces have minimal horizontal green spaces which lead to lesser greenery for the entire building and community. The usage of the outer surface of the buildings by implementing vertical greenery would allow the amount of greenery to be increased in high density cities where horizontal green areas are at minimum [4]. Therefore, results shown by Bass and Baskaran [5] appear that planting on walls turn out to be an inventive and expeditious developing field towards the direction of sustainable construction.
Apart from that, since the vertical surface area of buildings is much larger than the available horizontal surface area, there is more potential for the adoption of vertical greenery. Hence, the chances of improving environmental issues through vertical greenery are greater than green roofs [6].

As mentioned by [2], building sector generates energy and accounts for 40% of energy consumption. Although there are abundant of great technological methods to reduce the negative impacts, green might be a simpler, easier and cheaper method, making it accessible to more people as compared to technological manners. Likewise, the usage of plants provides benefits because plants are a clean source [7][8].

2. Vertical Greenery
The term vertical greenery has a divergence of meaning collected from various authors. Vertical greenery is generally defined as plants growing on vertical surfaces. [3] defined vertical greenery as structures that allow vegetation to spread over a building facade or interior wall. Based on [9] “Vertical greenery are different forms of vegetated wall surfaces, based on the spreading of plant species across the wall surface by using vertical structures, which may or may not be fixed to an indoor wall or to a building facade.”

All the vertical greenery definitions stated has similar meanings. There are other similar terms for vertical greenery, namely green walls, living walls, green facade and so on. Nonetheless, vertical greenery is a comprehensive and commonly used term for plants growing on surfaces vertically [10]. As such, the term vertical greenery will be used for this research.

3. Significances of Implementing Vertical Greenery
The significances of implementing vertical greenery are divided into three categories, that are, environmental, economic and social benefits.

3.1 Environmental Benefits
One of the significances of implementing vertical greenery is that it is able to reduce and regulate the surrounding temperature. There was an experiment carried out in Hong Kong, where [11] observed that tall buildings with walls and roof covered with plants resulted to a temperature reduction by 8-9 °C.

As a result, energy efficiency can be improved through external temperature regulation. Vertical greenery is a promising solution to make buildings more energy efficient [2]. Energy efficiency is also improved through ambient temperature reduction via shading and evaporation by plant processes. A buffer zone is created by these vertical greenery against the wind during winter period contributing to energy efficiency [12].

Moreover, vertical greenery plays a crucial role in shaping the urban microclimate [13]. Vertical greenery is used as a new bioclimatic design concept of buildings in order to reduce urban heat island effect [14][15][16]. This is possible as plants take in a significant amount of solar radiation for respiration, transpiration and photosynthesis [17]. By reducing urban heat island effect, natural cooling processes are promoted and ambient temperature in urban areas are reduced.

Another significance of vertical greenery is that it is able to absorb dust and clean the air, thus, improving the air quality [18][19]. By the same token, vertical greenery is able to reduce the greenhouse effect by carbon dioxide absorption. By implementing vertical greenery, it is a step to reduce greenhouse effect because as plants grow, greenhouse gases are absorbed from the atmosphere.

In addition, vertical greenery provides ecological restoration for plants and also on faunas. The design of vertical greenery for biodiversity requires designers to have a certain knowledge of the plant requirements and the specific needs of the faunas. For example, climbing plants like Climbing Hydrangea (Hydrangea anomala petiolaris) and Morning Glory (Impomea tricolor) are known to attract butterflies and hummingbirds [12].

Other advantage of adopting vertical greenery is that it can improve rainwater retention. Rainwater is collected in the hydroponic system and this is used for plant irrigation [20]. Thus, it is more logical to make use of the rainwater to irrigate the vertical greenery as it is more economical this way.
3.2 Economic Benefits

Lately, sustainable cities discovered that implementing greenery is an essential element in addressing noise pollution, leading to the increase in popularity of vertical greenery [13]. In the same manner, vertical greenery can control noise and act as a noise barrier [20]. The substrate where plants grow possess a sound absorbing effect and this is able to provide acoustic benefits [21]. Besides that, Wong [13] stated that indoor vertical greenery is may be effective in protecting speech privacy.

Another significance of vertical greenery is that it is an effective tool for energy savings. The shade effect comprises of solar radiation interception provided by plants [3]. One method is by using vertical greenery as window shadings [5]. It has properties of appropriate shading system by increasing daylight while decreasing discomfort glare [22]. During the summer months in Hong Kong, an average daily electricity savings of 16% was attained by implementing vertical greenery [23].

The next economic benefit is that vertical greenery is suitable for retrofitting projects. It is crucial to initiate energy conservation retrofits such as incorporating vertical greenery to reduce energy consumption as 32% of energy consumption originates from heating and cooling [24]. By doing so, it is also more economical than the demolition of the old building and reconstruction of a new building [25].

The implementation of vertical greenery helps to create new job opportunities in the economy. Therefore, new businesses and job opportunities are formed in the economy when the government and private sector initiate on adopting vertical greenery to enhance the environment and have an identity in the green market [26].

Besides that, adopting vertical greenery can increase property values because of its aesthetic and functional properties. This means that vertical greenery is a marketable green feature as it adds value to homes and businesses.

3.3 Social Benefits

Vertical greenery is aesthetically pleasing as it enhances the architectural design. In the urban environment, vertical greenery can hide and obscures unappealing sights by covering the deformed structure surfaces with plants [26].

Moreover, vertical greenery can serve as a function to isolate views. Mechanical and electrical components of a building’s system requirement that ruin the aesthetic of the building can be hidden by using vertical greenery [12].

Other than improving the appearance, several studies have linked plants to improving human health and mental well-being. Symptoms like headache might be reduced to a minimum of 20% [27]. Mental health can be improved as green plants in working environment and classrooms are able to decrease absenteeism among employees by 5-15% while the stress level of students decreased; at the same time the productivity of the students increased by 12% [28].

Vertical greenery is developed to reduce the negative impacts of rapid urbanization by providing other alternatives for green spaces to city dwellers [26]. By connecting the occupant directly to natural elements, occupant satisfaction and productivity can be increased [29].

| CATEGORY          | SIGNIFICANCE                              | SOURCES                                      |
|-------------------|-------------------------------------------|----------------------------------------------|
| ENVIRONMENTAL     | Temperature reduction                     | (Wong et al., 2010); (Pe’rez et al., 2011);  |
|                   | Reduce urban heat island and regulate     | (Hunter et al., 2014)                        |
|                   | microclimate                              | (Gomez et al., 1998); (Lp et al., 2010);     |
|                   |                                           | (Sheweka & Mohamed, 2012)                    |
• Improve air quality (Amir et al., 2011); (Donahue, 2011)
• Enhancement of biodiversity (Sharp et al., 2008)
• Improve energy efficiency (Raji et al., 2015)
• Improve rainwater retention (Ottele, 2010); (Wan. 2011)

ECONOMIC
• Improve acoustic insulation (Wong et al., 2010); (Ottele et al., 2010); (Azkorra et al., 2015)
• Energy savings (Perez et al., 2014); (Bass & Baskaran, 2003); (Kim et al., 2012)
• Suitable for retrofitting projects (Birkeland, 2009)
• Create new job opportunities (Başdoğan & Çığ, 2016)
• Increase property values (Vancouver Green Wall Canada, 2009)

SOCIAL
• Improve human health and well being (Butkovich et al. 2008); (Bringslimark et al. 2009)
• Provide a pleasing and better environment (Urban Planters, 2018); (Başdoğan & Çığ, 2016); (Wood et al., 2014)
• Hides/Isolate unsightly features (Sharp et al., 2008)
• Aesthetically pleasing (White & Gatersleben, 2011)
• Greener skyline as part of city branding (Chiang and Tan, 2009)

Despite the above-mentioned advantage, intensive literature review found that vertical greenery is not a popular topic in Malaysia. No government authority or professional board has comprehensive record of vertical greenery building in Malaysia.

3.4 Barriers to Implementation Of Vertical Greenery
3.4.1 Cost of Green Construction. Based on the calculations, the total cost of vertical greenery for a surface area of 35 meters x 50 meters is certainly more costly than the conventional horizontal planting. The most expensive type of vertical greenery is ‘green facade (steel mesh)’. The material price of steel itself is high which leads to this type to be the most expensive, costing RM4,872,000. The is followed by ‘living wall’, being RM3,129,000 and lastly the most economical type of vertical greenery, ‘green facade (HDPE)’, costing RM2,520,000. This may be a reason why builders and clients choose to let go of option of incorporating vertical greenery in their buildings.

3.4.2 Lack of Technical Knowledge. [30] asserted that although innovative green technologies are introduced, the construction project team are not knowledgeable enough towards the technical specifications and operations of the green technologies. As a result of inadequate skills and unfamiliarity, there is a higher risk of error and delay that might occur during the construction period.

3.4.3 Possible Increase in Insect and Pollen. By implementing vertical greenery, the amount of plants may be a home to unwelcomed creatures, a source of diseases and a bearer of doom [31]. Although
vertical greenery is perceived to improve air quality, there are concerns towards the fear of more insects and the discomfort of pollen allergies that some people are allergic to it.

3.4.4 Damage to Building Façade. Through a micro scale, vertical greenery may be a potential damage towards the facade through the growth of the plants. The suckers and tendrils can damage the surface of the facade and leave pattern of marks when removed [32]. [32] also observed that rainwater goods may become blocked while extensive growth may force gutters and other fixtures from the wall. On a macro scale, there will be extra loadings of greenery on the building’s structural system [29].

3.4.5 Competition for Use of Façade. There is a significant competition for the uses of exteriors of buildings [33]. This indicates that there is limited usage of the building exterior as the facades may be financially maximized with glassing to provide solar access to building interiors. Alternatively, the building facade may also be used in the advertising field as advertisement signages and media facades, for instance, the GreenPix wall in Beijing.

3.4.6 Lack of Policy and Standard. A lack of standard for green exteriors is the cause of poor designs which results in undesirable situations [33]. Thence, developers are not keen to take a huge risk to implement vertical greenery as there are risks of having faulty designs.

3.5 Approaches To Increase The Implementation Of Vertical Greenery
Vertical greenery is something worth implementing hence initiatives and approaches should be taken to increase its implementation.

3.5.1 Public Awareness. To utilize greeneries in buildings, public awareness about the applications and significance of vertical greenery is needed [10]. As such, public awareness is needed to help ensure that people understand the pros of implementing vertical greenery and to encourage them to implement it.

3.5.2 Government Initiative. Government may increase grant allocations for research and development (R&D) to be conducted on vertical greenery. Since it is a relatively new field in Malaysia, grants can be allocated for vertical greenery to promote this emerging greenery.

3.5.3 Educational Programs. [34] identified that educational programs for developers, contractors and policy makers related to green building standard procedures was a significant strategy for boosting green building guidelines adoption.

3.5.4 Better Enforcement of Green Building Policies and Standards. Having a set of standards would give the builders a clearer direction and ensure that the construction to implement greenery is on track and built accordingly.

3.5.5 Green Rating and Labelling. The ratings and labelling a building as a green building would give the developer and owner a valuable recognition in the industry and this recognition would push stakeholders to be part of the green building adoption [35].

3. Methodology
The research approach for this research is qualitative method. Qualitative method is conducted to obtain facts and clarifications regarding vertical greenery. Structured interviews with five experts as per Table 2 were conducted to obtain valuable data. Structured interview is a formal interview whereby a detailed questionnaire is prepared. This is to guide the question order and the specific method the questions are addressed, thereby permitting more direct comparability of responses [36]. Interviews were conducted with interviewees from various positions but from similar background. This is done in order to obtain information on vertical greenery and understand their respective point of views on implementing vertical greenery in Malaysia.
The data were then analyzed through content analysis. Content analysis allows qualitative data to be analyzed in a systematic and reliable manner, followed by conclusions drawn from them. This research is conducted for the case in Malaysia as this country has yet to unfold in vertical greenery implementation for buildings.

Table 2. Position of Interviewees.

| No. | Interviewees                                      |
|-----|--------------------------------------------------|
| 1.  | Managing Director of a Vertical Greenery Company |
| 2.  | Operations and Engineering Manager               |
| 3.  | Project Architect / GBI Accredited Facilitator   |
| 4.  | Assessor of GreenRE                              |
| 5.  | Assistant Manager of GreenRE                     |

4. Results and Discussion

4.1 Findings 1: Significances of Vertical Greenery

The first objective of this research is to determine the significance of implementing vertical greenery in Malaysia. As a result, the findings on the significance of vertical greenery from the interviewees show that there are a number of benefits that vertical greenery brings. The benefits of vertical greenery are categorized as environmental, economic and social.

The most impactful environmental significance is temperature reduction. Significant differential of temperature reduction can be achieved in a hot and humid environment like Malaysia. This is in line with [37] statement whereby the potential thermal benefits of vertical greenery in a tropical climate leads to temperature reduction of the building facade surface temperature. Consequently, this leads to the cooling load and energy costs to be reduced. Majority of the interviewees also agree that vertical greenery can improve energy efficiency, improve air quality and reduce urban heat island effect and regulate microclimate. Based on analysis on data obtained from interviewees, rainwater retention improvement may not be the case for vertical greenery. Likewise, vertical greenery may not be beneficial in terms of biodiversity enhancement. This is because the facility management would usually use pesticides to get rid of the insects.

As for the top economic significance, energy savings ranks the first. Majority of the interviewees support that vertical greenery leads to energy savings. This is parallel to [23] research discovering that during the summer months in Hong Kong, an average daily electricity savings of 16% was attained by implementing vertical greenery. The following top economic significances are acoustic insulation improvement and the fact that vertical greenery is suitable for retrofitting projects. Most retrofitting projects have minimal ground space for landscaping, hence one of the solutions would be to allow plants to grow upwards where space is a constraint.

Moreover, the most impactful social significance is that vertical greenery provides a pleasing and better environment. All of the interviewees gave positive reviews on this benefit. By the same token, connecting the occupant directly to natural elements, occupant satisfaction and productivity can be increased [29]. The least impactful social significance is isolating unsightly features. Some interviewees agree that vertical greenery helps in this sense whereas some stated that vertical greenery is costly hence it is not used to hide unsightly features. It is more towards enhancing the appearance of the building.
4.2 Findings 2: Barriers to the Implementation of Vertical Greenery

The second objective of this research is to identify the barriers to the implementation of vertical greenery in Malaysia. As analysed through the data collected from the interviewees, the cost of green construction is the main barrier that building owners and builders are not keen to implement vertical greenery. The high cost in constructing vertical greenery leads them to think that vertical greenery is not a necessity. Aside from construction cost of vertical greenery, maintenance also incurs cost, so it must be taken into account as well. The reason behind the high cost of vertical greenery is because there are very few vertical greenery experts and so people do not see vertical greenery as a necessary cost to be included in their budget.

The following top relevant barriers comprise of lack of policy and standard and lack of technical knowledge. A lack of standard for green exteriors is the cause of poor designs which results in undesirable situations [33]. Based on the analysis on data obtained from the interviewees, possible increase in insect and pollen is not a barrier because insects and pollens can be minimized through careful considerations. Likewise, vertical greenery will not cause damage to building façade if proper construction has been planned out and if it is maintained properly. Having said that, these two points contradict the statements from the literature review.

4.3 Findings 3: Approaches to Increase the Adoption of Vertical Greenery

The third and final objective of this research is to provide approaches and recommendations to increase the adoption of vertical greenery in Malaysia. Based on analysis carried out, the government should intervene and impose policies on vertical greenery. Several policies that could be imposed would be to make vertical greenery a compulsory criterion for GBI buildings, government buildings and new buildings. Moreover, the government can provide financial incentive for building owners who implement vertical greenery. Financial incentives provide a beneficial economic support in the industry, especially for individual stakeholders or firms in the adoption process of green building technologies because it usually involves higher investment cost compared to traditional building technologies [35].

An interesting finding from one of the interviewees is that the ultimate reason vertical greenery is implemented is due to the fact that it is a premium addition to properties, as such it will increase property value. Another interesting finding is that vertical greenery is installed at areas with a lot of vehicle movement in order to improve the air quality. This is a great idea that can be applied to minimize the pollutants around these areas, thus providing better air quality.

5. Conclusion

More than half of the interviewees had given favourable feedback that Malaysia is heading towards the right direction in implementing vertical greenery and the progress is encouraging. With the positive possibilities that lie within vertical greenery, vertical greenery is a promising solution to improve the environmental, economic and social impacts. Although the barriers to implement vertical greenery exists, the significance of vertical greenery outweighs the barriers of it. Thereby, Malaysia should increase the implementation of vertical greenery.

Further research can be done on the benefits of vertical greenery, namely the temperature reduction and reduction of urban heat island and regulation of microclimate. This is to measure the actual impact that vertical greenery has on the two benefits stated. A scientific research can be conducted by comparing the temperature difference between a building with the presence of vertical greenery and a building without vertical greenery. This future research provides a good follow up to show the actual results.

Apart from that, Green Building Index (GBI) has a set of criteria for their assessment. Vertical greenery falls under the sixth and last category, that is ‘Innovation’. One point out of 100 points would be scored for vertical greenery that covers at least 10% of the facade area. According to these data, it
seems like GBI rating tool does not have a huge emphasis on vertical greenery. As such, further research should be carried out to identify reasons behind such assessment.

Another recommendation for future research is to identify which species of plants work best to achieve the benefits of vertical greenery. For instance, certain plant species have a higher potential in providing energy benefits. As each plant species would have slightly different characteristics, scientific research on selected plant species can be conducted to identify the most suitable plants for the intended purposes of vertical greenery.

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