International Journal of Engineering Research and Technology. ISSN 0974-3154, Volume 12, Number 12 (2019), pp. 3089-3095
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Green-Wall Benefits Perception According to the Users' Versus Experts' Views

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Abstract

The green wall is an old design element with new techniques that have been integrated into the design process of the built environment, especially the commercial administrative enclosure spaces in Egypt; therefore, there is a need to figure out the landscape experts and in parallel the public users awareness about vertical green walls systems and the benefits provided, while using the green wall inside the enclosure space helping in knowing the perception of both experts and users about the weight of importance of each benefit provided through using the green walls that will be a good layer to be used as an evaluation criterion for these several systems alternatives through the design process inside the enclosure spaces. Therefore, the paper focuses on the benefits of the green walls as a solution of built environmental problems in Egypt as the vertical living walls contribute to significant flexibility in the urban environment with high population density. The research paper aims to explore the viewpoints about vertical green walls being applied in Egypt the research of vertical green walls systems assumption in Egypt, taking into consideration the perception of landscape architects (experts) and the public in Egypt (users) about the appropriation of vertical greening in the built environment (enclosure spaces) and green walls environmental, flexibility, social (psychological and aesthetical), economic preferences of experts and users in Egypt according to the characteristics design of vertical green walls installations.

Keywords: Vertical green walls; Built-Environments; Aesthetics; Enclosure space.

1. INTRODUCTION

Throughout history, integrating green into the envelope of the building has drawn attention. Plant's impact on the envelope of a building is necessary for enhancing sustainability of the environment. It is visually and ecologically conventional as a suitable architecture element that upgrades the building envelope. Nowadays, energy consumption has been witnessing improvements leading to an energy-conscious design approach that protects high-density population urban areas from changing into a harmful natural environment.

In the 21st century, the green building envelope is yet again attracting interest so that it can bring nature back into the existing dense urban clusters. Growing care in the environmental problems created a base for integral solutions, combining nature with a technical approach to make use of the multiple benefits of green, forming a component of current urban design.

2. GREEN WALL

Green walls are formed of plants grown up in vertical supported systems that are in general connected to either internal or external walls; in rough cases, however, they can be self-supporting. Like many green walls, green roofs combine and integrate growing medium, vegetation, irrigation mechanism, and drainage into one single system. Living walls differ from green facades in that they incorporate multiple plantings to create the vegetation cover rather than depending on lower numbers of plants that are climbing and spreading to provide cover. Also, they are known as vertical gardens or bio-walls; (See Fig. 1) provides the two main typologies of green walls and some of their subcategories' typologies. While the Green facade in the form of building envelope is associated with the climbing plant, the living wall consists of building envelope associated with a system with growing media plus plant [1].

Fig 1. Types of green walls
(source: https://efb-greenroof.eu/green-wall-basics).

2.1 Green Facade

The green facade is constructed in the case of hanging or climbing plants alongside the wall. The plants be able to grow upwards the vertical building surfaces, as like the traditional ways; otherwise, they can grow downwards the vertical building surfaces, in case they are hanged at a certain height. It is classified directly (See Fig.3) or indirectly (See Fig. 4), in which the direct green building's facade is the case in which the vegetation is directly attached to the wall, while indirect green building's facade consists of the supporting structure for vegetation (See Fig. 2). [1]

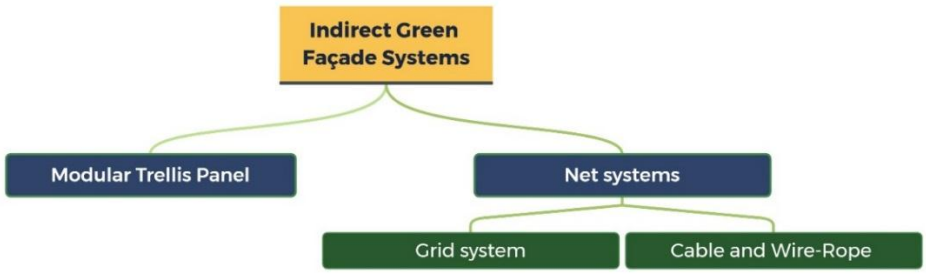

Fig.2. Indirect systems of green facades
(Source: Thompson and Sorvig 2000).

Fig. 3. Direct green facade in Amsterdam
(Source: https://www.urbangreenbluegrids.com/measures/green-facades).

Fig. 4. Indirect green facade in Amsterdam
(Source: https://www.urbangreenbluegrids.com/measures/green-facades/).

2.1.1 The Modular Trellis Panel System

The main structure of this system is a 3rd-dimensional, rigid, and lightweight panel fabricated from a galvanized coated powder and welded wire steel in which the vegetation is supported with both the depth of the panel and the face of the grid. It is designed to grip the green facade of the building envelope surface, so that vegetation does not attach directly to the building, providing a captive growing medium for the vegetation with dual supports for the tendrils and supports to maintain the integrity of a building envelope. The panels are joined and stacked covering large areas or structured to form curves and shapes; they are made of recycled content steel and are recyclable. As the panels are rigid, they can be used for freestanding green walls and span between structures (See Fig. 5). [2]

Fig. 5. Modular walls hung trellis (left) and curved trellis (right)
(Source: www.greenscrren.com).

2.1.2 Grid and Wire-Rope Net Systems

Both systems grid and wire-rope net are using ropes and cables (See Fig. 6 and 7). The grids are engaged on the designed green facades to upkeep a faster rate of growth for climbing vegetation with high dense foliage. While wire-nets are frequently used to upkeep a slower rate of growth for vegetation that needs the associated support, these systems exist at close intervals. Both systems are using steel cables with high tensile and anchors and with complementary equipment. Different patterns and sizes are able to provide flexible accommodations as vertical and horizontal by using the wire-ropes as they are connected through cross clamps. [2]

Fig. 6. Grid system, Ex Ducati Office, İtaly
(Source: http://preprodtest.archdaily.com).

Fig.7. Grid and wire-rope net systems, MFO Park, Switzerland
(Source: http://christianbarnardblog.blogspot.com).

2.2 Living walls

They are called bio-walls or vertical gardens. Those systems are structured of pre-vegetated panels, Mat walls, and modular living walls. They are made of plastic, expanded polystyrene, synthetic fabric, clay, metal, and concrete and support a great diversity and density of plant species. Living walls need more protection than green facades because of their diversity and density of vegetation. Living walls consist of 3 parts which are a frame made of metal, a layer of PVC, and a layer of air (no need for a soil) (See Fig. 8). This system has the ability to support a large number of plant species, such as a mix of vegetation that consists of perennial flowers, ferns, and low shrubs. It has a good performance rate in several climate environments. On the other hand, the living walls allow for a better species selection that may adjust to the different climatic conditions so that the system is easily maintained. In general, they are using an automatic system for irrigation and nutrition, so the process of maintenance of the living walls goes in an easy way. [3]

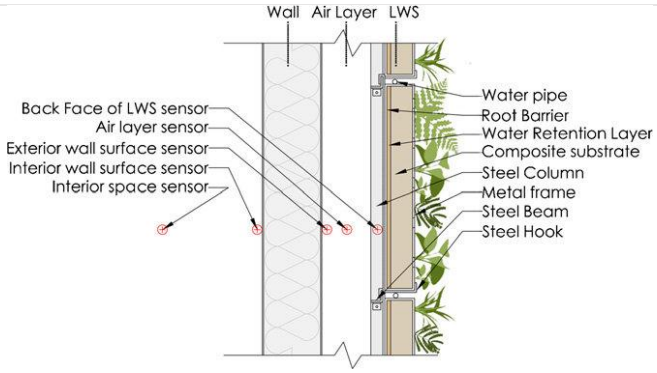

Fig. 8. Living wall system detail

(Source: https://www.researchgate.net/figure/Details-of-the-living-wall-system_fig3_286379887).

2.2.1 Vegetated Mat Wall

It is a special green-wall form founded via Patrick Blanc. It consists of 2 synthetic fabric layers with pockets that support growing media and vegetation in a physical way (See Fig. 9). It is backed by a membrane of waterproof and supported with a frame alongside the envelope of the building because of its content with high moisture. On the other hand, the nutrients are distributed primarily via an irrigation automated system that irrigates the water from the top to the bottom of the system. [3]

Fig.9. Vegetated Mat walls, Madrid, Spain
(Source: http://www.museumofthecity.org).

2.2.2 Modular Living Walls

The modular living walls arose through the use of modules in the applications of the green roof, with a large number of technological innovations. These systems are structured from panels with rectangular and square shapes holding the growing media to support vegetation material (See Fig. 10). The system takes different shapes like flexible bags, vessels, trays, and planter tile. The growing medium composition could be custom-made upon the unique combination of the selected vegetation and upon further design purposes. Most of the vegetation nutrient requirements can be found in the growing media inside the modules. On the other hand, the irrigation is provided with the modular system on different levels alongside the building envelope, using the factor of gravity to let the water move through the growing media. These systems often provide the ability to include pre-grown plantings, providing a direct greenery effect upon the installation completion. Considering that it takes between 12 and 18 months, it might be needed to generate a fully grown modular system. [3]

Fig. 10. Newcastle's Marks and Spencer store unveils a modular living green wall
(Source: https://i2-prod.chroniclelive.co.uk/).

3. BENEFITS OF VERTICAL GREEN WALLS

Vertical green walls are useful as they offer a settled number of public and private benefits such as the benefits below with ecological engineering principles [4]:

- **A. Social** benefits
- **B. Flexibility** benefits
- **C. Environmental** benefits
- **D. Economic** benefits

3.1 Social and Ecological Benefit of Green walls

Green walls social effects consist of 3 main aspects as follows: physiological aspect, aesthetic aspect, and health aspect, presenting the relationship between human activities and behaviour with the vertical green walls. [5]

3.1.1 Psychological Aspects

The psychological aspects depend on subjective attributes and responses of humans, putting into consideration people interaction process with the urban environment with a lack of nature within its context, causing depression and anxiety as a result from the lack of nature. Horticulture adaptable relationship between human and plant reducing blood pressure, anger, muscle tension, stress, and fear. [6]

3.1.2 Aesthetic Aspects

The visual quality of urban space symbolizes the character of the built-up environment. Public urban spaces ought to be able to provide a satisfying aesthetic and sensory experience. The visual quality of public urban spaces is formed by the urban image as well as manipulating the spatial behaviour of every separable element. [7]A good image for public urban space will encourage the emergence of good observation and meaning, encouraging the community to interact with a good reaction to its public urban spaces. [8]

3.2 Green Walls Flexibility

Flexibility is the motion range in one joint or set of joints; also it is the scheme in which joints are effectively movable over a complete range of motion. It is the capability of modification or adaptation with several conditions (See Fig. 11).

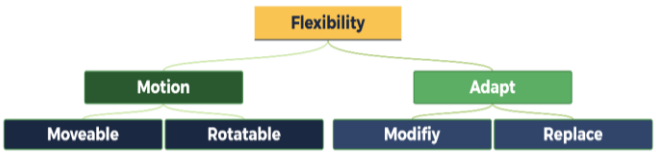

Fig. 11. Flexibility chart
(source: author).

The building envelope integrates green wall with dynamic facade; in recent years, it evolves conceptually from principally aesthetic design; otherwise, it is a designer artistic expression, and the vegetation becomes a building element, with definite functions to improve the building in addition to its relationship with the environment.

3.2.1 Kinetic Living Walls' Potential Applications

Typically, the human being has been the movable element to achieve access to immobile green walls. But, in case the wall itself becomes movable, it is a potential. The living wall design flexibility that keeps dimensions for dynamic mobility put forward several applications on structures level of typology and heights variety (See Fig. 12). [9]

The movable green walls are useful to be used for walls windows and doors shading; moreover, they provide food-growing plantings and vertical gardening for occupiers of multistory prototype buildings, as well as maintaining habitat structures, for example, bird perches; moreover, they provide the same visual effects as the natural green areas, for example, ornaments of gardens. [9]

Fig. 12. US pavilion at expo 2015 in Milan dynamic living walls

(Source: https://www.archiscene.net/location/italy/us-pavilion-expo-2015-milano-biber-architects/).

3.2.2 Living Walls' Kinetic Approach

Deploying living walls as kinetic facades provides flexibility of a living wall design which possesses the capacity for dynamic mobility, putting forward many applications on structures of several types and heights. Dynamic living walls can be used for the following:

- Shading walls.
- Windows and doors.
- Providing gardening.
- Food-growing.

These potential uses, kinetic living walls panels can take a variety of forms and movable mechanisms, to provide the manifold functions of shading joined with growing plants for a variety of purposes. Deploying these walls compromises an initial typology, established mainly on the movement aided within the wall motion (Figure 13). Variants of this typology are defined as follows (See Fig. 13): [10]

- The Hinged Green Window Wall.
- The Sliding Balcony Door Green Wall.
- Folding Green Brise-Soleil.

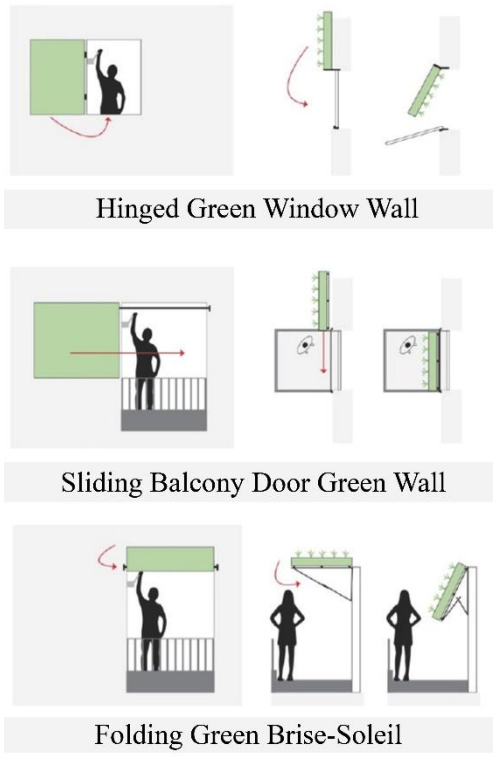

Fig. 13. Movable green walls design possibilities
(Source: https://green.uw.edu/gsf/project/2032).

3.3 Environmental Ethics

Facades and hardscape materials surfaces have an impact on the microclimate of the built-up environment surrounding causing rise in the temperatures rates around the buildings

which leads to discomfort inside and outside the buildings as well as increasing the amount of energy used for air-conditioning systems. The use of green infrastructure as green walls is an alternative for the building skin, which helps in heat energy consumed by evapotranspiration (See Fig.14). [11] Moreover, green infrastructure as green walls helps in mixing of air, so the temperature in contact with their surfaces is rated to be lower than the surrounding areas built. Warm air rises up over the hard surfaces and is swapped by the fresh air as well as reducing the heat island effect. The vegetation can help improve local air quality by reducing the assembly rate of smog and oxygen. "Smog" is reduced by using the two following techniques: [12]

- The first technique with reducing particle up in the air.
- The second technique reducing the temperature.

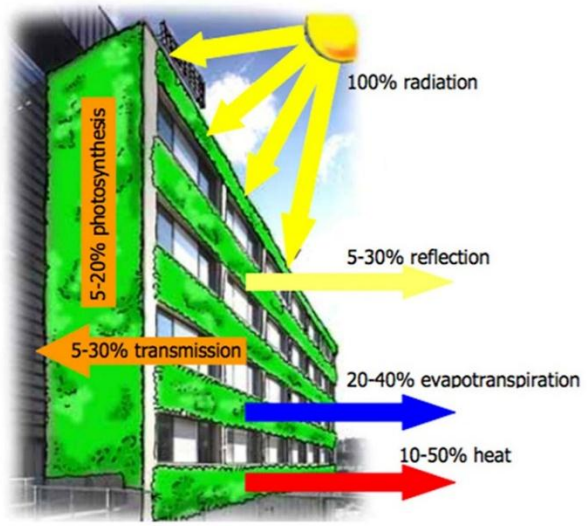

Fig. 14. Solar Radiation Transmission of Green Facade *(Source: https://content.iospress.com/).*

3.4 Economic Benefits

The economic benefits are in parallel to the environmental benefits of the green walls. The economic benefits of green walls can be realized through the utilization of plants on building's facade that reduces the climatic stress as well as protecting the construction integrity which leads to longevity of buildings. [13] Furthermore, the utilization of green wall reduces environmental effects on the building envelope, which decreases energy consumption. [14]

4. STUDY OBJECTIVE

The main objective of this study is to study the perception of landscape architects experts and the public user's prior knowledge about the green walls benefits and the importance of each benefit to be taken into consideration while designing green-wall alternatives, which helps in showing the social acceptance towards using it on building facades to achieve sustainable urban perspectives inside enclosure commercial administrative spaces in Egypt.

5. METHOD

A survey was designed to explore the green walls benefits importance weight to achieve sustainable urban perspectives inside enclosure commercial administrative spaces in Egypt. 100 questionnaires were distributed randomly to different users. Moreover, 50 questionnaires' prints were distributed equally to landscape architects. The researcher clarified the questionnaire type every time, without explaining the purpose of the questionnaire to avoid directing the answers in a certain direction. The experts and the users were asked to vote about the importance weight starting with the social benefits on the scale of these 2 branches: psychological and aesthetic; flexibility benefits, environmental benefits, and economic benefits, according to their opinion on how each quality can affect the psychological aspect of the urban perspectives inside enclosure commercial administrative spaces in Egypt on the scale as "1" is least while "5" is most important (See Table 1).

Table 1. Survey for experts and users.

Green walls benefits		1	2	3	4	5
Social	Psychological					
	Aesthetic					
Flexibility						
Environmental						
Economic						

6. QUANTITATIVE ANALYSIS OF OUTCOMES

The experts and users both were asked the same question that explores their awareness about the green-wall benefits with direct yes-or-no answers. The results show that the experts were majorly aware with a percentage of 89%. In contrast, the user's sample results show that they were equally divided between knowing the term and being unfamiliar with it. It is figured out that there is a variation between user's considerations and the landscape architects experts design priorities (See Fig. 15). When designing a contemplative green wall with testing five benefits of green walls performance through a quantitative analysis which shows the differences in the weight of importance for each aspect upon expert's point of view compared on the other side with the user's perceptions.

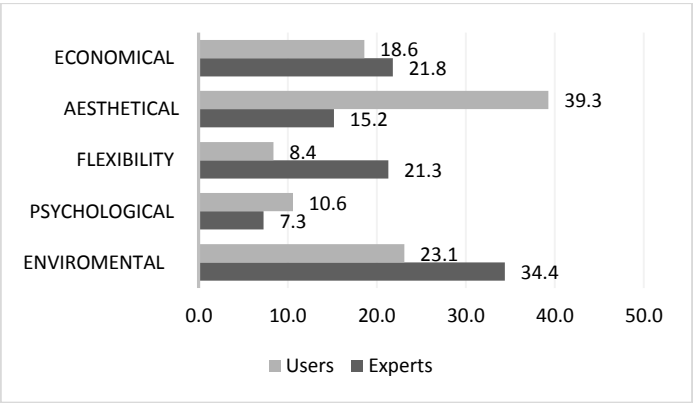

Fig. 15. The experts' (landscape architects) and users' perception about the benefits of green-wall importance weight. *(Source: author).*

7. CONCLUSION

According to the landscape expert architect's point of view, the most important aspect is the environmental factor. On the other hand, the user's perceptions aesthetics factor is the highest factor to be taken into consideration while the design process is taking place, so it was found that the landscape expert landscape architect's point of view and the user's perceptions have some variations in the weight of importance; therefore, the mean of these aspects is calculated to conduct the summarized consequences of the quantitative analysis.

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