

**Green interior walls and their use in sustainable  
commercial spaces**

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**Abstract**

The environmental, economic and social dimensions represent the basic pillars of sustainable development - and the environmental dimension aims at achieving ecological balance, preserving the natural and constructed environment from the negative effects and its repercussions on human health and productivity. One of the most important pillars of sustainable architecture is to achieve a healthy internal environment where it must be ensured the system of materials and buildings does not cause the emission of toxic gases in the internal environment, and to ensure the quality of the indoor air through continuous purification, and to take advantage of the properties of plants used in the indoor spaces.

Green interior walls are one of the solutions of contemporary interior architecture, which began to be used mainly in architectural facades, and moved to the interior spaces to realize its multiple benefits - which include environmental, psychological and economic aspects, and green interior walls require adequate awareness of the structural and design style of it, and Drainage and feeding operations, taking into account the insulation system, and its construction loads.

The research studies green interior walls, and the most important design and technical considerations for them. Its multiple benefits in contemporary commercial interior spaces, which include the environmental aspect such as indoor air purification, the design aspect in which the properties of these plants are employed in terms of the external line, color and texture of the selected plants, and the commercial side, where they can be used as central attractions that achieve advertising goals for institutions Commercial.

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### **Introduction**

Contemporary environmental problems, on top of which is the problem of pollution, have led to the existence of internal environments that are unsuitable for humans - in terms of proportions of air components, which cause many diseases to humans, as well as distance from the standard of indoor air quality and efficiency, which hinders a person from work and life. Creativity appropriately, and leads to exacerbating the problem of sick buildings, leading to other problems such as increasing the waste of resources and energy sources in order to achieve thermal and acoustic comfort in the internal space, which puts people in a vicious circle of environmental problems that lead to exacerbating the other. The environmental, economic and social dimensions represent the basic pillars of sustainable development - and the environmental dimension aims to achieve the ecological balance and preserve the natural environment built from the negative effects and its implications for human health and productivity.

The principle of achieving a healthy internal environment is one of the most important pillars of sustainable architecture. Where it is necessary to ensure that the system of materials and buildings does not cause the emission of toxic gases in the internal environment, and to ensure the quality of the indoor air because of its significant effects on the human feeling of comfort and increasing its productivity in working environments, and protecting it from many diseases and their symptoms. Green interior walls, or what is called - vertical gardens - are one of the contemporary environmental interior architecture solutions, through which the interior designer seeks to achieve an environmentally balanced and design interior design of. Through linking the human being to nature and its components, as the designer takes into account the economic needs of contemporary man - the most important of which is establishing the principle of not wasting environmental resources, reaching thermal and acoustic stability in the internal spaces and developing the concept of the creative image.

Integrated plastic in the internal sustainable commercial spaces.

### **Statement Of the Study:**

The limited environmental solutions for contemporary internal commercial spaces in Arab societies, which are in line with the rules of sustainable design, despite the exacerbation of environmental problems associated with these societies greatly, and the waste of natural resources and non-renewable energy sources, to confront these problems in contradiction with the general principles of sustainable development.

### **Research problem:**

- 1- How can the interior designer enhance the design of the internal environment for commercial spaces - in particular - (thermal, acoustic, and aesthetic) and reduce the negative effects of the sick building phenomenon without resorting to a solution that wastes energy?
- 2- What are the design and construction standards for green walls in interior spaces?

3- What are the best types of indoor coordination plants that can be used in green walls in commercial spaces to enhance the internal environment?

4- How can an interior designer use green walls to achieve the required visual communication, and support the marketing process for commercial products in an innovative and sustainable way?

**Green architecture and the use of the principle of internal coordination for contemporary interior spaces:**

As for the interior spaces - the green design refers to a complete system achieved by the design of the internal environment of the building. It does not harm the environment - likewise, the building

Green adapts to the environment and society to enrich human life. The principle of using internal coordination plants and employing them to purify the air is one of the concepts stipulated in sustainable architecture

(Green) as green buildings primarily aim at resource efficiency at all stages of the building's life cycle, reducing the overall impacts of the built environment on human health and the natural environment through energy and water use efficiency and reducing waste, pollution and environmental degradation in order to protect the health of the vacant space. The internal environment, raising the productive efficiency of workers in the space, and improving the internal environment to avoid sick building syndrome.

**Sick building syndrome and its causes:**

The quality of the air inside the buildings is very important, as its main function is to give an appropriate and healthy atmosphere to the users, as the occurrence of any defect in this air leads to disturbance in the building and its function and damage to the health of its users. Which is related to the place of work of the person or his place of residence with the sick buildings.

**The main causes of this disorder are:**

- Insufficient ventilation in the building.

Low humidity.

- Increased temperatures or a large change in temperature between day and night.
- Lack of light, which may cause glare to the eyes of users.
- Decreased standards of hygiene in the work environment.

**Ways to reduce the sick building problem and the symptoms it causes:**

Eliminate or reduce the source of pollution.

Imposing restrictions on (smoking behavior, use of wall paints, use of adhesives, solvents, and pesticides in a well-ventilated area, preferably not inhabited).

Always ensure the place is clean and remove the mold and algae that may accumulate due to the presence of moisture in certain areas of the building, such as ceilings, tiles and carpets.

Ventilation increased to 4.4 air exchange / 24h.

- Working to clean the air is a method that has certain limitations, but it is useful as it is done by using air filters, as these filters capture pollutants not completely, but in an amount that highlights the difference in using them from their absence in the place. Indoor coordination plants used to purify the air are scientifically known as biofilters, or

With biological therapy

The use of plants in the indoor environment is one of the most important reasons that work to achieve the quality of the internal environment by achieving the environmental standards set by Leadership in Energy and Environmental Design (LEED), which include quality.

Thermal, indoor lighting quality and indoor air quality (IAQ)

Yassin, Adel, Green Architecture, Supreme Council of Culture, 2002

Standards for "indoor air quality" seek to reduce volatile organic compounds and other air impurities such as microbial pollutants. As most building and cleaning materials emit gases, some of which are toxic, such as volatile organic compounds and formaldehyde. These gases can have a harmful effect on users' health, comfort, and productivity.

Controlling the accumulation of moisture in the internal spaces, which leads to the growth of mold and the presence of bacteria and viruses, as well as dust particles and other microbiological organisms, is considered, and this is achieved with adequate ventilation in order to eliminate moisture inside from its sources.

Also, maintaining the proper indoor temperature and controlling the airflow in the HVAC system, as well as having the building envelope properly designed also helps in increasing the building's thermal quality.

### **Indoor coordination plants and their role in air purification:**

Indoor air quality is a term that refers to the air quality in and around buildings and facilities, especially as it relates to the health and comfort of building residents.

The use of indoor coordination plants is one of the most important means to achieve IAQ indoor air quality, as it reduces the elements of air pollution and volatile organic compounds in indoor spaces and reduces the concentration of carbon dioxide CO<sub>2</sub>, which is directly related to the decrease in work performance in closed areas. NASA since the year 1141 researched to study the internal environments of space colonies in which the most important types of indoor plants were identified to raise indoor air quality and reduce airborne germs and toxins, for their ability to absorb volatile organic compounds.

### **The difference between Living Walls and Green Facades:**

Living Walls have a growth medium "soil" fixed vertically on the walls, while on the façades.

Green Facades, whose soil is only in the lower area of the vertical wall "in a soil container or directly in the ground" and in that case green plants are of the climbing type to create greenery or a green wall and are supported by cables or trellis and cable materials vary Of steel, galvanized iron, stainless steel, types of wood, plastic and aluminum. Living walls are installed on the wall of the building or freestanding, and may be external to the facades of the buildings or internal to the internal space (the subject of the research) Green walls grow in a sheet system Modular Panels, each of which is filled with natural soil, or one of the other growth media (such as foam, felt, perlite, or mineral wool) according to the natural method of plant growth - in order to adequately deliver nutrients to the plant.

### **Leaders in design and implementation of the green wall system:**

- Professor Stanley Hart White from the University of IllinoisUrbanachampaign, who obtained a patent for the first known vertical garden in 1134, and his paper was titled "Vegetation-Bearing Architectonic Structure And System" and related to the patent on the structure and the architectural system based on vegetation Verticals of any size, shape, or height are buildable, and White's ideas were not fully developed.

Patrick Blanc (born on June 3, 1153, Paris), a botanist working at the French National Center for Scientific Research, worked on inspiration for plant arrangements found in Thailand and Hawaii 8, to create patterns of vivid green shades that coats concrete walls. He collaborated with the architect AdrienFainsilber and the engineer Peter Rice to design and implement the first successful model of interior green walls in the Cité des Sciences et de l'Industrie in Paris in 1146.

### **Green Wall Systems:**

Green wall systems differ greatly in design and construction.

#### **Hydroponic green wall systems**

Water green wall systems can be either in standard containers or large panels. The systems are installed on the original wall-mounted structures, or as a stand-alone structure, to create an air isolating gap between the wall and the green system.

Medium is provided for the growth of plants such as horticultural foam, mineral fiber or felt mat, felt mat and these materials act as a sponge that retains water, and although this system is relatively heavy, it is characterized by its longevity without being damaged, and it does not accumulate fertilizer salts and nutrients. Over time, plant roots grow and bifurcate through the entire system to create a very strong network.

#### **Substrate-based system**

These systems use containers made of plastic or metal, or bags of water-permeable synthetic fibers. It is filled with soil directly. The containers are connected to each other and rest on the main wall or on a separate metal frame or rack that is structurally safe. The individual grow containers can be removed for maintenance or replanting. Most of the substrate-based systems are designed for automatic irrigation, just like green wall systems

### **Growth media for green gardens:**

#### **Loose media**

Soil-on-a-shelf "or" soil-in-a-bag "loose media" which is a soil transported into the building in the form of shelves or soil containers. The soil should be changed every two years in the internal vertical gardens. The vertical wall height of this system should not increase. For this system is suitable for domestic and seasonal indoor spaces, where the quality of cultivated plants is changed almost semi-annually.)



The system does not fully bear the movement changes that occur to the soil during plant growth, so it is preferable for regular semi-annual maintenance.

#### **Mat system: Mat media**

Using coir fiber or felt mats, which is suitable for indoor spaces and plants are small and medium in weight, the system is replaced as a whole every 3-5 years to overcome the problems of growth in the soil medium. An auxiliary irrigation system is needed for the soil because it is not able to fully retain water in view. Due to its limited thickness, the vertical wall height of this system does not exceed 241 cm

The two systems require a re-circulation system

Panel System: Sheet media

Semi-open cell polyurethane

The system allows adequate saturation of irrigation water, and this material does not biodegrade organically and thus may last for twenty years for green walls (and is also used for green roofs)

The sandwich construction uses a separate irrigation system, each separated by an insulating layer, then it is applied to the wall with alkanes.

#### **Construction Medium: Structural media**

The system is considered the best for achieving a variety of areas, shapes, thicknesses and water densities options for the variety of cultivated plants

Special needs for green walls in commercial interior spaces:

- **Pay attention to the quality** and quantity of suitable lighting for plants to ensure

Flower growth of different types of plants appropriately (tropical and subtropical plants are more tolerant to the lack of light compared to plants in the Mediterranean environment)

- **The need for good ventilation** as the wall plants occur

The green exterior provides effective ventilation, while in the interior spaces, care must be taken to have an effective ventilation system to prevent the plants from being exposed to the growth of fungi.

#### **Good Waterproofing:**

It can be achieved by creating an adequate air gap between the back of the planting system and the wall, where the air gap acts on the interaction between the inner wall and the plants and their roots, thus separating the walls from

Moisture, mold growth and susceptibility to dissolved salts in fertilizers. And if green walls are constructed without an air gap, waterproofing membranes can be used

The use of waterproofing membranes to protect construction walls from moisture and mold, and the figure shows the arrangement of layers used in one of the green wall systems, which are from left to right: (for the insulation layer - the structural system - the irrigation system - plants growth containers - plants).

#### **The most important environmental problems for commercial spaces (commercial centers - large stores) in Egypt, and**

##### **Employ green walls to alleviate them:**

- 1- Thermal comfort, where the need for an effective cooling and heating system and the waste of energy and electricity resources to achieve it.
- 2- Lack of indoor air quality in closed commercial centers.
- 3- Noise due to the large number of users of commercial spaces.
- 4- Poor contact with nature, as these areas are dominated by cold solid physical elements.
- 5- Poor effective visual contact, which would make parts of the commercial space visually or sensually interconnected by the viewer, and the absence of effective visual attraction points.
- 6- Weak use of green walls for advertising in commercial areas.

**First: Thermal comfort, where the need for an effective cooling and heating system and the waste of energy and electricity resources to achieve it.**

Green walls can reduce the heating and cooling expenses by reducing the heat gain or loss through the walls since the solar radiation is absorbed only a little, and also the heat is lost through the evaporation of water from the plants. Studies were conducted at Kobe University, Japan, and proved to reduce cooling and heating expenditures in the spaces

Which contain green roofs (external) and green walls significantly, taking into account the crowded centers and shops in Egypt need thermal comfort associated with cooling due to the high temperature of these spaces most days of the year, not only in summer.

Digram demonstrates the reduction of costs and energy wasted in cooling and heating in areas that contain green roofs and walls significantly (increases energy savings in the case of cooling, which gives a comparative advantage to the green wall system in crowded commercial buildings in Egypt)

Research at Università IUAV di Venezia, Venezia, Italy has also proven the ability of green walls to reduce costs associated with the cooling and heating system. Expenses are reduced by 40:10% in a Mediterranean climate. 15 “The Egyptian northern coast falls within the Mediterranean region.

**Second: Lack of indoor air quality in closed commercial centers:**

Green walls have an important role in repairing the poor air quality, whether in the interior or exterior areas Figure No. (20) and this is done by drawing the polluted indoor air across the wall covered with plants and returning it cleanly to the interior space. The system is integrated into the building's ventilation system.

The living wall removes up to 20% of common pollutants, which greatly improves indoor air quality and improves oxygen levels in an environmentally sustainable way.

**Third: Noise due to the large number of users of commercial spaces:**

Noise is produced by vibrating objects due to movement or knocking on them

Or its friction or resistance with other objects, as the side of the

Its energy into sound, the more energy converted into sound, the more

The sound was loud, and when an object vibrated, it pressed on the air in front of it

In one direction, then the air permeates as the object moves in the opposite direction and repeatedly

This results in a series of compression and rarefaction of the air, which spreads in it away from the vibrating body, and when it reaches the human ear, it causes the sensation of hearing.

Just as the sound waves emanating from more than one source can interfere, so the sound appears in some places with a greater intensity than the sum of the intensity of the sounds emanating from all sources in what is known as the constructive interference of sound waves, and when the waves are periodic and nearly regular, this leads to a feeling of pleasure and comfort, as in the case of music. As for the irregular, which consists of a large number of patrol vehicles, they hear noise, and thus the noise problem is one of the most important problems of commercial spaces in Egypt.

- The sounds of dozens or hundreds of cars that fall within the vicinity of the commercial building
- The sounds of songs and overlapping music.
- Voices of hikers and store-goers.
- People sitting in cafes and restaurants in the food court

Studies in Pontificia Universidad Católica of Ecuador PUCE have proven the ability of plants to control noise depending on the intensity, tension and direction of the sound, and on the location, height, width and density of vegetation cover, the nature of the species that make up it, and the way they are arranged in the vegetation barrier (cover). The vegetation with a width of 1.7: 17 meters reduces the noise by 10: 20 dB, that is, more than 70% of the noise level 17, and among the most important plant species with a strong anti-noise effect are evergreen species and high density species, and one of the most important plant types for vertical gardens are Achieved noise absorption in the interior spaces are ferns. ferns

Also, one of the factors that reduce noise using green walls is the suspended medium on which plants grow

**Fourth: Weak contact with nature, as these areas are dominated by cold solid material elements.**

In light of the significant increase in land prices for the establishment of commercial projects, it becomes very difficult to find suitable spaces for internal coordination plants that spread horizontally in the surfaces of commercial spaces in Egypt, in addition to providing green walls for comfortable and inspiring natural visual spaces for humans and providing the possibility for social interaction in An atmosphere of psychological comfort

And physicality to get rid of psychological pressure, deal with stress, and generate creative ideas 19 through the human being's association with green nature as one of the foundations of bio philia, which means the love and connection of man with nature and the consequent feeling of comfort or satisfaction with life. 20

One of the green walls in Miami, Vertical Garden In Miami, and how to transform the space that contains it from stagnation, coldness, flatness, and the lack of a sense of nature that gives an atmosphere of peace and psychological calm in the space to the diversity of colors, touch and connection with nature, which encourages a feeling of comfort and satisfaction

**Fifth: Poor effective visual contact, which would make the parts of the commercial space interconnected and communicated visually and sensually by the viewer, and the absence of effective visual attraction points.**

Green interior walls work to achieve visual sequencing and interconnection in the interior space effectively, as well as serving as central attractions for visitors to commercial spaces. Example:

The Third International Conference: Creativity, Innovation and Development in Architecture, Heritage, Arts and Literature “Future Visions in the Civilizations and Cultures of the Arab Nation and the Countries of the Mediterranean Basin” Alexandria 28-30 April 2018  
The new central part of Papadakis Building for Integrated Sciences at Drexel University Philadelphia-Drexel University's

Integrated Sciences Building Philadelphia, new Papadakis, which has obtained LEED Gold certification from the US Green Building Council of the United States 21, which contains a green wall that is 41 feet high and 22 feet wide and is designed by Nedlaw Living Walls. The wall brings a new dimension to the inner courtyard

It enriched the vertical visual communication in the space of the courtyard and worked to reduce the coldness of colors and materials used in the design and reduce the repetition in the architectural elements that make up the six-storey balconies overlooking the courtyard, and also added diversity in the touches in the design of the interior through the diversity of sizes, shapes and growth patterns of plants used In the green wall, whether flowering

Or not, and this becomes clear when comparing the design of the two sides of the inner courtyard contained on the green wall and the other side of the courtyard The third international conference: Creativity, innovation and development in architecture, heritage, arts and literature “Future visions in the civilizations and cultures of the Arab world and the countries of the Mediterranean basin” Alexandria 28 - 30 April 2018

**Sixth: Weak use of green walls for publicity and advertisement in commercial areas.**

Green walls can be used as a medium for advertising well in commercial spaces, Example (1): Adidas Sports Company () A, B - Example (2): Shop in san-diego\_laporta Adidas promotes environmental and social sustainability, as shown by one of its exhibitions Using green wall design for publicity after accidents in the Bangladesh apparel industry, international sportswear giant Adidas has strengthened efforts to improve working conditions for workers. The brand is encouraging factory workers affiliated with its Asian suppliers to share opinions and grievances. An ILO initiative that works better and encourages direct and easy communication between the company and factory workers. In 2111 this company was the first sporting goods company to report on sustainability. Use green walls to design a shop logo in san-diego\_laporta, and do diversity in

The use of indoor plant types and the contrast between colors and textures to highlight the brand's design, in addition to the previously mentioned benefits of indoor green walls for interior spaces, it has general environmental benefits.

**The Most Important Results**

- 1- Returning to communication with nature is one of the most important factors that support a person's physical and psychological health, his ambition and his performance at work - so we must not ignore it.
- 2- Vertical solutions for employing internal coordination plants are among the most appropriate solutions for commercial spaces in Egypt in light of the high price of land and the narrow urban areas for their residents.
- 3- The use of green walls in the field of propaganda and advertising works to spread the environmental culture indirectly, by seeing these live works of art by a large number of people who are the visitors of the Egyptian commercial centers
- 4- The vertical walls represent successful focal points, dividing and directing traffic routes in the busy shopping centers.



Green walls greatly increase the material value of the buildings they contain, which constitutes economic aspects that cannot be neglected by the owners of these buildings

### **Recommendations:**

The possibility of using green walls in commercial spaces to grow some fruit plants and use them (such as peas and spinach that are already grown as green wall plants) and medicinal) as is the case in the MaPharmacie pharmacy in Paris, which uses the walls inside it to grow approved medicinal herbs and sell them as approved medicines and That exploitation of green walls carries with it the economic value of the green wall, and connects the vacant commercial interior spaces with their environment and society.

- Encouraging the work of the green wall system in the Egyptian commercial areas to solve environmental problems instead of the tendency to waste energy - in the era of challenges in the field of energy.
- Supporting biodiversity in the green wall environment is one of the most important priorities that we encourage in the era of the extinction of many rare plant species, as there are 42 types of local wild plants threatened and endangered in Arab societies out of more than 411 types of plants that were registered with the Ministry of State for Affairs Environment (template for an environment report in the United Arab Emirates)
- The necessity of using a gray water recycling and reuse system and a green wall irrigation function - to support the water conservation plan in Egypt, which we advocate repeatedly, in the current environmental and economic conditions.
- The importance of encouraging small and medium Egyptian investors to invest in the field of green walls, due to their large environmental, economic and design characteristics.
- Searching for less costly solutions that do not depend on major construction complications, to apply it as a green wall system and support expansion in Egypt.



**Recommendations:**

- 1- The research recommends the necessity of conducting studies and research on the creative industries that have become basic industries that contribute to the development of the economy in general.
- 2- Setting rules and legislations to protect the rights of creative production and supporting creative industries are among the priorities of cultural policies.
- 3- That the designer has a great understanding of sustainability principles.
- 4- Development of cultural, environmental and economic awareness among the segments of society

**Objectives:**

Understanding the most important design considerations for the use of green interior walls, as an environmental solution that alleviates many of the thermal, sound and design problems in the commercial spaces in Egypt. And contributes to achieving the quality of the internal environment, taking into consideration the energy efficiency in these spaces, and the large numbers which are constantly present in it.

**Results:**

- 1- Communication with nature is one of the most important elements that support human physical and psychological health, and support man ambition and performance in work - so we must not ignore that.
- 2- Vertical solutions for internal landscape plants are considered among the most important solutions which are suitable for commercial spaces in Egypt , Where land prices are rising and urban areas are shrinking for Its inhabitants .
- 3- Using green walls in the field of Publicity and advertising works to spread the environmental culture, by seeing these works of art by a large number of people in commercial centers.

4- The vertical walls represent successful focal points, for division and directing of movement paths in crowded commercial centers.

5- The green walls increase the monetary value of the buildings that contain them, which concederdas an economical aspects that cannot be neglected to owners of those buildings.

**Recommendations:**

1- The possibility of using green walls in commercial spaces to grow some fruit plants (such as peas and spinach, which are already cultivated as green wall plants) and medical plants (as in MaPharmacie in Paris, which uses the green walls to grow medicinal herbs and sell them as medicines). ). That exploitation of green walls gives economic value for it, and connects people in commercial spaces with their environment and society.

2- Encouraging the green wall system in Egyptian commercial spaces solve many environmental problems instead of the tendency towards wasteful energy in the era of challenges in the energy field.

3- Supporting biodiversity in the green wall environment is Considered one of the mostimportant priorities which we encourage in the era of extinction of many rare plant .

4- The need to use gray water recycling system in the green wall irrigation ,to support the water conservation plan in Egypt ,which we encourage in the current environmental and economic conditions.

5- The importance of encouraging small and medium-sized Egyptian investors to invest in green walls for their great environmental, economical and design properties.

Find less expensive solutions that do not rely on large structural complications to be applied as green wall system and support its spread in Egypt.

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