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Investigating the Challenges of Implementing the Vertical Greenery Systems in Egypt from the Public's Perception

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Abstract

Sustainable solutions are needed to protect the environment and the planet from the adverse impacts of human activities, such as pollution, resource depletion, and global warming. Vertical greenery systems (VGS) enhance biodiversity, reduce urban heat island effects, provide indoor and outdoor comfort, and improve air quality. The Authors adopted a data collection strategy to study the VGS benefits in various aspects and review its types and the important aspects of their longevity, in addition to studying the primary challenges of implementing VGS in Egypt including cultural and social, economic, environmental, Government Policies, infrastructure and technology challenges with a detailed explanation of each challenge. The Authors then adopted a Data analysis strategy by conducting an online questionnaire to investigate how the public perceives the challenges involved in implementing VGS in Egypt, by examining the most significant aspect of each of the multiple challenges limiting the installation of VGS in Egypt and rating the impact of each challenge based on how much it would limit the adoption of VGS in Egypt, as well as ranking the challenge that has the highest impact on Egypt's implementation of vertical greenery systems. The Authors concluded a prospected framework concerning the primary challenges of implementing the vertical greenery systems in Egypt from the public's perception, highlighting the challenges that have the highest impact on avoiding the implementation of the VGS in Egypt.

Keywords

Vertical greenery systems; Implementation challenges; Public's Perceptions; Egypt; Economic Challenges

1. Introduction

There are certain negative impacts of human activity and rapidly expanding cities on the environment. To safeguard the environment and the planet from harmful effects of human activity such as pollution, resource depletion, and global warming, sustainable solutions are required. Using vertical greenery systems has several positive impacts on the economy, the environment, and society in addition to lowering temperatures (Safikhani, Abdullah, Ossen, & Baharvand, 2014 a).

Creating a greener building envelope with an emphasis on vegetated green facades is an excellent illustration of a new construction technique. In the case of living wall systems (LWS), plants and partially growing materials serve a variety of advantageous purposes, such as enhancing biodiversity and ecological value, reducing the impact of the urban heat island effect, providing comfort both indoors and outdoors, improving air quality, and enhancing the social and psychological well-being of city dwellers (Ottelé, Perini, Fraaij, Haas, & Raiteri, 2011).

Egypt is going through a period of rapid economic growth, urbanization, and shrinkage of green space, which is causing environmental issues including pollution, drought, and the heat island phenomenon to arise in the metropolitan regions (Momtaz, 2018).

Temperatures in urban areas have risen over time relative to the surrounding rural areas as impervious surfaces have replaced vegetated surfaces. Considering that concrete surfaces radiate, absorb, and hold much more solar energy than trees and grass (Momtaz, 2018).

It is more important than ever to make better use of the planet's limited resources through proper architectural solutions. One of the most significant developments in this field is the application of wall greeneries to lower energy usage, carbon emissions, and city temperatures in large cities (Gawad, 2018).

Accordingly, the primary objectives of the research can be illustrated through the following:

- Studying a general interface for the vertical greenery systems highlighting the main advantages, benefits & roles in various aspects, in addition to reviewing its types and the important aspects of their longevity.
- Studying the primary challenges of implementing the vertical greenery systems in Egypt including cultural and social challenges, economic challenges, environmental challenges, Government Policies, Regulations & Stakeholders Engagement challenges, and infrastructure & technology challenges with a detailed explanation of each challenge.
- Conducting an online questionnaire aimed at investigating how the public perceives the challenges involved in implementing vertical greenery systems in Egypt. This questionnaire was widely disseminated to responders from several Egyptian governorates to examine the most significant aspect of each of the multiple challenges limiting the installation of vertical greenery systems in Egypt and to rate the impact of each challenge based on how much it would limit the adoption of vertical greenery systems in Egypt as well as to rank the challenge that has the greatest impact on Egypt's implementation of vertical greenery systems.
- Conducting a prospected framework concerning the primary challenges of implementing the vertical greenery systems in Egypt from the public's perception, highlighting the challenges that have the highest impact on avoiding the implementation of the VGS in Egypt.

2. Methodology

The methodology of the research is divided into Three main phases; the first phase is the Theoretical part followed by the data analysis method, and finally, the third phase aimed at conducting a prospected framework concerning the primary challenges of implementing the vertical greenery systems in Egypt from the public's perception. **Figure 1** shows the methodology of the research.

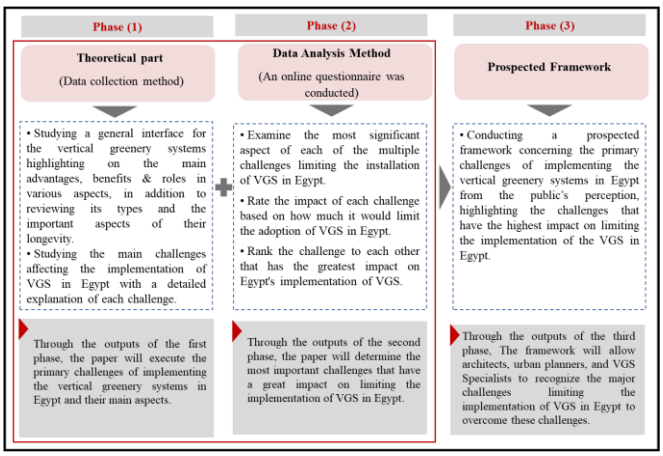

Figure 1. Research Methodology (Authors).

3. Vertical Greenery Systems (VGS)

Vertical greenery systems have become more important as sustainable building design elements since they can improve a structure's environmental impact. Vertical greenery systems are plants grown on vertical surfaces. This allows for the vertical growth of one or more plant species on any surface, whether natural or artificially created, within or outside of a building, attached to a wall, or standing alone in front of a wall. Vertical greenery systems are defined as those that grow all types of plants on all types of vertical surfaces. These systems were referred to by a variety of names and terminologies, such as biowalls, vertical gardens, vertical landscaping, and vertical greenery systems (Safikhani, Abdullah, Ossen, & Baharvand, 2014 a).

The incorporation of vegetation onto structures, such as green roofs or vertical greening, has a positive impact on both the inhabitants' well-being and the climate of metropolitan areas. On the other hand, one of the primary causes of the urban heat island effect has been identified as the relative absence of vegetation in many cities (Gawad, 2018).

Recently, an increasing number of individuals are becoming aware of the financial advantages of vertical greenery systems. Using vertical greenery systems as window shadings is one method. Appropriate shade systems, which are facilitated by vertical greenery systems, have the qualities of increasing daylight and minimizing uncomfortable glare, which ultimately results in a decrease in the need for electricity. They can also regulate storm waters and function as porous surfaces. Vertical greenery systems are more cost-effective than demolition and reconstruction and are appropriate for eco-retrofitting projects that aim to improve human and environmental conditions (Safikhani, Abdullah, Ossen, & Baharvand, 2014 a).

As a result of their role in the vertical mixing of air, they also tend to have cooler temperatures than the built-up areas around them. Fresh air replaces warm air that rises over hard surfaces, reducing the impact of the heat island effect (Gawad, 2018). The temperature drop might impact the building and the surrounding urban area, depending on how densely the plants are arranged in the green walls (Gawad, 2018).

In every categorization, the type of vertical greenery systems is mostly determined by the location of growing media. The growing media provides nourishment to the roots of plants. Growing media may remain on the ground, allowing only vertical plant growth to envelop the vertical surfaces. Known as the "green facade," it is typical of traditional architecture. Furthermore, growing media can be positioned vertically in front of the vertical surfaces. The term "living wall" refers to this contemporary method (Safikhani, Abdullah, Ossen, & Baharvand, 2014 a), as shown in **Figure 2**.

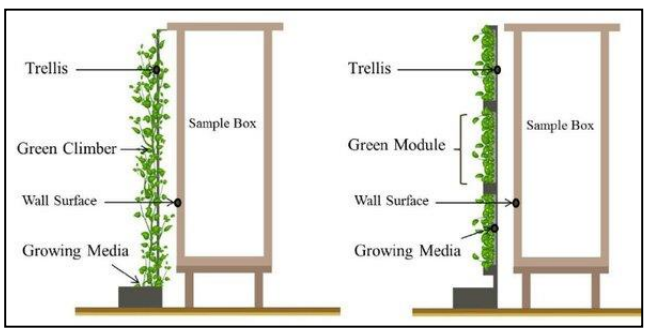

Figure 2. Types of Vertical Greenery Systems (Safikhani, Abdullah, Ossen, & Baharvand, 2014 b).

Living walls may support a wider variety of plants since their substrates are arranged vertically and include growing media in carriers. The panel, felt, or container systems are frequently used for living walls. Panel systems are

affixed to the structures with pre-planted panels. Felt systems are made up of felt pockets that are planted with plants and affixed to the structures' waterproof walls. Plants in container systems are potted and climb the trellises (Safikhani, Abdullah, Ossen, & Baharvand, 2014 a).

An important aspect of the longevity of vertical greenery systems is the selection of suitable vegetation. To determine which, plant species are appropriate for a given climate, investigations into the life, growth, and environmental adaptation of plants are necessary. Since some plant species can only survive in a particular environment and others cannot, these studies are especially significant for outside plants. In addition, the performance of vertical greenery systems is influenced by the watering system, maintenance practices, and installation techniques (Safikhani, Abdullah, Ossen, & Baharvand, 2014 a).

The efficiency and performance of vertical greenery systems can be enhanced by strategically selecting plants for specific uses. While monitoring is necessary throughout the growth period for both living walls and green facades, different criteria apply when choosing appropriate plants. Long-stalk vines are suitable for covering green facades and are typically chosen for this purpose (Safikhani, Abdullah, Ossen, & Baharvand, 2014 a).

3.1. Challenges of Implementing VGS in Egypt

Egypt is not widely recognized for its huge urban parks and cutting-edge environmental initiatives. Both the natural environment and the welfare and comfort of city inhabitants have been directly impacted by the "Cementification" of its urban areas and the greater amount of asphalted exteriors in comparison to urban greening. This problematic state could also be related to the metropolitan environment's deficiency of greenery and vegetation, which studies have shown to be essential for inhabitants' psychological welfare. However, the use of greenery on building facades promotes an energy-conscious design philosophy that keeps crowded cities like Cairo from degenerating into a decaying natural habitat and, as a result, plays a significant part in determining the real estate value of the urban area (Gawad, 2018; Momtaz, 2018).

The amount of space available for urban greenery increases in price and scarcity as a city's population grows. The creation of three-dimensional urban space and the complete utilization of existing urban levels, building planes, and facade spaces for greenery are the results of the conflict between the scarcity of urban land and the rising demand for urban greenery. Even if there are progressively more buildings with vertical gardens, there are still certain difficulties. Among the most crucial is the requirement for immediate financial gains. This mostly entails translating environmental and social benefits into indirect economic gains, which somewhat reduces development drive (Wu, Wang, & Wang, 2023).

To compensate for the expensive input and maintenance costs within 10 or even thirty years, additional tasks must be done. As a result, choosing an appropriate building space carrier is essential. The primary motivation for encouraging the continued development of building greenery is the carrier's ability to maintain certain economic advantages while optimizing the environmental and social value to cover its operational costs (Wu, Wang, & Wang, 2023).

Climate is an important consideration in determining which plant species are suitable for a certain area, and each climate and region should have its own unique set of tests conducted. The results of the investigations show how crucial plant quality and climate adaptation are to the growth process and wall surface covering of plants. Further research is needed to understand the applications, qualities, substrate structures, and other maintenance requirements of the plants used for living walls, even if the plant species selection is more varied than for green facades and is not restricted to plants with long stalks (Ottelé, Perini, Fraaij, Haas, & Raiteri, 2011).

The most significant green wall systems currently available are living walls and green façades, each of which has some subcategories that are constantly emerging in the market. When selecting the right green wall for a given project, consideration should be given to both the overall benefits and drawbacks of the option as well as its construction method, climatic constraints, and aesthetic

appeal (El Menshawy, Mohamed, & Fathy, 2022).

Over the past decade, Cairo has seen several projects and programs that support urban gardening on rooftops and other locations to promote more environmentally friendly architectural solutions around the nation. Thankfully, Egyptian citizens and the government have responded favorably to these measures when they have been followed and put into action (Gawad, 2018).

Green facades have historically been associated with buildings with façade covered in vigorously growing vegetation. Climbing plants are a natural way to cover a building's facade, but they require an extended period to flourish. Unfortunately, the use of urban greenery has been linked to upkeep expenses, insect attraction, and deterioration of building materials. In comparison to the conventional ones, newer approaches that permit greening building facades have recently progressed both technically and conceptually. Various groups of building greenery systems and products are already starting to be placed, depending on how the greening of a building or construction's facade is designed, considering the various building greenery products and systems that are available on the market (Gawad, 2018).

One of the main advantages of green façades is how wastewater is managed. Watering is particularly effective when using a hydroponic or drip irrigation system. At the bottom of the garden, wastewater gathered. As an alternative, recycled water can be reused again (El-Zoklah, 2016).

Since green façades are living systems, they require maintenance. The client's maintenance schedule has a significant role in design elements, which influence the selection of plants and system types. Some plants will produce fruit or be deciduous, which can call for extra care. Cable tension needs to be checked regularly for wire-rope systems and cables. When deciding on the design of the facades, the type of vertical garden, plant selection, and design requirements, it is crucial to have a conversation with the customer about care (El-Zoklah, 2016; Momtaz, 2018).

Variations in the kind of materials utilized, their longevity, capacity for recycling, water usage, and vegetation durability can all have a significant impact on the overall environmental weight. Each VGS, in turn, has unique qualities, benefits, and drawbacks based on their cost, maintenance requirements, and aesthetic possibilities. The best system to use depends directly on the building's orientation, accessibility, and height as well as the local climate, which includes rainfall, exposure to the sun, shadow, and wind. It is crucial to comprehend their primary traits and compositional variations as a result (Gawad, 2018).

Modular living wall systems have become increasingly popular in Egypt to reduce issues with replacement, maintenance, and installation. However, some untested installations suffered partial harm because of poor upkeep (nutrients or irrigation) or poor design (choice of plant species or façade orientation) (Gawad, 2018; Susorova, 2015).

Analyzing the applied systems' longevity as well as the rationale behind their installation is crucial. For instance, a panel of a Living Wall system constructed using Felt Layers has an average lifespan of ten years, but a Living Wall system relying on Planter Boxes is considerably more durable (lasting more than fifty years) (Ottelé, Perini, Fraaij, Haas, & Raiteri, 2011).

4. The Challenges of Public Acceptance in Implementing VGS in Egypt

The primary barriers to the public acceptance of vertical greenery systems in Egypt are the public's mistrust of the technology and its perceived efficiency. Egypt's public acceptance of vertical greenery systems is probably going to encounter a lot of resistance due to concerns including low perceived efficiency, expensive costs, and a lack of information or advice. The government should prioritize making the systems accessible and affordable in addition to giving clear, accurate, and current information to deal with public concerns to enhance acceptance (Knifka, Karutz, & Zozmann, 2023; Bakar, Mansor, & Harun, 2014). The adoption of VGS may be limited by Egyptians' cultural preference for customs and mistrust of foreign or Western-influenced technology. It is imperative to address

these cultural biases through community engagement and focused awareness initiatives (Morsi, & Elian, 2021).

Furthermore, the hot and dry climate of Egypt presents significant barriers to the effective application of VGS. The combination of high temperatures, little precipitation, and direct sunlight may stress the growth of plants and raise maintenance needs (Morsi, & Elian, 2021).

4.1. Cultural & Social Challenges

Traditional cultural norms, concerns about open spaces, fear of the unknown, and skepticism towards new ideas hinder public adoption of vertical greenery systems. Western roots and cultural attachments to historic structures may clash with modern vertical gardening techniques. The public's lack of knowledge about the advantages of green walls prevents them from being fully included in architecture (Jozay, Zarei, Khorasaninejad, & Miri, 2024).

Cultural and social considerations for implementing vertical greenery systems including resistance to change, lack of knowledge about the benefits of VGS, misconceptions, and misinformation, limited access to information, aesthetic preferences as well as traditional farming practices are fully discussed through the following.

- **Resistance to Change**

Public adoption of vertical greenery systems has been limited by several factors, including traditional cultural norms, concerns that place a higher value on open spaces and natural landscapes than on vertical greenery systems, fear of the unknown, and skepticism towards new ideas and technologies. Additionally, there appears to be a reluctance to accept foreign concepts and methods because vertical greenery systems are perceived as Western in origin. A further issue is cultural ties to old buildings and the maintenance of traditional aesthetics, which could conflict with the installation of contemporary vertical greenery methods (de Lamartinie, 2021).

- **Lack of Knowledge about the benefits of VGS**

The public's lack of understanding and awareness of the advantages of green walls prevents their acceptance and incorporation into urban planning and architecture (Jozay, Zarei, Khorasaninejad, & Miri, 2024). Additionally, there aren't enough grants or subsidies available for putting vertical gardening systems into action (Wong, Tan, Tan, Sia, & Wong, 2010).

According to other research, the degree to which locals accept vertical greening depends on how familiar they are with the system. To increase public understanding of the value and advantages of vertical landscapes, public awareness campaigns on these systems' benefits are required in Egypt (Gawad, 2018).

- **Misconceptions & Misinformation**

There is a lack of public awareness regarding the various kinds of vertical greenery systems that are accessible and how well they work in Egypt's various conditions. The public's lack of acceptance or appreciation of green walls in Egypt could limit their adoption and incorporation into urban areas (Jozay, Zarei, Khorasaninejad, & Miri, 2024).

In reference to the previous misconceptions, a study was carried out wherein stakeholders who had previously implemented wall greenery covering in their residential units attested to the fact that it did not meet their requirements and that they would not recommend this method to others. Based on the conducted interviews, wall planting is seen as a rather challenging task. Residents and users are primarily concerned with enhancing the design of these systems to achieve optimal performance throughout the installation, usage, and maintenance phases (Gawad, 2018).

- **Limited Access to Information**

Architects, engineers, and urban planners are not given enough training or information on the design and application of vertical greenery systems, which prevents them from being integrated into new construction projects. For architects, designers, and practitioners who need to comprehend the useful components of each approach when incorporating greenery into their designs, this information is essential (Manouchehri, López, & López, 2024).

Furthermore, the lack of case studies and success stories demonstrating the advantages of vertical greenery systems in other nations limits the incentive and inspiration to implement these systems. A study focused on First and

Fifth Settlements, a new neighborhood in New Cairo that is home to the Mid-to-high socioeconomic classes. Residents' choices for wall planting, balcony planting, and fence covering were the subject of a questionnaire that was also completed as part of the study. It was found that most flat owners would rather see an example to follow before adding any vertical vegetation to their homes (Gawad, 2018).

Additionally, there is a lack of outreach and communication from relevant organizations, such as environmental groups and associations for green buildings, to inform the public about the advantages and difficulties of utilizing vertical greenery systems (Umar, & Khamidi, 2012).

- **Aesthetic preferences**

The use of vertical gardens is a highly impacted approach to modifying the urban landscape by utilizing sophisticated materials and technology to encourage sustainable urban development. The innovative use of vertical gardens as an architectural solution to introduce plant elements for the renovation of historic structures undoubtedly improves the aesthetics of our towns (Momtaz, 2018). According to studies done to assess the aesthetic impact and perceived level of restoration that can be achieved by adding green facades to buildings, buildings with integrated green walls were viewed as more beautiful, aesthetically pleasing, and beneficial than those without any vegetation. Furthermore, from an aesthetic perspective, the significance of a suitable variety of plant species in the installation of a green wall (Momtaz, 2018).

There has been a substantial advancement in the field of Green and Living wall systems, as evidenced by the analysis of the most relevant systems used in Egypt. Several commonly used examples, either continuous or modular, highlight its minimal weight by utilizing polymeric and geotextile materials. When applying these technologies to the recovery of buildings, can be quite helpful. Additionally, aesthetic considerations are considered when evaluating the system, as the usage of façade plants may raise the economic value of some new neighborhoods (Gawad, 2018).

- **Traditional Farming Practices**

Since traditional farming methods are firmly embedded in the cultural and historical identities of many communities, many people still prefer them over vertical greenery systems. Farming practices are strongly rooted in the local knowledge base, customs, and way of life, having been handed down through the years. Giving up these deeply rooted customs can be challenging and disruptive (Kalantari, Tahir, Joni, & Fatemi, 2024).

The range of products that can be generated at a given time is the main difference between traditional farming and vertical farming or VF. In contrast to traditional farming, which produces only one crop at a time—a practice known as monoculture—VF farming allows for the simultaneous production of several crop varieties on several floors. Another benefit of vertical farming (VF) is that, in contrast to traditional farming, which is limited to a specific period of the year, plants grown in VF can thrive all year round (Kalantari, Tahir, Joni, & Fatemi, 2024).

Vertical farms, which bring agriculture indoors, may maximize the amount of crops per acre of land while simultaneously saving space and producing a range of food products. As so, vertical space can also be utilized efficiently, unlike in conventional farming (Kalantari, Tahir, Joni, & Fatemi, 2024). Outdated notions of urban or rural models need to change, as does the false belief that there is no room for farming within cities (Kalantari, Tahir, Joni, & Fatemi, 2024).

4.2. Economic Challenges

Due to financial and resource limitations, misconceptions about care requirements and costs are the root cause of fallacies regarding the viability and sustainability of vertical greenery systems, especially in Egypt (Jozay, Zarei, Khorasaninejad, & Miri, 2024). Economic Considerations including the cost of implementing VGS, financial constraints, and return on investment are fully discussed through the following.

- **Cost of Implementing VGS**

There are misconceptions regarding the viability and long-term sustainability of vertical greenery systems due

to a lack of understanding of the care needs and expenses involved. Green walls require a lot of infrastructure and maintenance, which might be difficult in Egypt because of possible budget and resource constraints (Jozay, Zarei, Khorasaninejad, & Miri, 2024).

Technical details, care guidelines, and information about plants appropriate for vertical greenery systems are limited in the area (Wong, Tan, Tan, Sia, & Wong, 2010). As a result, several options are suggested, including providing a set of instructions to help clarify the installation process of Green Walls, evaluating the viability of the project economically and outlining maintenance plans, and, finally, providing a list of potential suppliers and installers which could potentially be contacted for implementation and maintenance in the area (Gawad, 2018).

- **Financial Constraints**

Landlords and investors are cautious about requesting the implementation of vertical greenery systems due to a lack of knowledge about the economic and environmental advantages of these systems, even though their installation is reasonably inexpensive and has many advantages. People typically employ vertical greenery systems for their elegant characteristics; their ability to lower temperatures and provide economic benefits are less well-liked. To use these systems as efficient components for lowering temperature and cooling energy demand, a new push to employ them depending on their economic and environmental benefits is required (Safikhani, Abdullah, Ossen, & Baharvand, 2014 a).

- **Return on Investment**

Although installing vertical greenery systems is relatively inexpensive and has numerous benefits, landlords, and investors are hesitant to request their implementation because they are unaware of the systems' positive effects on the economy and the environment. Vertical greenery systems are usually used for their exquisite features; people are less enthusiastic about their capacity to reduce temperatures and offer financial advantages. A renewed drive to employ these systems based on their economic and environmental benefits is necessary to use them as effective components for lowering temperature and cooling energy consumption (Wu, Wang, & Wang, 2023).

To compensate for the expensive input and maintenance costs within 10 or even thirty years, more work must be done. As a result, choosing an appropriate building space carrier is essential. The primary motivation for encouraging the continued development of building greenery is the carrier's ability to maintain certain commercial benefits while optimizing the environmental and social value to cover its operational costs (Wu, Wang, & Wang, 2023).

4.3. Environmental Challenges

Climate is a major factor in deciding which plant species are appropriate for a certain area, and every climate and region should undergo a different set of tests. Findings of further research demonstrate how essential plant quality and climate adaptation are to a plant's ability to grow and cover its walls (Ottelé, Perini, Fraaij, Haas, & Raiteri, 2011).

Public awareness of the need for biodiversity conservation and how vertical greenery systems can enhance and support regional systems is lacking (Schlichenmayer, & Baeriswyl, 2021). Environmental considerations including potential harm to biodiversity, soil degradation and erosion, water pollution and depletion, and disruption of natural ecosystems are fully discussed through the following.

- **Potential Harm to Biodiversity**

The public has a limited knowledge of the value of conserving biodiversity and the ways that vertical greenery systems can support the preservation and improvement of regional systems. Because it promotes biodiversity, the green facade has an ecological value equivalent to roughly 80 mature deciduous trees (Schlichenmayer, & Baeriswyl, 2021). Urban vegetation can provide vital habitats and pathways for birds and other species. Biodiversity is a prerequisite for a healthy urban environment (NSW Government, 2015).

Additionally, adding greenery to an urban setting increases vegetation without utilizing any street-level space and improves the urban image indirectly by enhancing biodiversity (Ascione, De Masi, Mastellone, Ruggiero, &

Vanoli, 2020).

Collins et al. calculated the public's "willingness to pay" (WTP) to gauge their perception of the value of Green Walls (GWs) to urban biodiversity using Southampton as a case study. In-depth comparisons between (Living Wall) LW and (Green Façade) GF designs and "no green policy" have been made. A greater degree of WTP was linked to the LW in this investigation. Knowledge of biodiversity and aesthetic judgment were important factors in estimating the worth of the greening programs, which was more than the expected cost of investment (Ascione, De Masi, Mastellone, Ruggiero, & Vanoli, 2020).

- **Soil degradation and Erosion**

The roots of the plants get their nourishment from the growing medium. It could be felt, foam, regular dirt, or lightweight soil. The vegetation spreads out to cover the vertical wall of VGS when the growing medium is set up there. On the wall surface, the growing medium can be arranged vertically. Usually, the soil used will dry out if adequate and consistent watering is not given (Morsi, & Elian, 2021).

- **Water Pollution and Depletion**

On VGS, drip irrigation systems with automated timing mechanisms are frequently utilized. Time and money issues can arise from numerous irrigation system malfunctions. Regular maintenance should be performed on irrigation systems due to their limitations, and in the winter, appropriate precautions against the cold can be adopted. Other issues include huge containers, dry land, and leaky water. The soil and plants in the VGS containers tend to dry out rapidly, especially when they are left in full sun. Additionally, the water starts to exit the setup. All of the water that leaked from VGS would impact the wall and the entire process. Controlling the amount of nutrients during irrigation is crucial (Morsi, & Elian, 2021).

- **Disruption of Natural ecosystems**

Egypt's hot, dry weather can make it difficult for plants to thrive and survive in green walls, necessitating careful maintenance (Jozay, Zarei, Khorasaninejad, & Miri, 2024).

4.4. Challenges of Government Policies, Regulations & Stakeholders Engagement

The lack of awareness among Egyptian government officials regarding the advantages of vertical greenery systems, both socially and economically, is impeding the creation of positive laws and regulations. Funding and other measures may be required to promote green walls (Jozay, Zarei, Khorasaninejad, & Miri, 2024).

Considerations of government policies, regulations, and stakeholder engagement including the lack of supportive policies, complex regulatory framework, inconsistent enforcement, and involvement of non-governmental organizations and civil society organizations are fully discussed through the following.

- **Lack of Supportive Policies**

The lack of knowledge among government officials and policymakers regarding the possible economic and social advantages of encouraging vertical greenery systems is impeding the creation of laws and regulations that would be beneficial. Since current laws might not offer enough incentives or direction, it might be necessary to create a more encouraging regulatory framework to promote the adoption of green walls in Egypt. In Egypt, green walls can be greatly aided by government initiatives and funding. To promote their acceptance and incorporation into urban design, further encouraging laws and programs might be required (Jozay, Zarei, Khorasaninejad, & Miri, 2024).

- **Complex Regulatory Framework**

There is no comprehensive set of rules and regulations in Egypt that are designed with vertical green walls in mind. This can result in inconsistent implementation and confuses developers. Many government organizations are involved in the permitting procedure, which can be misleading when constructing vertical greenery walls. Project costs could rise as a result of delays.

- **Inconsistent Enforcement**

Many developing-nation cities lack the financial resources, authority in politics, or capacity necessary to carry out essential operations and provide essential services efficiently and effectively. Many municipal bodies

are fragmented and lack defined tasks and responsibilities, in contrast to the governing frameworks found in industrialized cities. In certain places, these institutional gaps prevent direct action since there are insufficient legal and informal laws, as well as insufficient tools and mechanisms for adaptation. Such gaps are enforced by the absence of formalized environmental policy.

There is insufficient supervision and enforcement of current green space regulations for new construction. Furthermore, there is insufficient coordination and conflicting priorities among several government agencies. The implementation of VGS will be fragmented if the departments of construction, environment, and urban planning do not harmonize their policies.

- **Involvement of non-governmental organizations and civil society Organizations**

Many non-governmental organizations (NGOs) and commercial civil entities are imitating some of the successful global "Agro-Housing" initiatives that are being developed, which aim to create vertical farms where families can grow food near their homes (Gawad, 2018).

These Egyptian organizations were able to establish hydroponic farming training programs and collaborate with locals in several Cairo informal areas to build gardening initiatives on walls and rooftops. Their goal is to raise the economic status of those living in these kinds of communities in Cairo, keeping a tiny portion of their earnings for their own operations, and selling their products on the neighborhood market (Gawad, 2018).

These private civil initiatives could integrate public environmental awareness with the local economic and social development of the Egyptian community by collaborating with the underprivileged citizens of the area (Gawad, 2018).

4.5. Infrastructure & Technology Challenges

Maintenance should not be an afterthought once the project is completed but rather should be considered throughout the planning stage to ensure the livability of green walls (El Menshawy, Mohamed, & Fathy, 2022). Also, assuring that the VGS has adequate structural support can be challenging from a technical standpoint (Morsi, & Elian, 2021). Infrastructure and technology considerations including maintenance, structural support system, and irrigation and drainage system are fully discussed through the following.

- **Maintenance**

To guarantee the longevity and livability of green walls, maintenance should be considered during the planning process rather than as an afterthought after the project is finished. As a result, a maintenance plan ought to contain the following: an explanation of the maintenance goals, performance standards, necessary skills, and resources. To ensure long-term success, a thorough maintenance plan must be created. This plan should consider the need for frequent inspections on three primary levels: the structural integrity of the fencing walls and building envelopes, the effectiveness of the irrigation system, and the development and survival of the plants. Therefore, professionals with the expertise of structural engineers, irrigation consultants, and horticulturists must be involved in this crucial stage (El Menshawy, Mohamed, & Fathy, 2022).

Since green façades are living systems, they all need maintenance. The client's maintenance schedule has a significant role in design elements, which influence the choice of plants and system type. Some plants will produce fruit or be deciduous, which can call for extra care. Cable tension needs to be checked regularly for wire-rope systems and cables. Before deciding on the design of the façade, the type of vertical garden, the plants to use, and other design elements, it is crucial to have a conversation with the customer about maintenance (El-Zoklah, 2016).

- **Structural Support System**

It can be technically difficult to ensure that the VGS has enough structural support to withstand the weight of the plants, growth medium, and watering system, especially when retrofitting onto older buildings. Effective load distribution requires careful engineering and design (Morsi, & Elian, 2021).

- **Irrigation & Drainage system**

It is necessary to guarantee sufficient irrigation, drainage,

and structural reinforcement. It's crucial to choose suitable plant species that can flourish in the local climate (Abd Ghafar, Abdulkarim, Said, & Jasmani, 2024).

It is essential to provide the VGS with a dependable and effective irrigation system since ineffective irrigation can result in problems like mold growth, water stagnation, and plant wilting. Moreover, efficient drainage is a crucial technical factor in preventing water damage (Conejos, & Chew, 2021).

5. Investigating the challenges of implementing the Vertical Greenery Systems (VGS) in Egypt from the public's perception

To precisely investigate how the public perceives the challenges involved in implementing vertical greenery systems in Egypt. A Google form was used to conduct an online survey that was widely disseminated to responders from several Egyptian governorates. To ensure that every question from the public was correctly understood, the questionnaire was prepared and written in both Arabic and English languages.

5.1. Stimuli

There are three sections to the questionnaire. The respondents' demographic information is in the first section. Using a multiple-choice format, participants selected the most significant aspect for each of the various challenges limiting the installation of vertical greenery systems in Egypt in the second section. Next, they rated the influence of each challenge on the implementation of vertical greenery systems in Egypt using a linear scale.

In the third and final section, participants were asked to rate the challenges according to each other in terms of how much they would affect Egypt's adoption of vertical gardening systems.

5.1. Procedures

An online questionnaire was used to collect the relevant data. There are three primary sections to the questionnaire form:

The first one: asked about the participants' age, gender, education level, governorate, whether they specialize in Vertical Greenery Systems, and rating their knowledge of Vertical Greenery Systems.

The Second one: employed multiple-choice questions to examine the most significant aspect of each of the multiple challenges limiting the installation of vertical greenery systems in Egypt. The participants were then asked to rate the impact of each challenge based on how much it would limit the adoption of vertical greenery systems in Egypt using questions on a linear scale.

In the third section: participants were asked to rank the challenge that has the greatest impact on Egypt's implementation of vertical greenery systems. This was accomplished using a multiple-choice grid with one answer required in each column, representing a rating scale from 1 to 5, where 1 represents the least importance while 5 represents the most importance, and the rows represent the five main challenges.

6. RESULTS & DISCUSSION

The results of the questionnaire can be discussed through the following:

The first section:

Overall, there are 150 respondents, and their demographic information is shown in the first section. Of the participants, 61.3% were from Cairo, 14.7% were from Al Qalyubiyah, 10% were from Giza, and the remaining participants were from other governorates. **Table 1** displays the findings of the participants' demographic data.

Table 1. Analysis of participants' demographic data (Authors).

	Age					Gender		Educational Level		
No. of participants	20-30	30-40	40-50	50-60	Above 60	Male	Female	Bachelor's degree	Master's degree	PhD Degree
150	27	61	37	14	11	62	88	56	31	63

By questioning participants if they were specialized in VGs or not, the results revealed that 10.7% of them were specialized in VGS while 89.3% were not. **Figure 3** illustrates their knowledge of Vertical Greenery Systems.

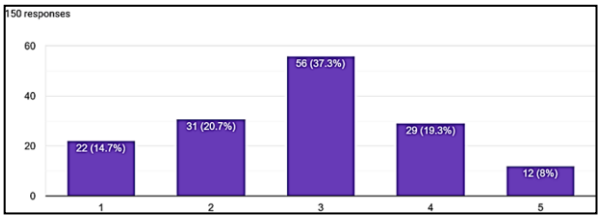

Figure 3. Participants Knowledge about VGS (Authors).

The second section:

The second section asked respondents to select the most effective aspect of each of the five challenges and then rank the importance of each challenge based on its influence on limiting the adoption of VGs in Egypt. The results were as follows:

- **Cultural and Social Challenges:**

By employing multiple-choice questions to examine the most significant aspect of each of the cultural and social challenges limiting the installation of vertical greenery systems in Egypt. The results revealed that the most effective aspects were the lack of knowledge about the benefits of VGS by 37.3%, resistance to change by 17.3%, limited access to information by 14.7%, misconceptions & misinformation by 14.7%, traditional farming practices by 10.7%, and aesthetic preferences by 5.3% respectively.

The participants were then asked to rate the impact of cultural and social challenges based on how much it would limit the adoption of vertical greenery systems in Egypt using a question on a linear scale. The participants' ratings of the Cultural & Social Challenges' effect on restricting the use of VGS in Egypt are displayed in **Figure 4**.

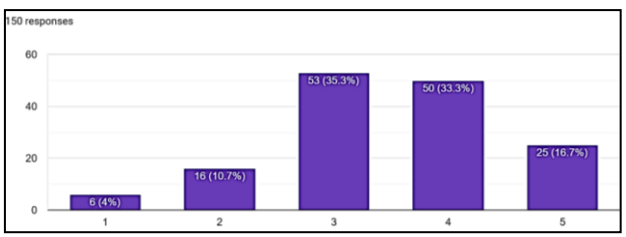

Figure 4. Rating The impact of the Cultural & Social Challenges on limiting the implementation of VGS in Egypt (Authors).

- **Economic Challenges:**

By employing multiple-choice questions to examine the most significant aspect of each of the economic challenges limiting the installation of vertical greenery systems in Egypt. The most effective aspects were the cost of implementing VGS by 54.7%, financial constraints by 26%, and return on investment by 19.3% respectively.

The participants were then asked to rate the impact of economic challenges based on how much it would limit the adoption of vertical greenery systems in Egypt using a question on a linear scale. The participants' ratings of the economic challenges' effect on restricting the use of VGS in Egypt are displayed in **Figure 5**.

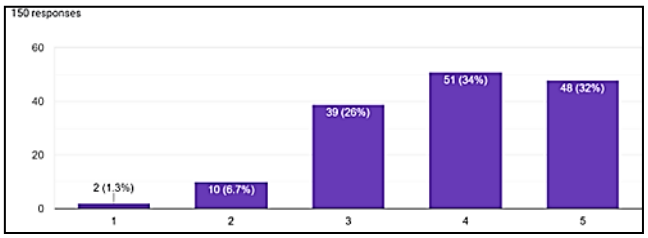

Figure 5. Rating The impact of the Economic Challenges on limiting the implementation of VGS in Egypt (Authors).

- **Environmental Challenges:**

By employing multiple-choice questions to examine the most significant aspect of each of the environmental challenges limiting the installation of vertical greenery systems in Egypt. The most effective aspects were water pollution and depletion by 39.3%, disruption of natural ecosystems by 28.7, soil degradation and erosion by 17.3%, and potential harm to biodiversity by 14.7% respectively.

The participants were then asked to rate the impact of environmental challenges based on how much it would limit the adoption of vertical greenery systems in Egypt using a question on a linear scale. The participants' ratings of the environmental challenges' effect on restricting the use of VGS in Egypt are displayed in **Figure 6**.

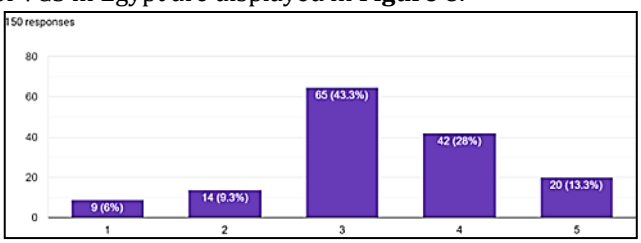

Figure 6. Rating The impact of the Environmental Challenges on limiting the implementation of VGS in Egypt (Authors).

- **Challenges of Government Policies, Regulations & Stakeholders Engagement:**

By employing multiple-choice questions to examine the

most significant aspect of each of the Government Policies, Regulations & Stakeholders Engagement challenges limiting the installation of vertical greenery systems in Egypt. The most effective aspects were the lack of supportive policies by 60.7%, the complex regulatory framework by 20%, inconsistent enforcement by 15.3, and the involvement of non-governmental organizations and civil society organizations by 4% respectively.

The participants were then asked to rate the impact of Government Policies, Regulations & stakeholder engagement challenges based on how much it would limit the adoption of vertical greenery systems in Egypt using a question on a linear scale. The participants' ratings of the Government Policies, Regulations & Stakeholders Engagement challenges' effect on restricting the use of VGS in Egypt are displayed in **Figure 7**.

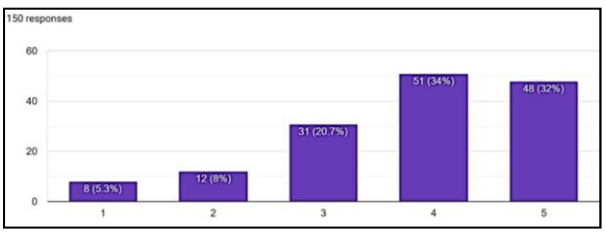

Figure 7. Rating The impact of the Government Policies, Regulations & Stakeholders Engagement Challenges on limiting the implementation of VGS in Egypt (Authors).

- **Infrastructure & Technology Challenges:**

By employing multiple-choice questions to examine the most significant aspect of each of the infrastructure and technology challenges limiting the installation of vertical greenery systems in Egypt. The most effective aspects were maintenance by 50%, irrigation & drainage system by 34.7%, and structural support system by 15.3%.

The participants were then asked to rate the impact of infrastructure and technology challenges based on how much it would limit the adoption of vertical greenery systems in Egypt using a question on a linear scale. The participants' ratings of the infrastructure and technology challenges' effect on restricting the use of VGS in Egypt are displayed in **Figure 8**.

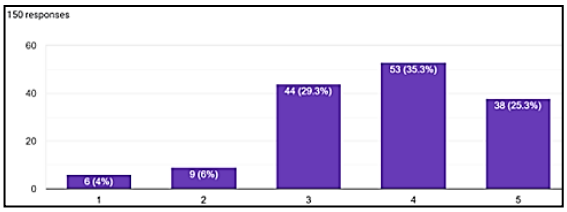

Figure 8. Rating The impact of Infrastructure & Technology Challenges on limiting the implementation of VGS in Egypt (Authors).

The Third Section:

The respondents were asked to rate the five challenges to each other in a multiple-choice grid question, with 1 representing the least impact and 5 representing the highest impact, to determine how much, they would limit the implementation of Vertical Greenery Systems in Egypt. The results of this section are displayed in **Figure 9**.

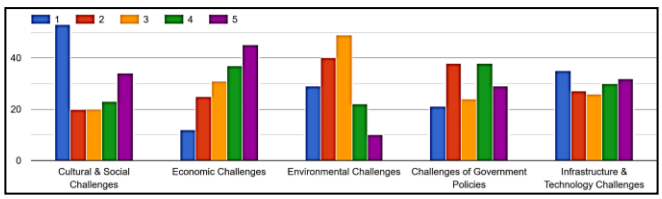

Figure 9. Rating the Challenges to each other according to their impact on limiting the implementation of VGS in Egypt (Authors).

Table 2 shows that economic challenges have the highest impact on the implementation of VGS in Egypt, followed by challenges related to government policies, regulations, & stakeholder engagement, infrastructure & technology challenges, cultural & social challenges, and environmental challenges, which have the least impact.

Table 2. Ranking of the challenges to each other (Authors).

Challenges		Level of Importance					Mean	Ranking
		1	2	3	4	5		
1	Cultural & Social	53	20	20	23	34	2.77	4
2	Economic	12	25	31	37	45	3.52	1
3	Environmental	29	40	49	22	10	2.63	5
4	Government Policies, Regulations & Stakeholders Engagement	21	38	24	38	29	3.11	2
5	Infrastructure & Technology	35	27	26	30	32	2.98	3

Figure 10 illustrates a prospected framework that was conducted based on the previous data collection and data analysis methods.

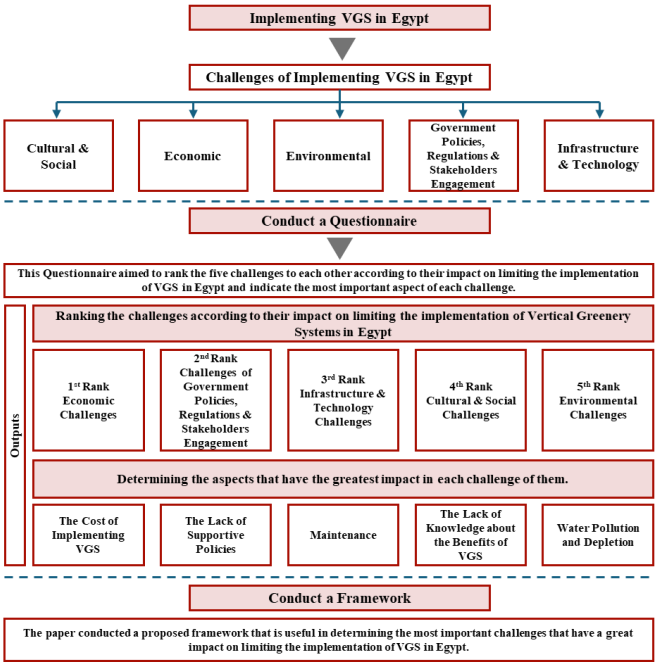

Figure 10. Prospected Framework (Authors).

Based on the results of the questionnaire and according to **Table 2**, **Figure 9**, and **Figure 10** it was shown that:

- Economic challenges are the key reason for avoiding the implementation of vertical greenery systems in Egypt. A lack of knowledge about the costs and maintenance requirements associated with vertical greenery systems has led to misconceptions about their feasibility and long-term sustainability. Vertical greenery systems need extensive infrastructure, which could be challenging in Egypt due to potential financial and resource limitations. Solutions can be framed through Cutting Down on Start-Up Expenses by Using Low-Cost Materials and Plants That Fit the Local Climate Using prefabricated or modular VGS systems to cut installation costs looking into tax breaks, subsidies, or other government support for green building initiatives. Moreover, maximizing long-term benefits by putting VGS into practice to lower building energy expenses and usage, raising the value of properties and rental income for structures equipped with VGS, lowering maintenance expenses by carefully choosing and designing plants for preservation
- Additionally, the lack of awareness among government officials and policymakers about the potential economic and social benefits of fostering vertical greenery systems is limiting the development of useful legislation and regulations. To encourage the implementation of VGS in Egypt, a more supportive legislative framework may be needed, as current legislation may not provide adequate incentives or guidance. VGS in Egypt can be substantially benefited by financing and initiatives from the government. Creating national rules and legislation to assist the implementation of VGS, as well as training property managers, property owners, and investors about the possible economic benefits of VGS, are ways to promote awareness and adoption.
- The public's skepticism of the technology and its perceived efficacy are also the main obstacles preventing vertical greenery systems from becoming widely accepted in Egypt. There will likely be strong opposition to vertical greenery systems in Egypt due to issues with low perceived efficiency, high costs, and a lack of knowledge or guidance. To improve acceptability, the government should place a high priority on providing clear, accurate, and up-to-date information to address public concerns while also making the systems affordable and accessible.

7. Conclusions

The use of vertical greenery systems supports an energy-conscious design philosophy that keeps crowded cities like Cairo from degrading into deteriorating natural habitats and, as a result, plays an important role in deciding the real estate value of the metropolitan region.

Economic challenges, lack of knowledge about costs and maintenance, and limited government awareness about the benefits of vertical greenery systems in Egypt are hindering their implementation. The lack of funding and government initiatives can significantly benefit the adoption of these systems. Public skepticism and perceived efficacy are also significant obstacles, requiring clear, accurate, and up-to-date information to improve acceptability and make the systems affordable and accessible.

References

Abd Ghafar, A., Abdulkarim, K. H., Said, I., & Jasmani, Z. (2018). Vertical greenery systems and its effect on campus: A meta-analysis. Journal of BIMP-EAGA Regional Development, 4(1), PP. 42-56, https://doi.org/10.51200/jbimpeagard.v4i1.3113.

Ascione, F., De Masi, R. F., Mastellone, M., Ruggiero, S., & Vanoli, G. P. (2020). Green walls, a critical review: Knowledge gaps, design parameters, thermal performances and multi-criteria design approaches. Energies, Vol. 13, No. 9, https://doi.org/10.3390/en13092296.

Bakar, N. I. A., Mansor, M., & Harun, N. Z. (2014). Vertical greenery system as public art? Possibilities and challenges in Malaysian urban context. Procedia-Social and Behavioral Sciences, Vol. 153, PP. 230-241, https://doi.org/10.1016/j.sbspro.2014.10.057.

Conejos, S., & Chew, M. Y. (2020Sustainability and Maintainability of High Rise Vertical Greenery Systems (VGS): its Lessons and Assessment Scoresheet. XV International Conference on Durability of Building Materials and Components (DBMC 2020), https://doi.org/10.23967/dbmc.2020.225.

De Lamartinie, T. P. The acceptance of vertical farming by the ecotourist population. Thesis for: Bachelor's degree in Business Administration of Hospitality Management, The Hague, available from: https://www.researchgate.net/publication/355360584 The acceptance of vertical farming by the ecotourist population, accessed in (28 July 2024).

El Menshawy, A. S., Mohamed, A. F., & Fathy, N. M. (2022). A comparative study on green wall construction systems, case study: South valley campus of AASTMT. Case Studies in Construction Materials, 16, e00808., https://doi.org/10.1016/j.cscm.2021.e00808.

El-Zoklah, M. H. S. (2016). Green Facades. Int. J Sci Tech, Vol. 2, PP. 325-40, DOI-http://dx.doi.org/10.20319/mijst.2016.s21.325340.

Gawad, I. O. (2018). The use of living walls in Egyptian residential buildings: Identifying the perceptions and challenges. AMPS Proceedings Series 11. Health: The Design, Planning and Politics of How and Where We Live, PP. 99-110.

Ibrahim Momtaz, R. (2018). Vertical garden as a sustainable urban perspective in Cairo. JES. Journal of Engineering Sciences, Vol. 46, No. 2, PP, 246-262, https://dx.doi.org/10.21608/jesaun.2018.114517.

Jozay, M., Zarei, H., Khorasaninejad, S., & Miri, T. (2024). Maximising CO2 Sequestration in the City: The Role of Green Walls in Sustainable Urban Development. Pollutants, 4(1), PP. 91-116, https://doi.org/10.3390/pollutants4010007.

Kalantari, F., Tahir, O. M., Joni, R. A., & Fatemi, E. (2018). Opportunities and challenges in sustainability of vertical farming: A review. Journal of Landscape Ecology, 11(1), PP. 35-60, https://doi.org/10.1515/jlecol-2017-0016.

Knifka, W., Karutz, R., & Zozmann, H. (2023). Barriers and Solutions to Green Facade Implementation—A Review of Literature and a Case Study of Leipzig, Germany. Buildings, 13(7), 1621, https://doi.org/10.3390/buildings13071621.

Manouchehri, M., Santiago López, J., & Valiente López, M. (2024). Sustainable Design of Vertical Greenery Systems: A Comprehensive Framework. Sustainability, 16(8), 3249, https://doi.org/10.3390/su16083249.

Morsi, A. A. G., & Elian, N. A. Z. (2021). The Vertical Greenery Systems Significant Role in Achieving Better Architectural and Urban Thermal Performance. MEJ-Mansoura Engineering Journal, 46(2), 102-115. https://doi.org/10.21608/bfemu.2021.188836.

NSW Government, 2015, Urban Green Cover In NSW: Technical Guidelines. State of NSW and Office of Environment and Heritage, Sydney.

Ottelé, M., Perini, K., Fraaij, A. L. A., Haas, E. M., & Raiteri, R. (2011). Comparative life cycle analysis for green façades and living wall systems. Energy and Buildings, 43(12), 3419-3429, https://doi.org/10.1016/j.enbuild.2011.09.010.

Safikhani, T., Abdullah, A. M., Ossen, D. R., & Baharvand, M. (2014 a). A review of energy characteristic of vertical greenery systems. Renewable and Sustainable Energy Reviews, Vol. 40, PP. 450-462, https://doi.org/10.1016/j.rser.2014.07.166.

Safikhani, T., Abdullah, A. M., Ossen, D. R., & Baharvand, M. (2014 b). Thermal impacts of vertical greenery systems. Environmental and Climate Technologies, Vol. 14, No. 1, PP. 5-11, doi: http://dx.doi.org/10.1515/rtuect-2014-0007.

Schlichenmayer, A. & Baeriswyl, V., 2021, Green roofs – overview, https://toposmagazine.com/green-roofs/, accessed in (19-4-2024).

Susorova, I. (2015). Green facades and living walls: vertical vegetation as a construction material to reduce building cooling loads. In Eco-Efficient Materials for Mitigating Building Cooling Needs (pp. 127-153). Woodhead Publishing, https://doi.org/10.1016/B978-1-78242-380-5.00005-4.

Umar, U. A., & Khamidi, M. F. (2012). Determined the level of green building public awareness: application and strategies. In International conference on civil, offshore and environmental engineering, Kuala Lumpur Malaysia (pp. 1-6), https://www.academia.edu/download/51621122/Determined the Level of Green Building P20170203-6558-wgy8rt.pdf, accessed in (21-6-2024).

Wong, N. H., Tan, A. Y. K., Tan, P. Y., Sia, A., & Wong, N. C. (2010). Perception studies of vertical greenery systems in Singapore. Journal of Urban Planning and Development, Vol. 136, No. 4, PP. 330-338, https://doi.org/10.1061/(ASCE)UP.1943-5444.0000034.

Wu, Y., Wang, Z., & Wang, H. (2023). Vertical Greenery Systems in Commercial Complexes: Development of an Evaluation Guideline. Sustainability, Vol. 15, No. 3, https://doi.org/10.3390/su15032551.