ASSESSING PLANT SELECTIONS FOR VERTICAL GREENERY SYSTEM ON COMMERCIAL BUILDINGS IN AN URBAN SETTING

[*1] Jamilah Othman, [1] Izzatie Azhar, [1] Afrina Azlan
[1]*Department of Landscape Architecture, Kulliyyah of Architecture and Environmental Design, International Islamic University Malaysia, 50728 Kuala Lumpur, Malaysia*
**Correspondence Author: jamilah_61164@iium.edu.my*

ABSTRACT
Vertical greenery describes a system that allows plants to grow on a facade of a building. The system is classified into two: Living wall and Green façade. In Malaysia, a Vertical Greenery System (VGS) has been practice for about eight years. Though the method is no longer new in the landscape architecture profession, technical knowledge on VGS and selection of plant species is in need of more research. This paper documents the application of VGS on commercial buildings in an urban setting with the objectives of providing information on the implementation of VGS and identifying plant species used in VGS of commercial buildings. It is common knowledge that rigorous urban development can cause environmental issues such as urban heat island, noise, and air pollutions and others. Therefore, one of the ways to reduce environmental problems is by adopting more landscape solutions. To further probe into it, the study had data collected using a review of literature, personal field observation and interview of experts. The finding indicates that the VGS implicates not only environment, but also aesthetics quality. Hence, the result suggests that quality urban scape can be enhanced through landscape solutions, while VGS is one of them.

Keywords: Vertical Greenery System, Urban setting, Commercial buildings, Plant selections, Environment and Aesthetic

INTRODUCTION
VGS is sometimes explained as a vertical garden, living wall, green wall, green facade or vertical vegetation (Ahmad Ridzwan, O. & Norshamira, S., (2016). The authors also note that the green system can enhance an urban environment through better air quality. Rampant environmental issues have continuously alarmed some major cities like Kuala Lumpur. Here, ecological issues concerning urban heat island, air and noise pollution need more attention and with better solutions. The system may also enhance a bare wall for better visual impact. The study aimed to investigate the application of VGS on the facades of some selected commercial buildings in an urban setting with the following objectives: 1) to provide information on the implementation of VGS and 2) to identify the plant species used in VGS of commercial buildings.

The paper further provides an overview of VGS, types of VGS, implications of VGS, plants selection, maintenance together with a review of commercial buildings. The first section describes the development, definition, types, characteristics, and benefits of VGS from several perspectives. Besides that, it explains the methods used to collect the necessary data. Finally, the paper concludes that more discoveries on the technology of VGS are needed to assist for practical application with better outcomes in an urban setting. Professionals like landscape architect, architect, horticulturists, and arborists should take the lead to sustain quality urban landscapes using VGS.

An Overview of VGS
VGS is a system that allows plants to grow up vertically on a building wall. The system is also known as a living wall, green facade or vertical vegetation. The concept is similar to a natural growth, where plants may grow on a vertical surface like waterfalls, riverbanks, seeping rock, cliff,

caves or slopes. In principle, VGS can either be a wall that is part of fully covered with plants. VGS symbolises a garden concept having associated with a vertical structure, where plants are attached to its surface. This explains climbers have self-clinging roots that grow directly on a wall, trellis or pergolas. Some plants may grow up with twining plants or survive within the crevices of stacked rocks.

The knowledge of vertical garden design is not new. Perhaps, the earliest invention can be directed to the ancient Hanging Gardens of Babylon, sometimes created in 600B.C. (Jain, R. & Janakiram, T., 2016). In recent years, several contemporary systems have been established using varieties of plant species and techniques. The modern concept of VGS was initially introduced by Stanley Hart White, a Professor in a landscape architecture discipline. Since the last two decades, the system was becoming popular in the subjects of the built environment. Perhaps, a theory on VGS developed by a botanist named Dr. Patrick Blanc in the 1980's has equally influenced to that.

The planning of VGS includes site location, local climate, selection of plant species, setting up a supporting structure and appropriate irrigation system. The system can be built at various location, in which to achieve a practical result would require a proper selection of plant species. In short, the construction of VGS includes designing, installation and maintenance. Table 1 provides information on the types of VGS available and commonly used in the built environment, while **Fig. 1** briefly displays the installation techniques.

Table 1 shows the types of VGS

Types	Description
Carrier Systems	Carrier system comprises of some modular unit containers with growing medium that can be quickly attached to metal framings as attached on wall surfaces. This system connects to a building facade
Support Systems	Support system consists of planters mounted on welded wire trellises. The trellis is suitable for planting a climber to create 'green screen.' The system mostly uses wire-rope or cable for plants to climb up and provides a planter box that contains soil and for watering purpose.
Planter Systems	Planter system consists of a single pot mounted on a structure. Draping plant selection is suitable to the system to produce continuity of VGS. The system is attached to a building façade and has its planter for each level of plants.
Pocket Systems	A pocket system contains fabricated panels. A mat is attached to an inflexible backup for support. The pockets are designed at the external layer for placing plants. The system has both wire-rope and planter system at each level.

Source: *Allan, S. S. T. and Kim, H. I., (2016) & Terrence, (2014)*

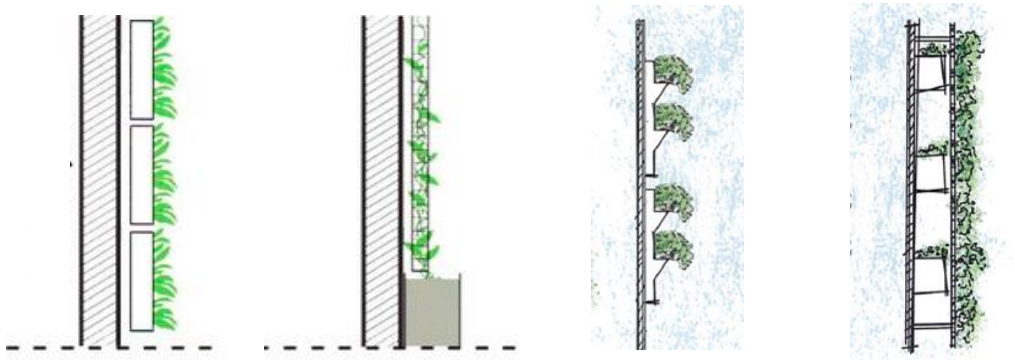


Fig. 1: Shows various installation techniques of VGS.
Source: *Terrence, (2014)*

The significant implications of VGS must have related to environmental and visual quality. It is agreed that the system helps improving air quality by reducing heat and noise pollutions. For better visual quality, greener urban environment is more appreciated. However, this paper does not intend to elaborate more on the operation of VGS. In summary, the system can be a useful tool for sustainable urban landscapes having more green impact. Besides, VGS increases better connectivity between man and nature. Table 4 lists implications of VGS, which includes aesthetics, ecology, and economy.

On the other hand, VGS can be very costly to install and maintain. Among VGSs, a living wall is considered more expensive, due to the cost of panels, plant species, irrigation, and installation technique. Maintenance of VGS is also costly that involves substitution of water pipes, panels, and plant species. The practice refers to pruning exercise and disposal of planting debris, which requires transportation from a site to a dumping area. Therefore, to enhance the environment of an urban setting using VGS has economic implications. This is true when extensive use of VGS is in demand for quality urbanisation.

Techniques of VGS

VGS can be classified into two: i) Green Façades, and ii) Living Walls (Shaikh A. F., Gunjal. P. K. and Chaple, N. V., (2015). The work of Perez, G., Coma, J., Martorell, I. and Cabeza, L.F., (2014) provides details explanation on that. **Fig. 2** displays the classification of VGS. The methods can be installed for both indoor and outdoor spaces either at freestanding structure or attached to a wall. Here, a wall explains a structure that is attached to a wall or the wall itself that is covered with plants. Most of the VGSs have mixed irrigation systems including drip, hydroponic, sprinkle, mist, or water hose. Besides that, a pump can be an alternative irrigation system and would be efficient for daily usage.

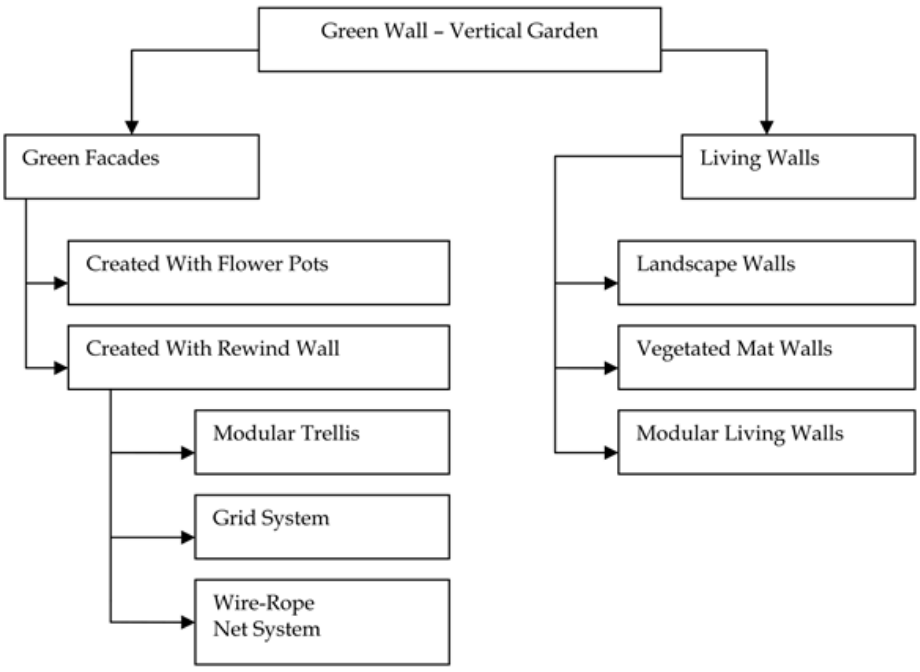


Fig.2: Classification of VGS

Source: *Timur, B.O. and Karaca, E., (2013); Perez, G., Coma, J., Martorell, I. and Cabeza, L.F., (2014) & Shaikh A. F., Gunjal, P. K., and Chaple, N. V., (2015)*

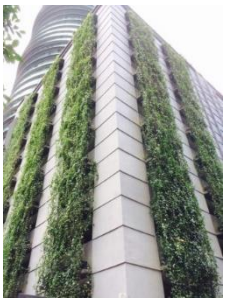
VGS is not only enlivening an outdoor environment but also enhancing its aesthetic value. Traditionally, a green wall can reduce heated gas in the air and temperature of a building. In summary, the system provides healthier outdoor air quality with better landscape ambiance. A

typical plant species used for VGS are small herbaceous plants such as ivy-leaved toadflax, and wallflower. Others may include mosses, lichens, and grasses. Besides these, plants that can naturally climb up over a rock face, tree or shrub are also recommended. For better growth, a support structure is used and attached to a wall. The followings describe the installation techniques of Green Façades and Living Walls.

i. *Green Façades*: The technique explains that a wall is covered with self-adhering plants or non-adhering plants that need a support structure for the development of tendrils and twining stems. In other words, both climbers and plants may grow directly on the façade or on a specific supporting structure. The others categories of green façade include modular trellis, grid system, and wire-rope system as described in Timur, B.O. and Karaca, E., (2013). The plant shoot matures up on a façade while being deep-rooted to the ground surface.

ii. *Living Walls*: The wall consists of a modular system that allows for an intricate design with vertical, angled or horizontal planting interface using organic or inorganic growth media. It is watered and fed over irrigation lines hydroponic 'felt'-based systems. The living wall falls into three sub-categories; landscape walls, vegetated mat walls and modular living walls. The modular panels are often encompassed of an irrigation system, geotextiles, polypropylene plastic containers, a growing medium, and vegetation. **Table 2** illustrates types of VGS application, based on personal field observation on commercial buildings.

Table 2: Classification of VGS based on personal field observation

Location	**Application**	**Location**	**Application**
Gurney Plaza, Penang	Living Wall (LW)	Mercu Summer Suites, KL	Green Facade (GF)
			
Platinum Central, Kuala Lumpur Central	Living Wall (LW)	Cross Road Hotel, Kuala Lumpur	Living Wall (LW)
			

Selection of Plant Species for VGS

The study assessed choices of plant species for better VGS application. The focus was on both *green facade* and *living wall* systems. It is agreed that plants are the main component in VGS application. Selection is challenging, for there are limited of species found able to climb up or

survive on a vertical surface effectively. Based on personal field observation, it was found that fern, herb, shrub, and climbers are among the common species used. Importantly, individual species has a unique capability, strength, and characteristics to sustain. This finding agrees to the work of Jian, R. & Janakiram, T., (2016). For better outcomes, a selection of plant should consider a local climatic condition, size of a building façade, ecology and visual impact.

It was observed that a clustered shrub or ground cover provides thick and dense growth. This is among the criteria for plant selection. However, plant selected for each system may be different, due to individual function and issues relating to irrigation, pesticide control, fertilising and maintenance. In the case of *green façade*, a facade or structure is installed for climbers to bind themselves. Here, to identify types of supporting structure that is suitable for climbers to grow successfully would be significant.

For better results, it is necessary to refer a plant selection issue to horticulturist, arborist and other experts because it can influence the type of system selected. Table 3 shows the common plants species applied to VGS under *green facades* and *living walls*, while Figure 3, 4, 5 and 6 display views on some tropical species. Jian, R. & Janakiram, T., (2016) provide a comprehensive study on the plants of VGS, which finding has supported this study. In conclusion, though there are choices of plants and climbers, the most suitable should observe the criteria described in Jian, R. & Janakiram, T., (2016).

Table 3: Plant species recommended for green façade and living wall

Types of VGS	**Scientific name**
1) Green Façades	*Hedera helix, Parthenocissus* spp, *Hydrangea petiolaris, Polygonum bauldschianicum, Lonicera* spp. *Clematis* spp. *Aristolochia* spp. *Jasminum officinale, Passiflora caerulea,*
2) Living Wall	*Dracaena, Phalaenopsis* spp, *Asparagus sprengeri, Kalanchoe, Cordyline* spp.*Chlorophytum* spp., *Haworthia* spp., *Tradescantia* sp, *Fittonia* spp, *Nephrolepsis, Clematis, Gardenia* spp., *Asplenium nidus, Maranta* spp., *Cotoneaster,Euonymus fortune, Hedera, Hydrangea, Lonicera, Parthenocissus, Polygonum,Pyracantha, Selaginella, Wisteria, Rose, Petunia, Nasturtiums,* Daisies, Bromeliads and even some vegetables like tomato, chillies, cucumber, peas, lettuce

Source: Jian, R. & Janakiram, T., (2016)

Fig.3: *Thunbergia laurifolia* (Blue trumpet vine)

Fig.4: *Epipremnum aureum* (Money plants)

Fig.5: *Anemopaegma chamberlaynii* (Yellow trumpet vine)

Fig.6: *Hedera helix* (English Ivy)

Maintenance of VGS

Both *green facade* and *living wall* need regular irrigation and soil fertilisation. For instance, plants of a *living wall* are automatically watered using pipes that are installed vertically or horizontally. They are invested in soil or on the wall surface. Watering system is installed at the top of a living wall, where later it is automatically distributed down to plants in everyone to two hours.

The irrigation system must be examined from time to time to certify the reliability of building materials, irrigation systems, and plant condition. Besides that, a *green facade* system can be naturally, manually, or automatically irrigated. Maintenance of a *living wall* requires exceptional equipment such as suspended platforms, or scissor lifts depending on the height of a wall. On the other hand, *green facade* system may need more pruning exercises for adequate cooling and visual outcomes.

Application of VGS on Commercial Buildings

VGS can be applied to any commercial building like hotel, office, shopping mall, retail shops with parking and so forth. Selection of VGS would rely upon the size of a building and the function of a system used. For example, a *green façade* with a wire-rope system is suitable for a commercial building with parking. It screens out a noise and reduces heat from a building as well as from parking. Here, selection of plants should relate to the type of commercial buildings built and building materials, since some species are sensitive to some systems and building materials.

Interestingly, the application of VGS on a commercial building may reduce the cost of wall painting and also decrease wall deterioration caused by UV (ultraviolet) rays. However, one needs to consult with a contractor and a group of experts for a better selection of plants and VGS concerning building construction materials and plant maintenance. This explains that proper installation of a system together with plant species may provide a compelling environmental and aesthetics implications in an urban setting.

There are various types of commercial buildings found in the city of Kuala Lumpur. They can be divided into several categories: leisure, retail, industrial, healthcare, office, and multifamily. In many cases, most commercial buildings are built with different sizes, shapes, and units with various functions. Also, there are diversities of materials used in the construction. A building material is another factor to be considered when selecting for relevant VGS and plants species.

METHODS OF STUDY

A *personal field observation* was used to identify types of plant species used for VGS on several commercial buildings in Kuala Lumpur. The site inventories were conducted at the followings buildings: i) Flora by Cross Road Hotel, Jalan Ampang, ii) Mercu Summer Suites Servicing Apartment, Jalan Sultan Ismail and iii) Genius Parking Vortex @ KLCC. Each site location is within walking distance, which is near to KL Forest Eco Park, Bukit Nanas. The study areas are among the popular tourist's spots in Kuala Lumpur. A checklist was used to determine the followings information: i) Type of VGS, ii) Functions of a system, iii) Type of irrigation system, and iv) Type of plant species. Earlier, review of literature was to obtain general information on the operation of VGS for sustainable design using landscape solution.

Secondly, a *semi-structured interview* was used to support the data established in the personal field observation. Three experts with VGS background were interviewed. The experts provided information on the application of VGS at commercial buildings, including plant selections and VGS implications. The contents of the interview were divided into two sections; Section 1): an introduction to VGS and its technical consideration having highlighted on definitions, development, and implications of VGS and Section 2): types of plant selections, irrigation system and experts' views on the installation of VGS on commercial buildings in an urban setting. Both data collected were collapsed and analysed using content analysis.

RESULT AND FINDING

For simplicity, findings are described and organised based on the methods and objectives of the study. The followings describe the details of the results:

i) Literature Review

Review of literature provided fundamental information on the application of VGS. The theoretical knowledge on techniques of VGSs and how they are installed had guided authors to establish relevant research strategy and methodology.

ii) Personal Field Observation – Objective no. 1 / Objective no.2

The finding shows that types of plants species applied to each commercial building inventoried on Jalan Ampang (e.g., hotel; VE1), Jalan Sultan Ismail (e.g., servicing apartment; VE2) and Jalan Ampang (e.g., parking garage; VE3) are different, yet sharing similar functions.

Secondly, there are seven varieties of plants species found at the VE1 location. The plants at the location have adequately covered the façade of the commercial building for environmental and visual purposes. In contrast, a single plant species has partially covered on the facades of both commercial buildings at the VE2 and VE3 locations with similar environmental and visual purposes. *In summary, both façade designs and functions of each commercial building have influenced the choice for plants selection as well as the techniques installed.*

Finally, it was found that the use of *Thunbergia laurifolia* in VGS at the VE3 location has encouraged species of insects like the bees, ant, and caterpillar. But this requires further investigation whether the experience can implicate healthy urban ecology. Review of Timur, B.O. and Karaca, E. (2013) describes similar implication of VGS on insects and birds.

Table 6 lists the plant species identified at commercial buildings of different locations within an urban setting, while Figures 3-6 show the views of original facade of similar commercial buildings and sites. In conclusion, the results of both personal field observation and semi-structured interview have consist findings.

Table 6: Identification of plants species at three commercial buildings on Jalan Sultan Ismail and Jalan Ampang

Location/Code	**VE1-** Flora by Crossroad Hotel, Jalan Ampang	**VE2-** Mercu Summer Suites, Jalan Sultan Ismail	**VE3-** Genius Parking, Vortex, KLCC, Jln Ampang
Plant species	1. *Allamanda cultivars* (Alamanda 'Alba') 2. *Alternanthera ficoidea* 'white carpet' (Brazilian snow flower) *3. Nephrolepsis biserrata* 4. *Philodendron erubescens* 'Gold' 5. *Philodendron hederaceum* var. hederaceum (Heartleaf rohili dendrum) 6. *Spathoglottis plicata* Blume (Malayan ground orchid) 7. *Syngonium podophyllum* (Arrowed vine)	1. *Anemopaegma chamberlaynii* (Yellow trumpet vine)	1. *Thunbergia laurifolia* (Blue trumpet vine)

Source: *Field Observation (2018)*

Fig.7: VE1
Source: Field Observation (2018)

Fig. 8: VE2
Source: Field Observation (2018)

Fig.9: VE3
Source: Field Observation (2018)

iii) Semi-Structured Interview – Objective no. 1 / Objective no.2
Three experts were interviewed and asked to identify suitable plants species for VGS of commercial buildings. All agreed that proper selection is significant for better VGS outcomes. Only two experts agreed that the choice should relate to the purposes of the system installed (e.g., plant Vs. purpose of VGS). *This explains that the purposes of the method used shall determine the types of plant species.* On the other hand, the third expert agreed that the selection of plants should relate to the type of VGS used (e.g., plant Vs. VGS). *This explains that the nature of the system used shall determine the types of plants species.* In conclusion, the results show that a selection of plants species is crucial for any application of VGS.

Interestingly, the experts had suggested some new species claimed to enhance the application of VGS in an urban setting. Besides the ones listed in Table 6, new species like native plants were suggested. They are of limestone and edible species. The edible species include fruit, vegetable, and herb. But the idea of using limestone species is to imitate its natural vertical character and adapt it into an upright human-made character of a green wall. In conclusion, results of both personal

field observation and semi-structured interview have consistency with findings described in literature review.

CONCLUSION

This preliminary study provides initial results on the importance of plants selections for practical application of VGS on commercial buildings with an urban setting. It is evidenced that VGS can enhance a quality urban environment through better ecology and visual impacts. This paper shows that VGS has a high relationship to sustainable urban landscape since its major contributions have an association with environmental and aesthetic value. Therefore, further research should be established to develop new, creative and innovative ideas on the VGS technology.

The study points out the rational reasons for using the local plants' species for future VGS of commercial buildings, taking note that the species are more durable and acceptable to the local climate. The idea of borrowing limestone plants species for VGS can be acceptable. However, this may require in-depth explorations. Discoveries for more effective results of VGS may be established through collaborations among the professionals in the built environment like architect, landscape architect and engineer. Besides that, horticulturist and arborist should provide information on the aspects of best maintenance and irrigation practices. Collaborations of all parties should include the local authorities, which supports regarding research funding and training provide a platform to designers and researchers for improvement.

REFERENCES

Ahmad Ridzwan, O. & Norshamira, S., (2016). Vertical Greening Façade as Passive Approach in Sustainable Design, *Procedia: Social Behavioral Sciences*, Vol: 222, 23.6.2016, pp. 845-854. https://www.sciencedirect.com/science/article/pii/S1877042816302609. [Accessed 23 March 2018]

Allan, S. S. T. and, Kim, H. I., (2016). Study of Workflow for Simulations of Vertical Greenery Systems. *Journal of Department of Architecture, National University of Singapore, Singapore*, 6(6): 142-153. https://scholar.google.com.sg/citations?user=mFtFJfsAAAAJ&hl. [Accessed 28. March 2018]

Jain, R. and Janakiram, T. Vertical Gardening: A new Concept of Modern Era. In: *Commercial Horticulture*, Editors: N.L.Patel, Chawla and T.R. Ahlawat. New Delhi: New India Publishing Agency, 2016. pp. 527-536. https://verticalplantlife.files.wordpress.com/2016/03/green-walls-benefits.pdf. [Accessed 5 April 2018]

Perez, G., Coma, J., Martorell, I. and Cabeza, L.F., (2014). Vertical Greenery Systems (VGS) for energy saving in buildings: A review. *Renewable and Sustainable Energy Reviews*. Vol.: 39, Nov 2014, pp. 139-165. https://www.sciencedirect.com/science/article/pii/S1364032114005073. [Accessed 23 March 2018]

Shaikh A. F., Gunjal. P. K. and Chaple, N. V., (2015). A Review on Green Walls Technology, Benefits & Design. *International Journal of Engineering Sciences & Research Technology*. Vol: 4(4), pp. 312-322. http://www.ijesrt.com/issues%20pdf%20file/Archives-2015/April-2015/47. [Accessed 29.March 2018]

Terrence, (2014). Components of vertical greenery systems – The green wall. Urban Green Lab. Science. Practice. Education. https://ugl.sg/2014/02/16/components-of-vertical-greenery-systems-the-green-wall/ . [Accessed 8 April 2018]

Timur, B.O. and Karaca, E., (2013). Vertical Gardens. In: *Advances in Landscape Architecture*. Edited: Ozyavuz, M. Published online. https://www.intechopen.com/books/advances-in-landscape-architecture. [Accessed 8 April 2018].