

# ARE GREEN WALLS OF COLOMBO MEANINGFULLY GREEN? THE SINCERITY OF VEGETATED BUILDING FACADES AND THEIR CONTRIBUTION TO ENVIRONMENTAL SUSTAINABILITY

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## Abstract

*The number of people who are affected by urbanization has radically increased. However, the economic boom over the past decades has escalated potential environmental problems among other solutions, environmentalists have proposed vertical greening. Vertical greening refers to a structure that allows vegetation to grow on the vertical surface of a building. With other sustainability-oriented strategies, vertical greening is thought to help fight current environmental issues, as well as current health issues. It may prevent the cities from being unbearable during locked downs which impacts human's mental health due to social distancing measures. Green walls are an option for cities for people to engage with Nature. Known for their pleasantness to the senses and earthy qualities, they boost human health and improve air quality. Plants can thrive on walls, making it a popular trend globally and also welcomes antidotes to stress and isolation. Plants which contain day-to-day supply of nutrition and anti-germ characters, could be incorporated with green walls. However, more knowledge is needed to reap the potential benefits from it. With the demand for sustainability, green walls are increasingly appearing on clients' requirement lists but mostly as a visual and aesthetic representation of sustainability. This sensibility of clients, what architects provide, and what is eventually built, questions whether the true representation of vertical garden delivers the intended benefits. Are these walls environmentally-friendly or are they just a trend that takes advantage of the concern for the environment and human fondness to Nature?*

*However, there is a gap between what is actually proposed and what is practiced in Colombo in green walls. Certain measurements have been used to assess the above gap. During observation periods, for an example, number of utility bills were gone through and thermometer had been used frequently. Moreover, structured interviews were taken place with list of prewritten questions to learn about these gaps. The study identified The gaps, such as no adaptation to local environment, and what each individual needs to improve to curtail the shortcomings.*

**Keywords:** Environmental sustainability, vegetated facades, green walls, plant scraping, Colombo Sri Lanka

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## Introduction

Today, majority of people live in urban areas. Urbanization attracts many people, which leads to congestion which fuels explicit issues such as pollution, and diseases and implicit impacts such as climate change. Moreover, residents and visitors may be in danger in the future if these issues go spiral.

Should people want to live in non-infectious and risk-free environments, some solutions must be implemented to accommodate Nature in the cities. The best solution would be to use walls of buildings in these areas. Question may rise how to integrate these buildings with greenery. Thus, architects spend so much time on experimenting and learning how these ideas work and grow sustainably. It is important not only for architects but also for clients too, especially because the façade is what people see before visiting a building. Therefore, attention seeking (investors) use do various strategies to promote their buildings with green walls which are ecofriendly and popular.

Green walls could express the quality of the environments. They create positive energy and regenerate a person's immune system by being near these. Some might wonder how to plant which are potential air purifiers, produce great scents... etc. It is already proven by modern science and it is no longer difficult to attach natural cleansers to walls.

Colombo has joined the trend of constructing vertical green walls too. Numerous studies, i.e., scientific literature, on living wall have been published on this topic during the last five years. While these can aid, ideas change as they pass on across societies. One of the questions is whether there is any gap between the prevalent knowledge of green walls and what is practiced in Colombo?

## Theoretical Basis

### Background of Vertical Gardening



**Figure.1.** Illustration of 'hanging gardens of Babylon'.  
Source: Hand coloured engraving, Marten van Heemskerck, Dutch

Vertical gardening dates back to days as old as the Mesopotamian era (Petty, 2008). However, the earliest official record comes from Babylon as it had named their vertical gardens as 'hanging gardens of Babylon' (Petty, 2008). According to Petty, the Greeks shared a fair amount of vertical structures for agricultures (2008). In contrast, Romans used their gardens to better environments. Later, it was passed to the Persians (Bowe, 2004).

In the Sri Lankan history, vertical gardening was mentioned where pleasure gardens had been available for kings in Sigiriya and in Giri monasteries as well. (Bopearachchi,2006)



**Figure.2.** Step Terraces of Sigiriya  
Source: Vladimir KovalSky

Architect Hector Horeau was one of the first to take advantage of the novel materials of the time for his design for the Parisian boulevard by a light weight and transparent glass structure that was designed incorporating draping flowering plants. They were installed in pots with soil and were given rainwater harvested from the roof according to the need of the plant. This system of hanging plants became popular and was some of the first examples of Modern vertical gardening methods (Leenhardt and Lambertini, 2007).

During the end of 19<sup>th</sup> century, 'vertical gardening' was not only a part of a designers' vocabulary but part of botanists and landscape professionals' vocabulary too (Gothein,1966). The first contemporary examples of vertical gardening came from a Brazilian landscape architect Roberto Burle Marx (Leenhardt and Lambertini, 2007). He worked on the theory related to plants that grow with little or no soil. This character can be brought to the urban context and as the concept was proven by Safra Bank building, Sao Paolo. At the beginning of the 20<sup>th</sup> century, with the influence of the British, architects used climbers to cover the surfaces, especially in cottages and bungalows which could be seen in the Sri Lankan context as well.

General dissatisfaction with the prevailing architectural movement brought a counterculture which saw the books like Design with Nature (1968) by Ian McHarg. The work of James Wines, Malcolm Wells, SITE, and others sought to integrate architecture with the principles of



**Figure.3.** Green wall at Kandalama hotel by Archt. Geoffrey Bawa



**Figure5.** Clear point building, Rajagiriya by Archt. Milroy Perera  
Source: Sri Lanka skyline

Ecological planning (Petty, 2008). As an attempt to create regional specific architecture, some believed regional plant species could be used in buildings to give a specific character. Architect Ken Yeang's Menara Mesiniaga Tower introduces vertical gardening to create a structure that responds to the character of its surrounding ecosystem.

The first contemporary formal use of vertical gardening in Sri Lanka is in the bungalows of the British Period. Kandalama Hotel designed by Architect Geoffrey Bawa is a Notable example of the contemporary use of vertical gardening. Clear point building, Rajagiriya by Archt. Milroy Perera is considered the modern-day world's tallest vertical garden building. Despite it is seen as a plant tower, it is constructed as garden terraces.



**Figure.4.** Kandalama hotel

## **Green Walls and Vertical Gardening**

### **Vertical Gardening**

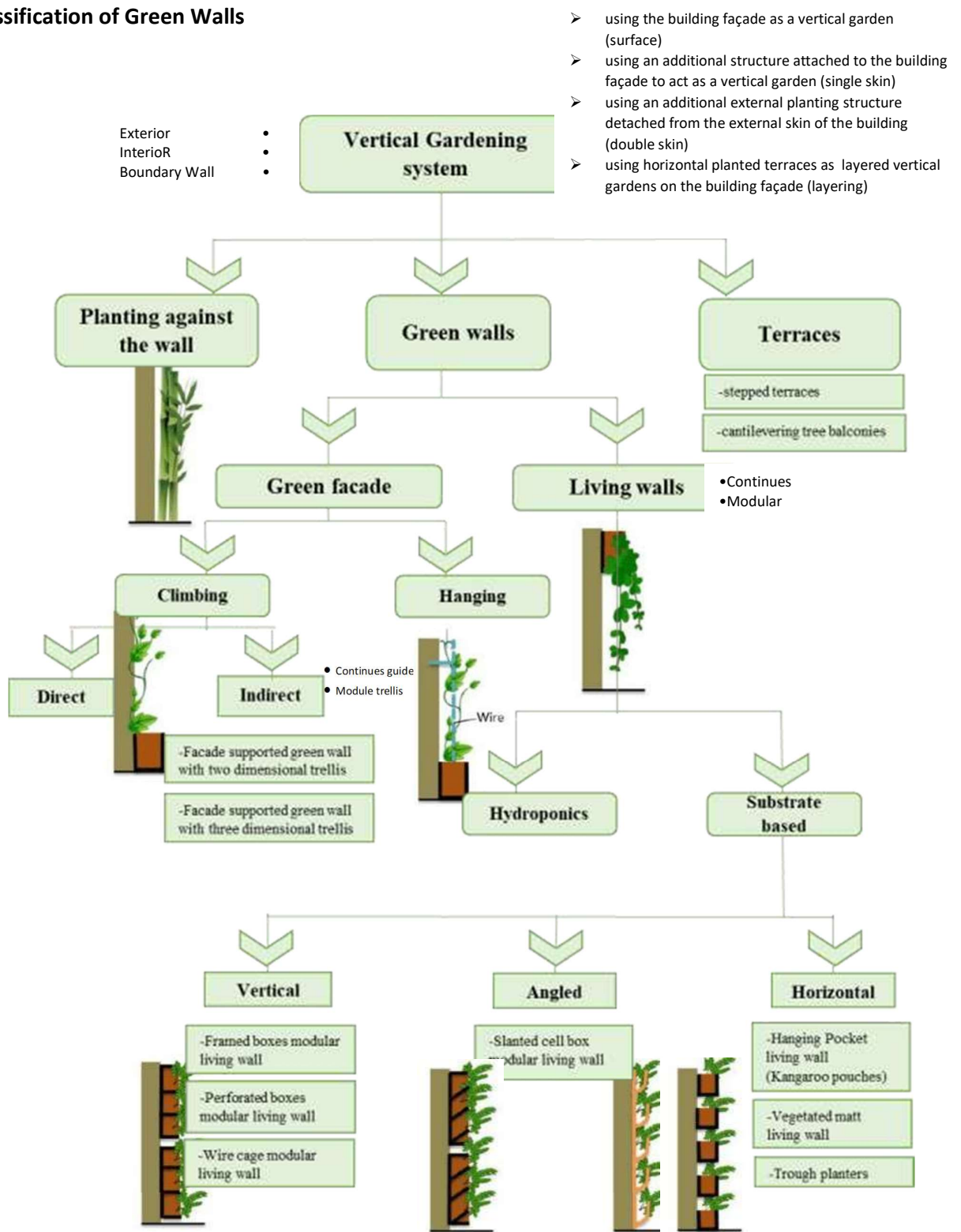
The term 'vertical garden' refers to any system of vertical planting that is attached to either the exterior or interior of a building and is self-sufficient in water and nutrients. These are also referred to as living walls or green walls. The plants receive water and nutrients from within the vertical support instead of from the ground (Tan, 2009). According to Peck (1999), the term 'vertical greenery' is used to define the growing of plants on, up, or against the façade of a building or feature walls. A green wall is essentially a living cladding system using climbing plants with many of the benefits of a green roof. Some have termed it an "organic wallpaper". "Vertical greenery" refers to having vegetation that grows directly onto a building's façade or to vegetation that is grown on a separate structural system that can be freestanding and adjacent or attached to the wall (Loh, 2008).

Modernism is believed to be the culprit behind the decline of green-clad architecture and the incorporation of Nature into a building (Petty, 2008).

The methods/strategies used can be broadly identified as follows.

- using the building façade as a vertical garden (surface)
- using an additional structure attached to the building façade to act as a vertical garden (single skin)
- using an additional external planting structure detached from the external skin of the building (double skin)
- using horizontal planted terraces as layered vertical gardens on the building façade (layering)

## Classification of Green Walls



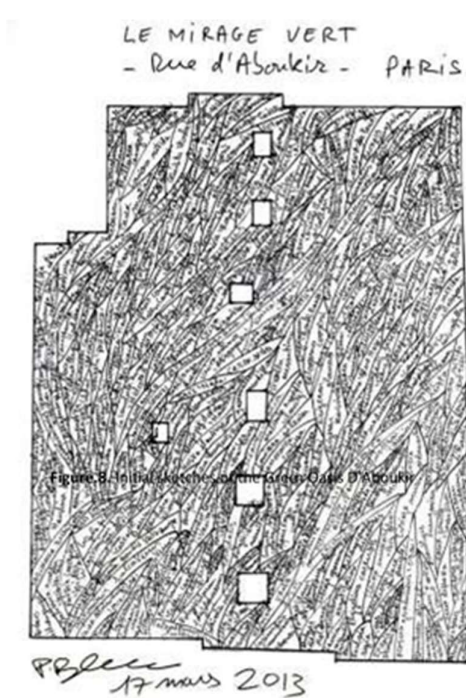
**Figure.6.** Types of Vertical gardening systems Source: by Author. Diagram based on book the Green walls in High-rise building (2014), Research paper Brković D, Marta, R Mina and Auer, T (2019)



**Figure.7.** Stages of the Green Oasis D'Aboukir, Paris, France by Patrick Blanc.  
Source: dezeen, year?

**Green walls**

All green walls are vertical gardens but not all vertical gardens are green walls. Main elements of a green wall are plants, planting media, structures that support and attach plants to the façade and irrigation systems (Wood, Bahrami and Safarik, 2014). Green walls have options of camouflage, decorate a building envelop or boundary wall. Also, stakeholder could choose when they want to add this to their building. Green wall listed as two type as green facades and living walls.



**Figure 8.** Initial sketches of the Green Oasis D' Aboukir Paris, France by Patrick Blanc.  
Source: Dezeen

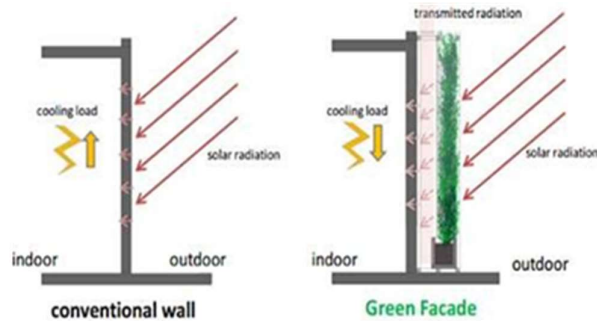


**Figure 9:** Green façade and living wall  
Source: pinterest

	<i>Green facade</i>	<i>Living wall</i>
<i>Cost</i>	Less expensive	More expensive
<i>Lifespan</i>	Up to 100 years and longer in some historical building covered by climbing plants/creepers.	10-15 years lifespan, which is usually shorter than the building lifespan.
<i>Maintenance</i>	Little maintenance required; plant pruning and visual inspection.	Higher level of maintenance required; plant pruning, regular inspection of façade structural integrity, and irrigation system required
<i>Irrigation</i>	Natural irrigation by rain, with manual and automatic irrigation supplemental systems often provided	Automatic irrigation system.
<i>Structural support</i>	Light weight structural support off the façade(cables, mesh, trellises)	More significant structural support; additional dead loads on building structural system need to be calculated.
<i>Thermal performance/ insulation</i>	Some thermal benefits	Better thermal benefits.
<i>Energy requirements</i>	Low; plants provide coverage through natural growth patterns.	Medium; dependence on automatic irrigation system, increased maintenance, and more significant material usage for structural support.
<i>Best climate zones</i>	All climate zones.	Temperature and hot climate zones

Green walls are used for boundary walls and interior as art Installations, Sculpture.

Green walls are mindfully used by architects, landscape architects and designers in creative and innovative ways to achieve various benefits for the building and for the people who live in them following images are few international examples.



**Figure.10.** Sansiri Vertical Living Gallery and office, Bangkok. Source:inhabitat

At present, green walls have become more than a just a wall. Sometimes people are unable to access the Nature as there are travel restrictions. In a situation where a city is locked down, it is nice to see Nature at your next door. Covid-19, for an example, have been a deadly virus that brought travel & tourisms to its knees and during this period, people were stuck at home.

Residents in the city must have appreciated these green walls as these structures produce scent of a forest and work as an air purifier at the same time.

### **Types and Technologies in Green Wall Installation Systems/Methods**

When considering the technology used in vertical gardening, factors that needs to be considered include: climate (humidity, temperature), orientation, wind, type of vertical gardening system, plants to be used, environmental factors (surrounding ecology), height of building, budget and degree of maintenance (Tan, et al., 2009). Availability of materials and technology, project time line and ability to customize needs to be considered as well.

Newly improved building materials are one aspect of improved vertical garden use. The climbers/ vines are easily supported for longer spans and heights through high tensile steel cables and meshes. Use of geo-textile has prevented roots from rotting and keeps the soil content ideal for growth. Modern automated drip irrigation systems have made it possible to irrigate wider areas and taller structures with minimal human interference, improving cost effective in large projects. Each of the materials changes the aesthetic and functional properties due to the different weight, profile thickness, durability and cost (Perini, et al., 2011).

### **Green Facades**

'Climbing' and 'Hanging' are the two types of green façade. Mostly creepers and vines involved in this. 'Climbing' method divide into direct (traditional) and indirect. Indirect methods continue Guides and modular trellis. Mostly these are commonly practiced using metal mesh, cable supports or rigid system utilizing two/three-dimensional trellis.

Examples:

- Facade supported green wall with two-dimensional trellis
- Facade supported green wall with three-dimensional trellis

### **Living Walls**

This could achieve by continues (light weight streams) and modular (Trays, vessel, planter tiles and flexible bags/geo textile pockets) systems. Living walls divided in to two types as 'Hydroponics' and 'Substrate based'. 'Substrate based' could place vertically, angled or horizontal ways.

Examples:

- Framed boxes modular living wall
- Wire cage modular living wall
- Perforated boxes modular living wall
- Slanted cell box modular living wall
- Hanging Pocket living wall (Kangaroo pouches)
- Vegetated matt living wall
- Trough planters/treys

In places were soil conditions are not suitable for vegetation, green wall provides an ideal way solution to overcome the issue (Eg- Nepal, Sri Lanka). By associating simple techniques and recycled materials people have shown that vertical gardens are not a luxury but a necessity in these instances.





Figure 11. Do it yourself (DIY) type Reuse/Recycle of a green wall. Source: Pinterest

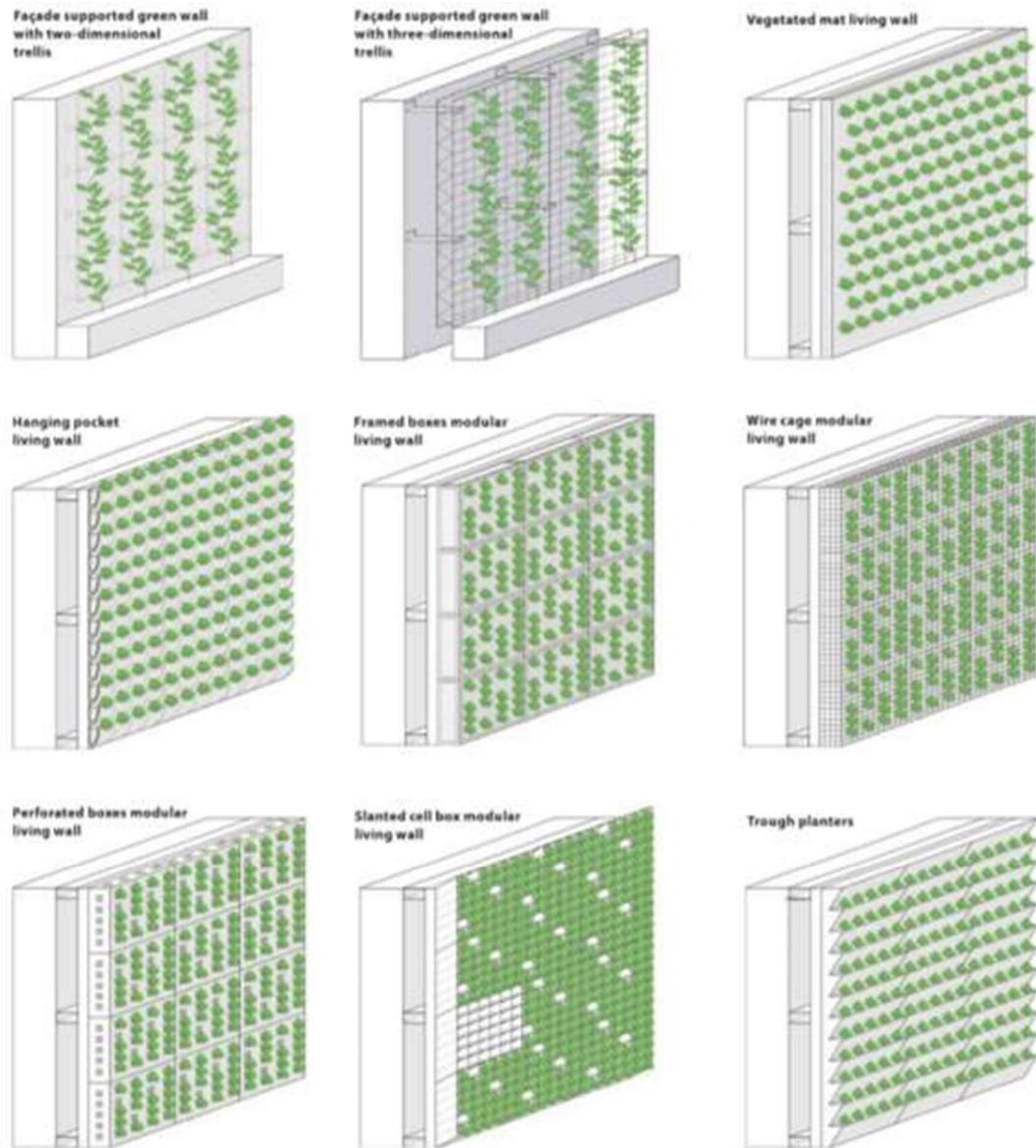


Figure 12. Types of a green wall Source: by book, the Green walls in High-rise building (2014)

## Concepts of Vertical Gardening in building Facades, Applicable to the City of Colombo

Each building has unique qualities, and these qualities brings attention from public such as entrances. For example, one has massive arched doorways and towering spires whereas another would pull people in by its welcoming large porch or wide windows.

Façade is the exterior wall or the face of a building as the word means front wall with an entrance, and it undergoes many architectural treatments unlike others. To design a façade, certain elements to be considered starting from entrance features to type of building materials such as stone, wood frame or brick. Also, it's important to consider fenestration or the size and Positioning of windows. As history suggests, architectural styles have been constantly changing and so were facades.

Scientific discoveries suggest that plants in tropical rainforest are capable of surviving on top trunks of the forest in vertical condition. Thus, motivate designers to use in projects such as Green Office-Meudon, Muharraw, Bharain, and Green Gate.

Plant is grown in vertical garden has a higher success rate. Vines and climbers are another option for gardens that stand vertically but cost for maintenance would depend on attributes, for example, height of the building, size & type of system, structure of the system etc. Further, lighting a green wall have been trending worldwide such as back lit (from inside), wall wash (mount light on surface) & flood lighting (shoot light to surface from a distance).

Colombo has a tropical climate. With late high urbanization, Colombo has become a popular but higher conversion of greenery to concrete blocks led to microclimatic changes and phenomenon such as Urban Heat Island (UHI) effect. In contrast, Green wall, a perpendicular structure to the land, can reintroduce greenery to the city by integrating vegetation into building envelope. Besides that, it has other benefits i.e. air purifier, long term economical & social benefits such as low energy consumption for cooling systems & sites to visits and enjoy. Also, buildings that contributes to green economy or vertical gardening would receive credit points under Sustainable Site category, in Green SL<sup>®</sup> Rating System of Sri Lanka Green Building Council (SLGBC) for green building certification.

The main purpose of green wall is to replenish air and produce good atmosphere. Colombo has higher number of vehicles that releases abundant of air filled with carbons. Also, city is filled with people who share this air. In addition, people may carry other infections from outer Colombo to here. Plants in a wall attached to the building should be able to recycle this air and make it disease free environment to public if correct methodology and plants are available.

There were green walls earlier which had to be taken down due to various reasons (Temple Trees boundary wall, Movepeck



**Figure 13.** Movepeck hotel before with green wall.

Source: walls pan

**Figure 14.** Movepeck hotel after without green wall.

Source: by Author

Hotel, Hilton Colombo Residencies and Shirohala Petal Guru). The main reason was high maintenance cost.

In 2015, Daily mirror mentioned about green wall in Temple trees had cost millions of Rupees per month for maintenance and since it is neither beneficial to the people nor the country, a decision was made to remove it. However, if the green wall went through proper channels of selection, there would be potential overcome and reduction of cost.



**Figure 15.** Temple trees boundary wall while removing the green wall  
Source: Daily Mirror



**Figure 16.** Temple trees boundary wall before with green wall  
Source: Daily Mirror

### **Role of Green Walls in a Green Categories**

Building becomes a Green building by based on how sustainability achieved through out preconstruction, construction & post construction phases. Wall can be sustainable by many ways. Green wall is a type of a wall which more in to gardening vertically. This study will intend to research toward buildings which have live wall and green facades being sustainable vs. achieving Green titles too.

There are green categories such as LEED, GREENSL, BREEM, Green star etc. These titles focused on building sustainability but overall, it contains some consideration on building being green by achieving vegetation requirement.so Green walls represent that role as an option especially in urban context with limited plot.

Green building title achievements & encouraging growing vegetation seems to become a trend among In relation to green rating systems like LEED, 18 credits can be achieved by the use of a vertical garden which in turn can be used as a marketing strategy. E.g. hotels use LEED Certificates as a marketing tool to emphasize its eco-friendly ventures to create an environmentally conscious image to their clients' Stake holders of Commercial buildings now a days.

### **Environmental Sustainability of a Green Wall**

As the interested has been renewed to improve way of living in dense city, vertical greening has become viable option to mitigate air pollution, global warming. City's image could be enhanced by the embrace of vertical gardening. A study in Singapore, for example, shows as the city grows, how vertical landscaping helps people to relieve stress. Moreover, it is best way to handle Urban

Heat Island (UHI) effect. Renewable source harvest, pollution creation, non- renewable resource depletion are main considerations of environment sustainability.

Construction industry cause environment pollution by consuming 30-40% energy & natural resources and contributing 30% to greenhouse gas emission. (Loh, 2008) Sustainable building practices can considerably reduce building's environmental impact in energy consumption. Covering a building envelope with green vegetation, is considered a sustainable construction practice, as green vegetation has a positive performance at energy savings, asthmatic, and air Quality. According to Susan Loh, Energy consumption of the modular panel living wall materials in manufacturing process and energy savings are evaluated and results demonstrate that the modular panel system requires 3 years to balance the energy consumed in the manufacture process. However, the environmental performance of living walls is influenced by the types of materials and plants chosen for the systems, as well as the external factors, such as climate and building type.

Living in a city with polluted or poisonous air is unbearable and lethal. Green walls could mitigate this issue by cleansing the air and killing viruses & bacteria and release antidotes to the environment.

### **Expectation/Properties of Green Walls Achieving Environmental Sustainability**

There are two ways people could gain benefits from environmental sustainability which are direct and hidden. These green walls could act as the natural air purifier. For a long time, industry have been heavily relying on fossil fuels which produces abundance of carbon into the atmosphere after its use by vehicles and factories. Also, some companies may acquire certain air purifying products that runs on electricity which may come from burning coals or something similar. Green walls would help people to stop using electric purifying machines and as the plants absorb lots of carbons for its photosynthesis, it produces fresh oxygen to the air. This would be great factor when it comes to people who are suffering from COVID-19 and shortness of breath. Common reason for shortness of breath is carbon monoxide; as there are less carbon monoxide air, and more oxygen would allow people to breath easily fight back COVID-19 virus.

Apart from explicit benefits, there are number of implicit benefits as well which may not catch people's eye right away. First, well-being of people inside the building is important and incorporating green wall provides great atmosphere but the green structure would depend on cost, lifespan, maintenance, irrigation, structural support, thermal performance /insulation, energy requirements and climate zone. Also, it is mentioned about the percentage of green coverage over total area (Wood, Bahrmi and Safarik, 2014). Wender states that being in touch with nature, in overall, has shown to make people happier in general. It is shown that nature changes brain chemistry in a positive way, improves mood, decreases stress, and provides opportunities for relaxing the mind. (Wender, 1998). Kellert further strengthens this claim by saying it is the spiritual and psychological benefits of nature which makes it important for human. According to Charlene Browne mixing landscape ground with natural elements tend to promote psychological and physical benefits (Kellert, 2007). It is easy to point out how humans' chemical reaction came to play with these walls during locked down period in cities which caused by COVID-19.

Vertical gardens are now considered part of landscape field as there are certain things these green walls express such as environmental perception, climate & contextual, Wealth & status (Swaffield,2002). Furthermore, there are rating systems maintained by LEEDS and GreenSL based

on sees management, sustainable sites, energy and atmosphere, materials and resources, indoor environmental quality, innovation and design process, social and cultural awareness.

Criteria for plant selection depend on types of systems used, the intended planting concept, environmental factors, budget, resilience, disease-tolerance and expected degree of maintenance (Tan et al.; 2009).

## Methodology

### The Overall Methodology

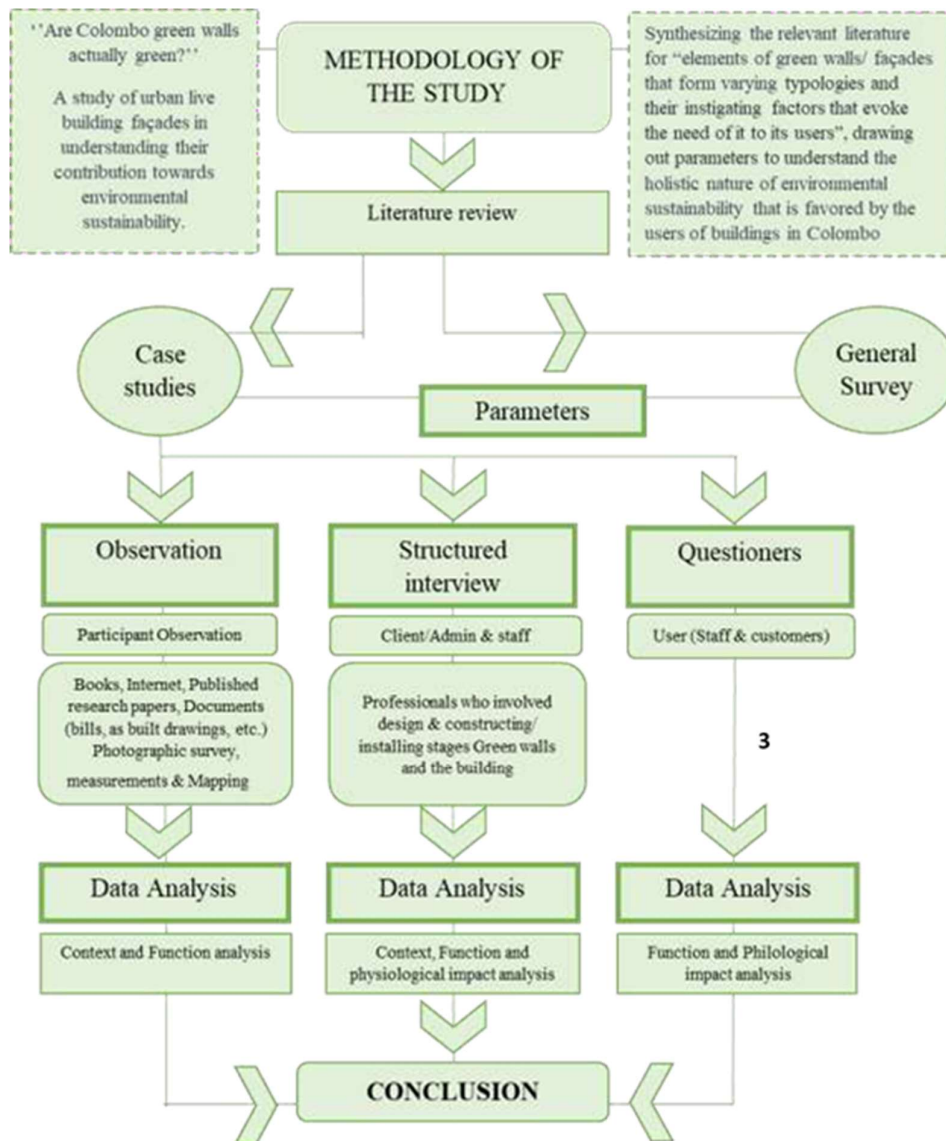
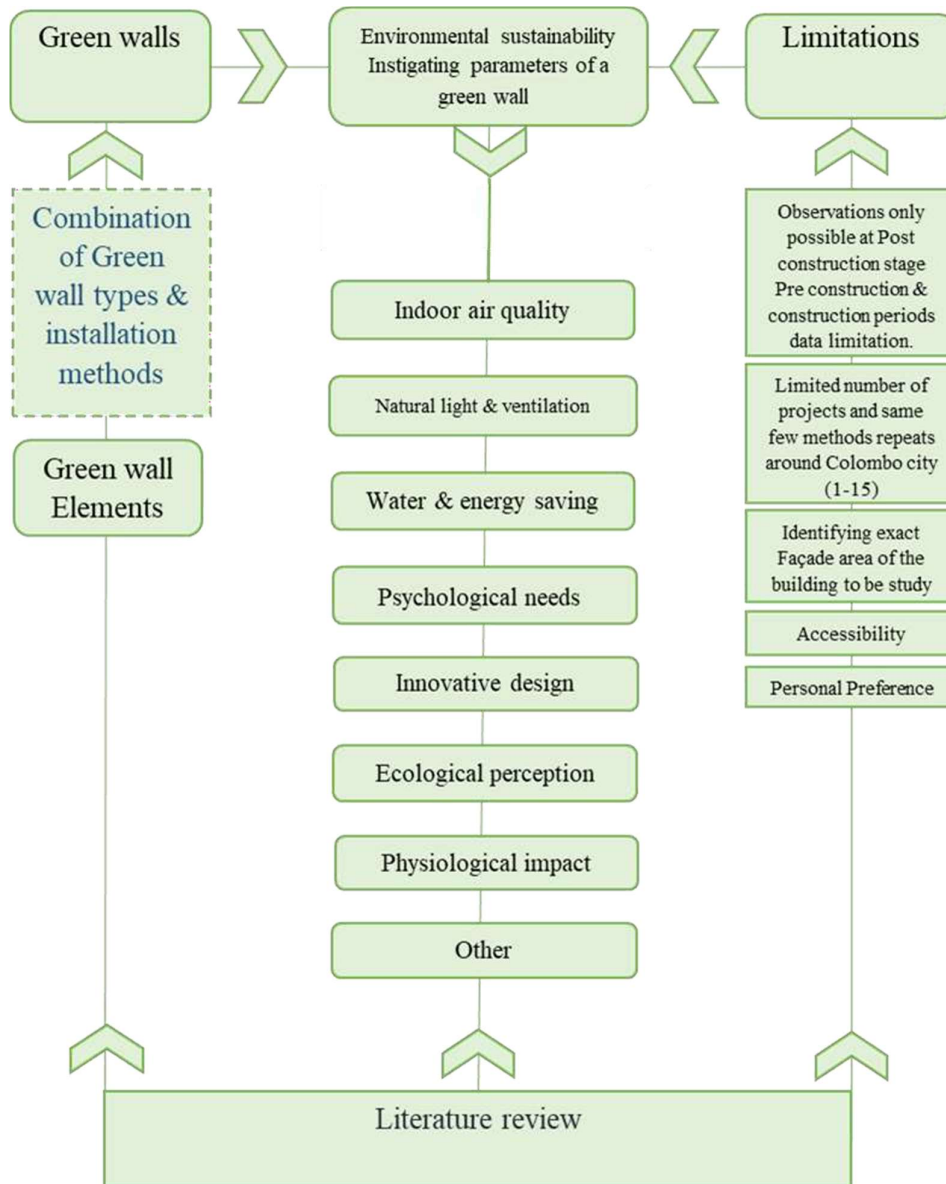


Figure 17. Diagram of methodology of the study.  
 Source: Author

### Research Approach



**Figure 18.** Diagram of research approach.  
Source: Author

**Table 1.** Post construction stage information detectors of the green wall of Case Studies.

Parameters based on the environment sustainability of a green wall	Factors to consider	Method of considering the factors in a qualitative way
Response to the site	Orientation	Respond to sun path < Observations >
	Sound/Acoustic barrier	< Observations >
	Responses to climate (Active/passive)	Shading devices and effectiveness Cooling effectiveness Insulation effectiveness Wind barrier effectiveness < Observations >
Indoor air quality	Carbon dioxide mitigation and oxygen re production	Total area of Vertical greenery Density of foliage Size of an average leaf <Observation>
	User comfort	Passive cooling? AC usage? Fans used? Temperature difference <Interviews>
	Dust proof	Dust layers on the leafs since the last watering / maintenance
Natural light & ventilation	Natural/artificial ventilation	<Observations & Interviews>
	Natural/artificial lighting	<Observations & Interviews>
Water & energy saving	Water supply/Irrigation system	<Observations >
	Embodied energy of the structure	Green vs. material (plastic, PVC, aluminum, etc. ) content per sqm <Observations >
	Maintenance & cost	Plants replacement, replanting, trimming, chemical use as a fertilizer or control mites & algae Water & electricity bills Average cost to maintain it monthly <Observations & Interviews>
Innovative design	Installation method	<Observations >
	Local material/local friendly	<Observations >
	Possibilities to improve	<Observations >
Ecological perception	Wild life + ecosystem response	<Observations & Interviews>
	Response to biodiversity	<Observations >
	Endemic plants or not	<Observations >
Physiological impact	Customer attraction/image building	Client, user (staff& customer) Time spent near green wall <Questioner, Observations & Interviews>
	land availability for gardening	with ample land or lack of land <Observations >
	Aesthetic	<Observations >

Source: Author

### Methodology for Analysis of the Case Studies

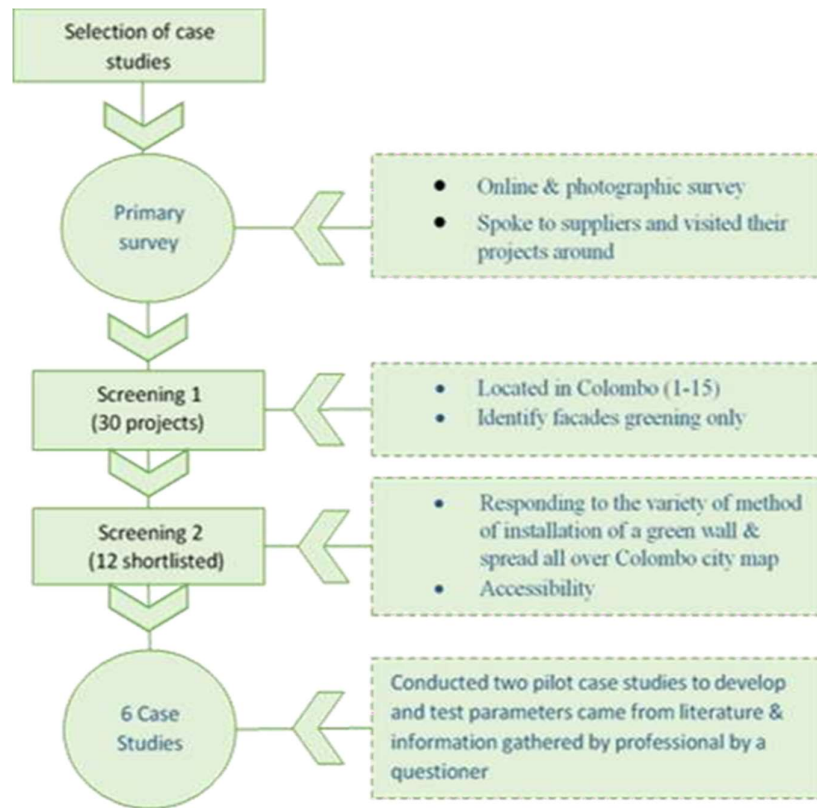
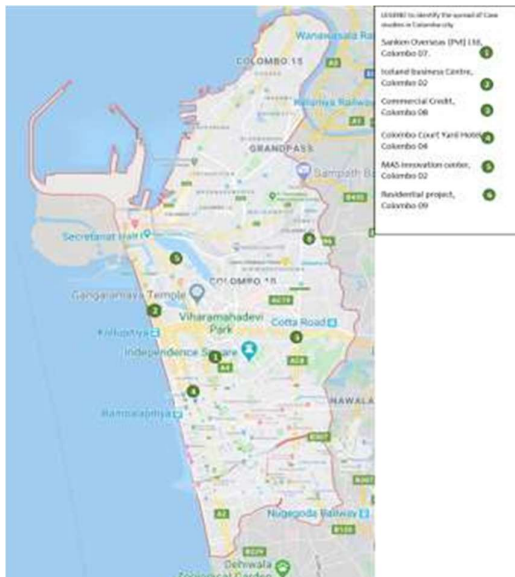


Figure.19. Diagram of Case Studies Selection of the study.  
 Source: by Author



#### -Justification for the selection of case studies

Case studies have been selected basis to randomly cover the Colombo and case studies that didn't change functionally over a year. Case study selection had to tackle the variety of methods of green walls in Colombo. Vegetated building Facades which have area more than 10sqm were considered while selection.

Figure 20. Map of case studies spread in Colombo city.  
 Source: by Author



## Findings, Analysis & Discussion

### Case Study 1 – Sanken Overseas (Pvt) Ltd, Colombo 07.



Company/Building name	Sanken Overseas (Pvt) Ltd
Location	Albert Crescent, Colombo 07.
Year of completion (Building, Green wall)	Renovation was done on 2010 Green wall design was part of the Renovation design
Function of the building	Office building
Company mission/vision	"Our services entail technology both cutting edge and eco-friendly to provide our clients services beyond expectation, within the most effective budget."

### Primary Observation

Being the city office, the building needed to achieve an iconic character while responding positively to the natural context of the surrounding the area.

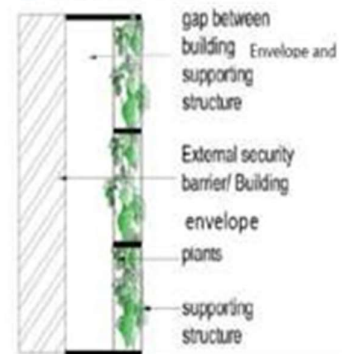
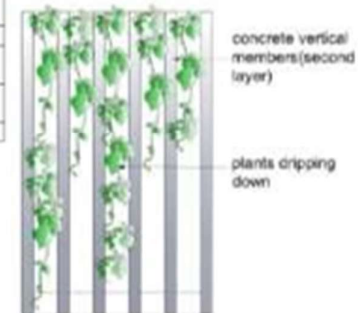
Green wall Type	Climbing façades -Faced supported green wall with three dimensional trellis
Plant types	Bengal clock vine <i>(Thunbergia grandiflora)</i> - sky vine Blue & white
Surface area of the vertical greenery compared to total building façade	197sqm/205sqm (rest of the facade is concrete fins(vertical strips))
Design strategies	The additive transformation of the facade greening has changed the whole front façade by the use of the second skin. The form has been changed from a horizontally emphasized building to a more vertically emphasized building (Visually taller). The second skin which is part of the vertical garden has been used positively to create a unique character for the building. This has been done using two methods. One is by the use of the second skin as an element emphasizing verticality. Secondly, trailing plants through the second skin to hang vertically downwards emphasizes this effect furthered.
Maintenance requirement	Less maintenance, once in six months main trimming and fertilizer provided. Watering the plant daily.
Other observations	Insects, ants, butterflies & spiders habitats are developing. Little birds nest was observed.as they used flowering plant changing façade is according.



### Placement Aspiration & Method

This was Design and built by Sankan team mainly Archt. Lal Thennakoon and Eng.Buwaneka Bihanlal Kulupana. The outer structure of the double skin is made of concrete fins. As this is a renovation the load from the addition of the vertical garden is carried down through these fins. Hedera helix creeper placed in pots are encouraged to merge through the gaps in the façade and drip down. Built-in cement troughs are also in place at the top and the bottom of the outer skin structure. Although not functioning now, a ground-up flood-lights system is expected to light up the vertical garden. When renovating the building the vertical garden was introduced. This was done to reduce dust and noise pollution entering the building, to create a better working environment for the occupants. But this was not the only reason behind this addition.

Parameters based on the environment sustainability of a green wall	Factors to consider	Reviews/Comments
Response to the site	Orientation	Avoiding sun path facade facing North. Large tree shading the building.
	Sound/Acoustic barrier	Sound controlled than other buildings around alone the main road.
	Response climate (Active passive)	Outer surface is not reflect heat (absorbs) comfortable than other building surface
Indoor air quality	Carbon dioxide mitigation and oxygen re-production	Almost complete facade area 96%. Comparatively bigger leafs spread all over. High number of leafs. Possible to assume Carbon dioxide mitigation and oxygen re-production are comparatively high but not applied directly to indoor air quality.
	User Comfort	Not applied directly. AC requirement is 20°-23°. Average temperature difference is 4°-6° in and out of the facade.
	Dust proof	Dust controlled than other buildings around alone the main road.
Natural light & ventilation	Natural/artificial ventilation	Natural ventilation applied to some levels only. Mainly air conditioned. Depend on the fenestrations open to the Facade act as a double skin.
	Natural/artificial lighting	Permeability (voids) of the facade controls the light as a shading device. Not applied directly Mostly use of Artificial lighting inside the office.
Water & energy saving	Water supply/ Irrigation system	Daily watering via irrigation system, maintenance is less.
	Embodied energy of the structure	Comparatively less embodied energy.
	Maintenance & cost	Impact on building reducing running energy. Cost is less. Low maintenance.
Innovative design	Installation method	Climbing facades -Facade supported green wall with three dimensional trellis(Concrete fins supports) Common method not so innovative.
	Local material/local friendly	Not considered.
	Possibilities to improve	Could have select local plants. Proper irrigation system.
Ecological perception	Wild life + ecosystem response	Insects, ants, butterflies & spiders habitats are developing. Little birds nest was observed as they used flowering plant changing facade is according.
	Response to Biodiversity	Blue & white Flower-ry vines-two variety.
	Endemic plants or not	Not considered.
Physiological impact	Customer attraction/ image building	All customers responded as they noticed and love the facade.
	land availability for gardening	No ample land available for gardening. Parking requirement taken most of it.
	Aesthetic	Changing facade according to flowers blooming seasons.



### Data Analysis & Conclusion

An existing tree shades the complete building façade and actively responding to the microclimate. As most of the building an air conditioned and artificially lit office space, green wall is not involved directly with natural ventilation lighting or indoor air quality. But it incorporates at upper levels. Facade act as a sound and dust barrier.

Daily watering via irrigation system makes maintenance less. This has comparatively less embodied energy and impact on building reducing running energy. It encourages Habitats of tiny creatures. Flowering makes the façade changing and aesthetically pleasing.

**Case Study 2 – Iceland Business Centre, Colombo 03**



Company/Building name	Iceland business Centre
Location	Slave Island, Colombo 03
Year of completion (Building, Green wall)	2015 building Green wall (2017) was a second thought not a part of initial design
Function of the building	Office building (multiple companies)
Company mission/vision	"In order to strengthen the ongoing expansion of the company, a Green Initiative for the company has been developed to demonstrate its commitment to sustainable development. Under this initiative, company has established an environmental friendly, modern business center" "Green strategies and measures to protect the environment and reduce operating costs."

**Primary Observation**

Green wall Type	Faced integrated living wall- Trough planters (movable)
Plant types	Devil's Ivy ( <i>Epipremnum aureum</i> ) ( <i>Globe amaranth</i> ) bachelor's button, Coleus ( <i>Plectranthus scutellaroides</i> ), Moss rose ( <i>Portulaca</i> ), Slender dwarf morning-glory ( <i>Evolvulus alsinoides</i> ), Mexican bush sage ( <i>Salvia leucantha</i> )
Surface area of the vertical greenery compared to total building façade	42sqm /315sqm (rest of the façade is glass)
Design strategies	Innovative design unique to the building green trough planters will run up & down along a track running around cog wheels. Patterns created by different flowery plants variation and placement. Units will rotate with the gravity floor with the water load.
Maintenance requirement	Twice a month. (Trimming and chemical fertilizer) Water supply and maintenance done from the roof slab.
Other observations	Moving structure by cog wheel and chain system. Variety of plant can be archived. Changing façades.



This green wall is an afterthought. They have thought of the mechanism of movable façades and changing façades by using different plants time to time.

Parameters based on the environment sustainability of a green wall	Factors to consider	Reviews/Comments
Response to the site	Orientation	Façade facing North East (on the sun path) to direct sun light.
	Sound/Acoustic barrier	Not involved directly
	Response to climate (Active passive)	No impact on reducing heat gain. Found no temperature difference in and out of the façade
Indoor air quality	Carbon dioxide mitigation and oxygen re production	Not effective enough. Average leaf size. Number of leaves are also comparatively less. Greenery is only 15% of the façade.
	User comfort	Not involved directly no major temperature difference identifies in and out of the façade
	Dust proof	Not involved directly
Natural light & ventilation	Natural/artificial ventilation	Not involved directly.AC requirement is 22°-24°.
	Natural/artificial lighting	Not effective enough. Mostly use of Artificial lighting inside the office. impact on people who works near façade when there's no blinds
Water & energy saving	Water supply/ Irrigation system	Daily Watering according to a systematic way. It does not use electricity to rotate planters. It is manually or gravity flow operated when water is filled in to planter.
	Embodied energy of the structure	Comparatively high embodied energy.
	Maintenance & cost	High maintenance and cost
Innovative design	Installation method	Innovative method/movable Faced integrated living wall-Trough planters (movable)
	Local material/ local friendly	Not considered.
	Possibilities to improve	Reduce, Reuse concept when replacing parts
Ecological perception	Wild life + ecosystem response	Not effective enough. Couldn't identify any living creature in the structure.
	Response to biodiversity	At last observation one plant type was used but throughout past few months at initial observation responded to variety of plants landscape service provider mention several plant types which they have been used after installation.
	Endemic plants or not	Not considered.
Physiological impact	Customer attraction/ image building	Most of the customers responded as they didn't notice the facade and it helped give an image to overall building but placed beyond eye level. Added points under vegetation criteria to achieve Green titles/Awards.
	land availability for gardening	Not ample land available for gardening. Front area gone for parking (paved) requirement.
	Aesthetic	Variety of plants could be achieved. Changing plants once in two months.



## Data Analysis & Conclusion

This is an innovative idea of placing and maintaining a green wall. All the services including maintenance are done from the roof top level. Daily watering is done in a systematic way.

It is only 42sqm out of 315sqm façade area; the rest of the façade is glass. The green facade area is not to give a proper impact on cutting the sunlight, it is not effectively help to reduce the electricity cost to run the air condition behind the glass facade. There is no visual connection between the green facade and the interior of the office. Those who close to the façade also use blind during daytime to cut off sunlight. This green wall does neither give microclimate impact, nor effect the indoor air quality, natural ventilation or light.

**Case study 3 – Commercial Credit City Office, Colombo 08**



Company/Building name	Commercial Credit City Office
Location	Colombo 08, Borella
Year of completion (Building, Green wall)	2018-Rebranding made to renovate the building. Green wall came with that.
Function of the building	Bank / Finance /Office
Company mission/vision	‘CLC will continue to grow and expand with its unique operating philosophy -‘Hithawathkama’ ..... To soar into the future, giving wings to the dreams, hopes and aspirations of our people and everyone who has a stake in the success of our enterprise. To forge ahead to reach new frontiers, to touch new horizons, seeking new challenges and exploring new opportunities. Together with our people with diverse strengths, committed to achieving personnel excellence and the continuous growth of our enterprise.’



**Mondo grass**  
*(Ophiopogon)*

(Drawf mondo grass, Variegated Mondo Grass)



**Roheo**  
*(Tradescantia spathacea)*



**Earth Star**  
*(Cryptanthus Bivittatus)*



**Ferns**  
*(Nephrolepis exaltata)*

(Poly ferns, deer ferns, silver ferns)

## Primary Observation

Green wall Type	Faced integrated living wall- slanted cell modular living box/pots
Plant types	Roheo ( <i>Tradescantia spathacea</i> ) ( <i>Ophiopogon</i> )Mondo grass (Dwarf mondo grass, Variegated Mondo Grass) Ferns ( <i>Nephrolepis exaltata</i> ) (poly ferns, deer ferns, silver ferns) Earth Star( <i>Cryptanthus Bivittatus</i> )
Surface area of the vertical greenery compared to total building façade	36sqm/ 108sqm
Design strategies	-Pattern was achieved by using variation of plants and color combination of actual plants themselves. -facing the sunlight -Drip irrigation system for the supply of water.
Maintenance requirement	Once a month (trimming and chemical fertilizer) day today watering happening according a systematic way of drip irrigation
Other observations	Couldn't find major living creature in the façade maybe because it is fully heat up with direct sunlight in the day time.

## Placement Aspiration & Method

Commercial Credit is a bank which recently rebranded and gave a new look. It is trying to restore all outlets within at new brand. Bank itself considers about the building façade and placement of green wall is now come with their design requirements and there is a minimum percentage of achieving a green wall in each outlet façade. As the first try of their new concept, this green wall was built at the entrance to emphasize it and maybe to get the attention of the customers

It comes from the first stage of the design and they have considered, low maintenance and, commonly found plants but when for the structure they have directly gone to supplier's recommendation.

Parameters based on the environment sustainability of a green wall	Factors to consider	Reviews/Comments
Response to the site	Orientation	Façade facing South West (on the sun path) to direct sun light as it opens to larger space (car park).
	Sound/Acoustic barrier	Not involved directly
Response to climate (Active passive)	Water content in the irrigation system and foliage absorbs heat and cooling the immediate entrance.	Water content in the irrigation system and foliage absorbs heat and cooling the immediate entrance.
	Carbon dioxide mitigation and oxygen re production	Not effective enough. Average leaf size. Number of leaves are also comparatively less. Greenery is only 15% of the façade.
Indoor air quality	User Comfort	Not involved directly. It impact on the immediate entrance only. Temperature difference 2°-4° in and out of the façade
	Dust proof	It impact on the immediate entrance only. It act as a dust barrier from main road and parking area.
Natural light & ventilation	Natural/ artificial ventilation	It impact on the immediate entrance only. AC requirement is 24*-26° In the office space which is normal.
	Natural/ artificial lighting	Not involved directly. Mostly use of Artificial lighting inside the office. Immediate entrance is shaded by the façade but naturally lit up by a fan light.
Water & energy saving	Water supply/ Irrigation system	Drip Irrigation system saves water.
	Embodied energy of the structure	Comparatively high embodied energy (Al structure, PVC pipes and plastic pots)
	Maintenance & cost	Once in a month. High cost on maintenance and installation. Require skilled labor
Innovative design	Installation method	Faced integrated living wall- slanted cell modular living box/pots
	Local material/local friendly	Not considered.
	Possibilities to improve	Could use of ecofriendly material. Use of local plant types. There's are potential to expand greenery area.
Ecological perception	Wild life + ecosystem response	Not effective enough. Couldn't identify any living creature in the structure.
	Response to biodiversity	Responded to variety of plants.
	Endemic plants or not	Not considered.
Physiological impact	Customer attraction/image building	Most of the customers responded as they noticed the facade entrance. It helped give an image and attraction.
	land availability for gardening	Ample land available for gardening. Parking (greening than paved) could have incorporate landscaping.
	Aesthetic	Variety of plants achieved an artistic pattern.





## Data Analysis & Conclusion

Only 36sqm is greenery while rest of the facade which is more than 2/3 is Aluminum cladding and concrete wall. The greenery surface & background incorporates plastic modular pots and PVC pipes for the irrigation system. It acts as completely solid structure imported & assembled here in this location. The embodied energy is high. This is not environmentally friendly nor locally produced. It's facing the open area and the façade is completely exposed to direct sunlight. This wall acts as a dust and sound barrier and provides shade to the entrance area. According to observations it's due to water and foliage. It absorbs the heat, unlike the cladding. It is thus aesthetically pleasing. This design has encouraged the use of a variety of plants. It's hard to find any creature in it.

### Case Study 4 – Colombo Courtyard Hotel, Colombo 04



Company/Building name	Colombo Courtyard Hotel
Location	Colombo 04, Bambalapitiya
Year of completion (Building, Green wall)	April 2012 Green wall was part of the renovation design plan.
Function of the building	Hotel & Restaurant
Company mission/vision	<p>"Ecofriendly hotel concept</p> <p>We embody the true meaning of the word 'Sustainability' together with world class hospitality... Instead, our boutique hotel has been designed by up-cycling old office buildings to create a true green environment. The buildings are structurally sound and aesthetically pleasing because we have made every effort to model an eco-friendly getaway experience that is both homely and luxurious at the same time. Thus, 'Sustainability' is not just a by-word at Colombo Court Hotel &amp; Spa. The material used to reconstruct the original buildings is all recycled material..."</p>

### Primary Observation

Green wall Type	Climbing façades -Faced supported green wall with three dimensional trellis	<p>The composite image includes: 1) A site map showing the building's location on a street. 2) A photograph of the green wall on a building facade. 3) A technical cross-section diagram of the green wall system with labels: 'fixing system connecting the building envelope and mesh frame', 'mesh frame', 'water proofing membrane', 'nutrient supply', 'plant bed slope to drain', 'planting media', and 'drain pipe'. 4) A photograph of a Bengal clockvine plant with blue and white flowers.</p>
Plant types	Bengal clockvine ( <i>Thunbergia grandiflora</i> )- sky vine Blue & white	
Surface area of the vertical greenery compared to total building façade &	63sqm/187sqm (rest of the façade is glass with Aluminum frames)	
Design strategies	-used green wall to block the direct sunlight and it saves the energy required to air condition the glass cube. -successfully achieved long span of climbing creeper method up to five floors & half of the façade	
Maintenance requirement	Less maintenance; main trimming and fertilizer provided once in six months. Watering the plant daily.	
Other observations	Insects, ants, butterflies & spider habitats are developing. Little birds' nest was observed. As the plant flowers the façade changes accordingly.	

It is by the architect at the clients' request from the initial design stage of the addition to the building. Placed in front of glass façades facing the sun all day, this was introduced to mitigate the heat gain. It wanted fast growing creeper, hence, plant selection.

Parameters based on the environment sustainability of a green wall	Factors to consider	Reviews/Comments
Response to the site	Orientation	Facade facing North West. Green facade blocking the direct sunlight is shading the glass clad building
	Sound/acoustic barrier	Sound controlled than other buildings around along the main road.
	Response to climate (Active passive)	Outer surface is not reflect heat (absorbs) comfortable than other building surface.
Indoor air quality	Carbon dioxide mitigation and oxygen re production	Facade area 40% Comparatively bigger leafs spread all over. High number of leafs. Possible to assume Carbon dioxide mitigation and oxygen re-production are comparatively high but not applied directly to indoor air quality.
	User Comfort	Not applied directly. AC requirement is 22°-26°. Average temperature difference is 4°-8° in and out of the façade.
	Dust proof	Dust controlled than other buildings around along the main road.
Natural light & ventilation	Natural/artificial ventilation	Not applied directly. Artificially ventilated.
	Natural/ artificial lighting	Permeability (voids) of the facade controls the light as a shading device. Not applied directly. Natural lights incorporates balance the light at the day time.
Water & energy saving	Water supply/irrigation system	Daily watering. no irrigation system. maintenance is less.
	Embodied energy of the structure	Comparatively less embodied energy.
	Maintenance & cost	Impact on building reducing running energy. Cost is less. Low maintenance.
Innovative design	Installation method	Climbing façades -Faced supported green wall with three dimensional trellis(Concrete fins supports) Common method -not so innovative.
	Local material/ local friendly	Not considered.
	Possibilities to improve	Could have select local plants. Proper irrigation system. Extended the greening.
Ecological perception	Wild life + ecosystem response	Insects, ants, butterflies & spiders habitats are developing. Little birds nest was observed as they used flowering plant changing façade is according.
	Response to biodiversity	Blue Flowery vines-Not considered about a variety.
	Endemic plants or not	Not considered.
Physiological impact	Customer attraction/image building	All customers responded as they noticed and love the facade. Added points under vegetation criteria to achieve Green titles /Awards.
	land availability for gardening	Ample land available for gardening.
	Aesthetic	Changing façade according to flowers blooming seasons.



**Data Analysis & Conclusion**

Green which facade covers half the glass facade placed to makes the space feel bigger from inside and reduces the heat gain. That makes the building habitable and reduces the power needed for the completely air conditioned; the permeability (voids) of the facade provides enough light. Daily watering is exercised. The green wall is subject to monthly maintenance. Aesthetic goal was achieved by creepers and their flowing changes the facade. Client uses it as a representation of environment sustainability to impress clients.

**Case Study 5 – MAS Innovation Center, Colombo 02**



Company/Building name	Twinery Innovation by MAS: Smart Clothes & Fashion Technologies (Innovation center)
Location	Union place, Colombo 02
Year of completion (Building, Green wall)	2016, both building & green wall
Function of the building	Auditorium, Institutional
Company mission/vision	"Our business is built around 3 main pillars: Innovation, Digital, and Sustainability. Every day we explore new ways to build new textile technologies and bring smarter apparel and soft goods ..... Our Vision 15/25 program sets out how MAS is tackling some of the most important environmental and social challenges of our time. We've made 15 promises for 2025 that will see us radically manage our own footprint, champion climate action and support a thriving planet, all in ways that put our people first and help our communities thrive."

### Primary Observation

Green wall Type	Climbing façades -Faced supported green wall with three dimensional trellis
Plant types	<i>(Pentalinon luteum)</i> hammock viper's-tail, licebush, wild allamanda.
Surface area of the vertical greenery compared to total building façade	54sqm/63sqm
Design strategies	-There's a corridor in-between the auditorium and the green wall which acts as an air gap. -Green wall acts as a shading device for the corridor. -Creepers are planted in a series of huge pots in a row that is featured on the façade.
Maintenance requirement	Less maintenance; requirement is once in three months but they does maintain whole garden monthly. (According to landscapist), Plants are watered daily.
Other observations	Company has used a flowery plant with comparatively thick leaves. Insects, bugs, spiders, lizards, skink, and ants habitat around



### Placement Aspiration & Method

This building is located on a small road which connects two main roads. The company's vision is to move towards sustainability in all possible aspects. So greening was a part of client's requirement. Architect used it wisely and in an effective way. The company logo also includes the green façade on its backdrop. This green wall also separates the building from the car park.



Parameters based on the environment sustainability of a green wall	Factors to consider	Reviews/Comments
Response to the site	Orientation	Facade facing South West. Facing to direct sunlight as it opens to larger space (car park)
	Sound/acoustic barrier	Sound controlled than other buildings around alone the road.
	Response to climate (Active passive)	Outer surface is not reflect heat (absorbs) comfortable than other building surface.
Indoor air quality	Carbon dioxide mitigation and oxygen re production	Green facade area 83%. Average sized thicker leafs spread all over. High number of leafs. Possible to assume Carbon dioxide mitigation and oxygen re-production are comparatively high but not applied directly to indoor air quality. It impact on the corridor area only.
	User Comfort	Not applied directly. AC requirement is 24°-25°. Average temperature difference is 4°-6° in and out of the facade. It impact on the corridor area only.
	Dust proof	Dust controlled than other buildings around alone the road.
Natural light & ventilation	Natural/artificial ventilation	Main area uses Artificial ventilation inside the auditorium. It impact on the corridor area only.
	Natural/ artificial lighting	Permeability (voids) of the facade controls the light as a shading device. Not applied directly Main area uses Artificial lighting inside the auditorium. It impact on the corridor area only.
Water & energy saving	Water supply/irrigation system	Daily watering. maintenance is less
	Embodied energy of the structure	Comparatively less embodied energy.
	Maintenance & cost	Impact on building reducing running energy. Cost is less. Low maintenance.
Innovative design	Installation method	Climbing facades -Faced supported green wall with three dimensional trellis(Concrete pot in row ) Common method-not so innovative
	Local material/local friendly	Not considered.
	Possibilities to improve	Could have select local plants. Proper irrigation system
Ecological perception	Wild life + ecosystem response	Insects, ants, butterflies & spiders habitats are developing. Little birds nest was observed.as they used flowering plant changing facade is according
	Plant Types-biodiversity	Yellow Flowery vine-not consider about a variety
	Endemic plants or not	Not considered.
Physiological impact	Customer attraction/image building	All customers responded as they noticed and love the facade.
	land availability for gardening	Ample land available for gardening. Parking (greening than paved) could have incorporate landscaping.
	Aesthetical aspects	Changing facade according to flowers blooming seasons

Greening include from the initial design of the building. Plant type, shape & material of the pot were decided in the design phase. During construction contractor has applied steel rods to hold and support the façade in the shape designer wanted



### Data Analysis & Conclusion

This shades and cools the corridor. According to the staff and the client, it reduced the air condition requirement of the auditorium and reduced the energy bill after the creepers grew fully. The permeability (void) of the creepers removed the need for additional light during the day and naturally ventilated the corridor. Auditorium is not connected to the outside, so, artificially lit and ventilated.

Green walls depend on daily watering twice a day. This foliage doesn't require high maintenance, expect periodic trimming. Tiny creatures inhabit around the green wall. Flowery plant of the green façade changes the facade seasonally. It aesthetically attracted everyone who entered the building.

**Case Study 6 – Residential Project- Colombo 09**



Company/Building name	Dr. Amila Walawaththa's house
Location	Mahavila Garden, Dematagoda, Colombo 09
Year of completion (Building, Green wall)	2015 Green wall was installed as a later 2016
Function of the building	Residential
Company mission/vision	(NOT APPLICABLE) *Client likes gardening

**Primary Observation**

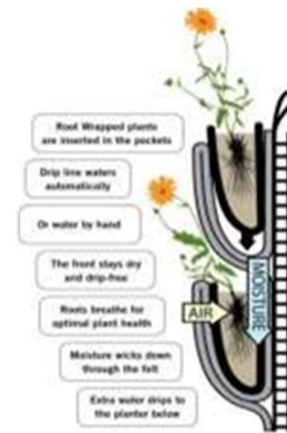
Green wall Type	Kangaroo pouches/Hanging (geo textile) pockets
Plant types	Roheo ( <i>Tradescantia spathacea</i> ) <i>(Ophiopogon)</i> Mondo grass (Dwarf mondo grass, Variegated Mondo Grass) Ferns ( <i>Nephrolepis exaltata</i> ) / Sword fern
Surface area of the vertical greenery compared to total building façade	14sqm/42sqm (rest of the façade is concrete walls & windows (glass with timber frames))
Design strategies	-A pattern created by placing a variety of plants. -easy to upgrade and maintain -the system itself sustains the water, soil and fertilizer
Maintenance requirement	Once in three months (but the client trim and upgrades monthly); there is a drip irrigation system to water the plants daily; the geo textile material sustains water within the system
Other observations	Insects, bugs, spiders, lizards, skink, and ants inhabit around. Pattern achieved via a variety of plants.



### Placement Aspiration & Method

The greening was done according to a request of Mrs. Walawaththa (Doctor.'s wife) who is in to gardening but the house was built on the entire plot. Client wanted an environmentally connected entrance to house. Architect encouraged for a roof gardening which is functioning well, but client was not satisfied by not seen any greenery until they go to roof. So, Client and his wife decided to cover the facade facing the roadway by using a green wall and upgraded the facade. They said, even though the initial placement was expensive, the maintenance and upgrading are easier due to the kangaroo pouches method.

Parameters based on the environment sustainability of a green wall	Factors to consider	Reviews/Comments
Response to the site	Orientation	Facade facing North West to direct sun light. (had no other option)
	Sound/Acoustic barrier	Sound controlled than other buildings around along the road
	Response to climate (Active passive)	No impact on reducing heat gain. Found no temperature difference in and out of the facade But isolated from the indoor as green wall structure fixed on existing concrete wall
Indoor air quality	Carbon dioxide mitigation and oxygen re production	Not effective enough. Average leaf size but Number of leaves are also comparatively high. Greenery is 35% of the facade. But isolated from the indoor
	User Comfort	Not involved directly. Temperature difference 2°-4° is and out of the facade.
	Dust proof	According to observation, it act as a dust barrier from road
Natural light & ventilation	Natural/artificial ventilation	Not involved directly
	Natural/ artificial lighting	Not involved directly
Water & energy saving	Water supply/irrigation system	Drip Irrigation system saves water. Geo textile material sustain water within the system.
	Embodied energy of the structure	Considerable embodied energy (Al structure, PVC pipes)
	Maintenance & cost	High cost initial stages at installation but less maintenance cost. Not Require skilled labor. once in three months
Innovative design	Installation method	Kangaroo pouches/Hanging (Geo Textile) pockets
	Local material/local friendly	Not considered.
	Possibilities to improve	Could use of ecofriendly material. Use of local plant types. There's are potential to expand greenery area.
Ecological perception	Wild life + ecosystem response	Insects, bees, spiders, lizards, skink, ants etc. are habitat around. Pattern achieved variety of plants.
	Response to biodiversity	Responded to variety of plants.
	Endemic plants or not	Not considered.
Physiological impact	Customer attraction/image building	Client responded as their visitors noticed the facade entrance. All appreciated it.
	land availability for gardening	Not Ample land available for gardening.
	Aesthetical aspects	Variety of plants achieved an artistic pattern.



In the construction stage they have gone through several options suggested by the supplier and gone with the option which would stand a long time. Plants were selected during that stage

### Data Analysis & Conclusion

Orientation of the green wall, facing the road was determined by the available area. The wall acts as a garden, making the entrance pleasing to those who enters and projects calmness to the surrounding. According to the client, sound was reduced after introducing the green wall. It does not change natural light or ventilation of the building as it is solid. The initial cost and embodied energy for this system, Kangaroo pouches are higher than that for climbing creepers. The system contains an aluminum structure and PVC pipe for drip irrigation. The way the geo textile materials are organized helps to sustain water, fertilizer and soil within the system. Upgrading the green wall and replacing plans are easy tasks not requiring of skilled labor.

Summary

Factors Basis on Environment sustainability of a Green wall						
Green wall Type	Climbing facade, 3-axis supported green wall with three-dimensional trellis	Fixed integrated living wall- through planter (sustainable)	Fixed integrated living wall- altered self modular living box pots	Climbing facade- 3-axis supported green wall with three-dimensional trellis	Climbing facade- 3-axis supported green wall with three-dimensional trellis	Kangaroo procedure Hanging (Use Trellis/pockets)
Surface area of total green coverage	15% area	42% area	36% area	63% area	83% area	14% area
Total percentage of green coverage	96%	13%	30%	40%	88%	33%
Response to the site	Not facing to the direct sunlight. An existing tree shades the complete building. Actively responded to the street view.	Facing to large open area and sufficient enough to cut off the direct sunlight.	Cutting off direct sunlight. Separates Car park area and road as a sound barrier	Cutting off direct sunlight. Shades and creates a livable space of day time	Cutting off direct sunlight. Separates Car park area and road as a sound barrier	Act as a sound barrier. Absorbs sun heat.
Indoor air quality	Not involved directly but act as an dust barrier	Not involved directly	It impact on the immediate entrance only. It act as a dust barrier	Not involved directly but act as an dust barrier	It impact on the early corridor area before the main space. It act as a dust barrier	Not involved directly but act as an dust barrier
Natural light & ventilation	Not involved directly. But incorporates in upper levels where open terraces and fenestrations.	Not involved directly. Impact on people who works near facade when there's no blinds	Shades and cooling effect by green and water inside the irrigation system	Shades and incorporated balance the natural light.	Permeability naturally lighting and ventilating the corridor area.	Not involved directly
Water & energy saving	Daily watering via irrigation system maintenance is less. Comparatively less embodied energy. Impact on building reducing running energy.	No impact on building running energy. Embodied energy is comparatively high. Should look into recycle and reuse aspects while replacing maintenance require skilled labor and high maintenance	Irrigation system uses water. Embodied energy is high due to the content of material used. Maintenance require skilled labor and high maintenance. Absorbs the heat gain. High cost on maintenance and installation.	Daily watering maintenance is less. Comparatively less embodied energy. Impact on building reducing running energy.	Daily watering maintenance is less. Comparatively less embodied energy. Impact on building reducing running energy.	Irrigation system One textile material retains water and recirculates within the system. Embodied energy is considerable. Maintenance is less upgrading not require skilled labor. Initial cost is high but long term effective method.
Innovative design	Not involved directly	Good thinking and innovative.	Directly used the improved elements and assembled. Potential to improve the system.	Not involved directly	Not involved directly	High Potential to improve the system also and upgrade to a domestic vertical farm
Ecological perception	Encourages habitats of tiny creatures. Flowsy.	Variety of plants. Future space for endemic indigenous plants. Flowsy	Variety of plants. Future space for endemic indigenous plants.	Encourages habitats of tiny creatures. Flowsy.	Encourages habitats of tiny creatures. Flowsy	Encourages habitats of tiny creatures and variety of plants. Future space for endemic indigenous plants
Physiological impact	Aesthetically pleasing. Everyone notices it and appreciates. Changing facade	Not involved directly. But changing facade.	Pattern achieved. Aesthetically pleasing. Everyone notices it and appreciates. Changing facade	Aesthetically pleasing. Everyone notices it and appreciates. Changing facade	Aesthetically pleasing. Everyone notices it and appreciates. Changing facade	Pattern achieved. Aesthetically pleasing. Everyone notices it and appreciates. Changing facade

- Above studies shows green wall methods used in Colombo are common, inexpensive, low maintenance. "Climbing facades faced supported green wall" is extremely popular.
- These walls are yet to catch up as all designs found in Colombo are rigid. Using a robust design can change based on necessity is recommended.
- The orientation and placement of irrigation systems are problematic, plants and installation methods should be more responsive to Sri Lankan client.



- More issues were observed regarding maintenance equipment.
- It is observed that green walls initiated by client and not architects, which is disappointed
- Above designs explicitly mark its presence in environmental and greenery discourses but they are still identified as greenwash as participation is not enough and attraction does not help the cause
- Green walls commonly used ground plants, air plants, grass types, ferns, and ivies.
- Double skin method is the most successful system to achieve bio-climatic benefits such as heat gain reduction, noise reduction and the therapeutic benefits.
- Kangaroo pouches/hanging (geo textile) pockets and climbing facades support green walls with three-dimensional trellis are easy to develop locally and easily adaptable to Colombo city.

### **Conclusions & Recommendations**

Are green walls of Colombo meaningfully green? No, they are not environmentally sustainable as they look.

They have achieved aesthetic aspects and given philological impacts, but other aspects are not full filled in a satisfactory level. As, most of the building an air conditioned and artificially lit office space, green wall is not involved directly with natural ventilation lighting or indoor air quality. Moreover, considering as high population density area, people struggles to find actual cleansing effect from these walls during lock-down periods such as COVID-19. Residents did not find any psychological satisfaction as there are lack of greeneries

In conclusion, reality in Colombo city area way below the idea promoted by environmentalists. Nonetheless, above examples achieved something that is locally acceptable and inexpensive methods connecting somewhat to local conditions. It is significant to identify the strengths (achievements) and build on them towards an environmentally friendly wall system than correcting purely on the grounds of foreign knowledge. Yet the architects and architecture programs need to be sensitized.

- Green walls could have extra benefits by having façade that provides herbs to kitchen and potential sales to public
- Innovations could provide cost effective solutions such Instead of using chemical, innovating solutions rainwater for drip irrigation system and sensors to detect dryness, would make maintaining cost effective.
- Green walls concept should be promoted to every building regardless of its location
- Proposing to use in endemic indigenous or local plants for local green walls; such as orchids, *Leucas biflora*, *Impatiens repens*, *Pyrrhosia heterophylla*, *Evolvulus nummularius*, *Pothos scandens*, *Psychotria sarmentosa*, *Ficus pumila*. Common plants used in Colombo are Bengal clock vine /sky vines (*Thunbergia grandiflora*) which are fast growing. The higher density of their big leaves can provide privacy.
- Kangaroo pouches/Hanging (geo textile) pockets are manufactured with eco-friendly material
- Extra income or tax relief could inspire addition of green walls to any constructions.
- Having a pretend forest in the city could help people psychological, especially during remote works or lock downs.

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