



# VERTICAL GARDENS AS A RESTORATION COMPONENT IN URBAN SPACES: A REVIEW

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**Abstract:** Vertical gardens are becoming a common component at urban living and are also essential because of shrinking land spaces. The healthy growth of vertical garden plants depends upon many factors like growing containers, choice of plants, media, etc. They are commonly also known as a green wall. The difference between green walls and green facades is that green walls have the media for growth supported on the wall, while green facades have only soil at the base of the wall, and climbing plants are supported on the wall to create a green façade. The living wall is helpful for urban agriculture and urban gardening as it beautifies the place. A green wall can be of any type indoor or outdoor, freestanding or attached to the existing wall, and varies in size. This review aims to focus on generating green cover in small spaces. Vertical gardens could enhance the quality of life through their restorative effect.

**Index Terms:** Vertical Garden, living wall, Eco-Friendly, urban agriculture, Benefits, Gandhinagar City

## I. INTRODUCTION

The term "green wall," sometimes known as "vertical garden," is used to describe all types of vegetated wall surfaces (Roof, 2008). Green walls are not only gorgeous, but they also assist to brighten up the atmosphere. Green walls absorb hot gas in the air, lowering both indoor and outdoor temperatures, resulting in better indoor air quality and a more attractive environment (Yeh, 2012). Rainwater is held or slowed by them, giving food and shelter for wildlife (Thompson & Sorvig, 2000). As previously stated, some plants can grow on walls by taking root in the material of the wall. Small herbaceous species like ivy-leaved toadflax, wallflower, and plants like mosses, lichens, and grasses are typical examples. Other species, on the other hand, have evolved to climb up and over obstacles like rock walls, trees, and plants. A support structure is usually required for them to grow properly on walls and buildings. (Green, 2004).

### 1.1 What is vertical garden?

A vertical garden is technique of growing plants on vertically hanging panel, which is a hydroponics-based technology. Vertical gardening is a type of urban gardening that is especially suited to tiny areas and may be used to decorate the walls and rooftops in a variety of ways. This is a different approach to gardening that allows you to grow plants in a vertical environment. There is very little horizontal area for outdoor gardening due to intensive urbanisation. Green walls are not only stunningly gorgeous, but they also assist to brighten up the atmosphere. Green walls lowers both indoor and outdoor temperatures by absorbing hot gases in the air, hence resulting in a healthier indoor air quality as well as a more attractive environment.

## II. HISTORY

Patrick Blanc, a French Botanist who has constructed multiple green walls across the world, experimented with and popularised the notion of green walls. (Blanc, 2008). Other major highlights in history of green wall are summarised below in Table no. 1.

Table 1: Major highlights in Green wall history (Shaikh *et. al*, 2015)

Year	Major Highlights
1920s	The British and North American garden city movements emphasised the integration of house and gardens through features such as pergolas, trellis constructions, and self-clinging climbing plants.
1938	The University of Illinois' Stanley Hart White patented a green wall system. (Malakar <i>et. al</i> , 2017).
1988	A stainless steel cable system for green façade is being introduced.
Early 1990s	Entry into the North American market of cable and wire-rope net systems, as well as modular trellis panel systems.
1993	The first significant deployment of a trellis panel system was at Universal City Walk in California.
1994	The Canada Life Building in Toronto, Canada, has an indoor living wall with a bio-filtration system.
2002	The MFO (Maschinenfabrik Oerlikon) Park Project in Zurich, Switzerland, launched with 1,300 climbing plants. It was a multi-tiered park structure with a length of 300 feet and a height of 50 feet.
2005	The highlight of Expo 2005 in Aichi, Japan, was a gigantic Bio Lung display funded by the Japanese government. This wall was made up of 30 distinct Japanese modular green wall systems.
2007	The Green Factor, which comprised green walls, was established in Seattle.
2007	Green Roof for Healthy Cities (GRHC) has offered the first full-day Green Wall Design 101 course in North America.
2008	Green Wall Award of Excellence and Green Wall Research Fund were established by GRHC.

## III. CLASSIFICATION

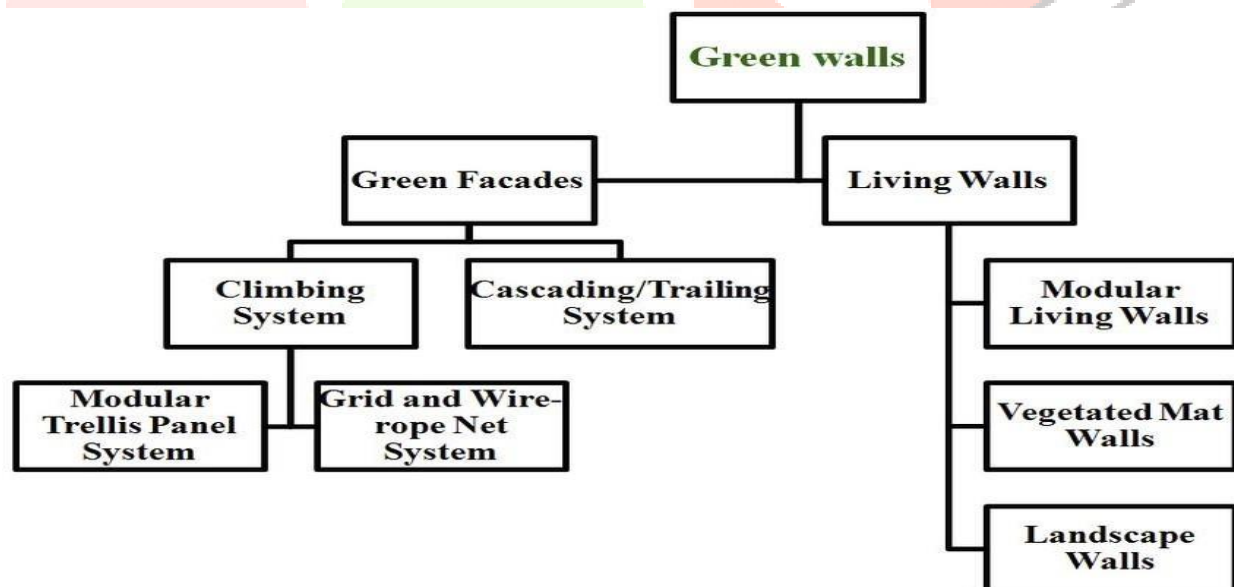


Fig 1: Classification of Green Walls (Sheweka & Magdy, 2011; El-Zoklah, 2016)

Figure 1 shows that Green walls are classified into two types: Green façades and Living walls. Climbing plants grow directly on the wall or, more lately, on specially constructed supporting systems to create green façades. While planted in the ground, the plant branch system rises up the side of the building. Stainless steel containers, a growing medium, geo textiles, irrigation systems, and flora are frequently used to create modular panels for a living wall. Although certain living walls can also be used as green walls for indoor use, the vegetation for a green façade is always linked to outer walls. Above mentioned two major groups are discussed below:

**3.1 Green façades:** System of containers and trellises Green façades are vines and climbers that grow from the ground or huge containers at various spots around the structure and are supported by the wall or a supporting trellis/mesh. The conventional green wall method is wall climbing. Climbing plants can naturally cover the walls of a structure; however, it is a time-consuming process. They are sometimes trained upwards using a trellis or other support structures.

**3.2 Living walls:** System of modular panels the panel system, also known as a living wall, is made up of pre-planted panels and vertical modules that hold growing media for plants and are attached vertically to a structural wall or frame. In comparison to the previous 532 Commercial Horticulture two kinds, the module type is the most recent notion. A vertical system necessitates more complex design and planning considerations before it is ready.

#### IV. BENEFITS OF GREEN WALL:

##### 4.1 Aid in Achieving Sustainability goals:

Urrestarazu & Bures (2012) has stated that several sustainable initiatives have been and can be introduced in green wall systems like use of recycled or recyclable materials in framework of the design and modules, grey water recycling, use of harvested rain water in irrigation and reuse of used water, use of renewable energy sources like solar energy as a source of light and to run automated systems etc.

##### 4.2 Urban Agriculture

Basdogan & Cig (2016) has reported that increased urban areas has gained momentum, adversely affecting the rural area coverage and hence, agricultural lands. Along with proliferation of urbanized land, population rate is also climbing, which makes the search of new food production facilities inevitable. As the horizontal surfaces for agriculture have greatly reduced, vertical farming in urban areas would not only make great use of available vertical space but also supply with the needs of fresh and healthy food, contributing to sustainability.

##### 4.3 Improved Aesthetics

Aesthetic variation creating visual interest is a key feature imparted by green walls which not only masks unsightly characters but also increases the value of the building (Sharp *et. al*, 2008)

##### 4.4 Indoor air quality improvement

Plants have long been regarded to be effective scavengers of both gaseous and particle pollutants in urban environments. They can help to purify the air by absorbing gaseous pollutants and eliminating airborne toxins in their leaves and branches. They filter airborne toxins and absorb gaseous pollutants through their leaves and branches. Bio-filtration consumes volatile organic compounds, or VOCs, which are eaten by both plants and planting medium. (Jain & Janakiram, 2016)

##### 4.5 Economic benefits

Jain & Janakiram (2016) has stated that Plants put around structures can help to strengthen them by decreasing the impact of the weather. Green walls reduce climatic stress on building facades while also increasing the Structure's service and useful life. It also helps to prevent building damage caused by UV (ultraviolet) rays. The decreased cost of painting supplies is one of the financial advantages of green walls. The energy required to cool a structure can be lowered by 28 percent in warmer areas, according to studies. Greenery can also boost a home's value.

##### 4.6 Improvement of Health and Wellness

Plant engagement, both visually and physically, has been demonstrated to have considerable health advantages. Green walls can offer calming effects that lower stress, improve patient recovery rates, and make people more susceptible to illness. The vertical plants absorb the harmful gases and volatile substances released by contemporary conveniences, reducing the risk of cancer, stroke, depression, heart disease, and respiratory issues. (Jain & Janakiram, 2016)

##### 4.7 Reduction of Urban Heat Island effect (UHI)

In urban areas, structures with impervious materials replace the vegetation. Such materials absorb heat and reflect sunlight in a manner that increases temperature due to heat. Hence, an urban area with increased heat is formed that has higher temperature than its surrounding rural areas, which is called Urban Heat Island and the effect is called Urban Heat Island Effect. This effect is effectively mitigated by the cooling effects of green walls (Sharp *et. al*, 2008; Timur & Karaca, 2013; Basdogan & Cig, 2016)

##### 4.8 Other Benefits of Green Wall given by Jain & Janakiram (2016)

- By installing them from the outside, you can reduce the internal roomtemperature by 5 to 10 degrees in the summer.
- Plants are away from soil-borne diseases.
- More plants within limited space
- Helps in saving water.
- Provides excellent air circulation for the plants

#### V. PLANTS SUITABLE FOR VERTICAL GARDEN

Jain & Janakiram (2016) has reported that plants should be chosen based on the climate of the area. Plants with a compact growth habit are more likely to create dense and thick cover. Short-growing plants should have a shallow fibrous root structure and a long life cycle. Depending on the region, plants should be able to tolerate full sun or full shade. The most usually used plants in vertical gardens are included in Table no. 2.

Table 2: Common plant used in different types of Vertical Gardens. (Jain &amp; Janakiram, 2016)

Types	Plant list
Green Facades	<i>Aristolochia spp.</i> , <i>Jasminum officinale</i> , <i>Polygonum bauldschianicum</i> , <i>Lonicera spp.</i> , <i>Hedera helix</i> , <i>Clematis spp.</i> , <i>Passiflora caerulea</i> , <i>Parthenocissus spp.</i> , <i>Hydrangea petiolaris</i> , , etc.
Living Wall:	<i>Euonymus fortune</i> , <i>Cotoneaster Hedera</i> , <i>Maranta spp.</i> , <i>Tradescantia spp.</i> , <i>Chlorophytum spp.</i> , <i>Haworthia spp.</i> , <i>Dracaena</i> , <i>Phalaenopsis spp.</i> , <i>Cordyline spp.</i> , <i>Parthenocissus</i> , <i>Fittonia spp</i> , <i>Asparagus sprengeri</i> , <i>Kalanchoe</i> , , <i>Gardenia spp.</i> , <i>Nephrolepis</i> , <i>Clematis</i> , <i>Asplenium nidus</i> , <i>Hydrangea</i> , <i>Lonicera</i> , <i>Polygonum</i> , <i>Pyracantha</i> , <i>Selaginella</i> , <i>Wisteria</i> , <i>Nasturtiums</i> , <i>Bromeliads</i> , <i>Petunia</i> , <i>Rose</i> , , <i>Daisies</i> , and even some vegetables like, peas , chillies, tomato, lettuce, cucumber, etc.
Exterior Wall:	<i>Rosmarinus</i> , <i>Thymus</i> , <i>Lavendula</i> or <i>Salvia</i> for full sunlight while <i>Fuchsia</i> , <i>Asplenium</i> , <i>Davallia</i> , <i>Begonia</i> and <i>Arum</i> for shady locations.
Interior Wall	<i>Begonia</i> , <i>Epipremnum</i> , <i>Saintpaulia</i> , <i>Columnnea</i> , <i>Aeschynanthus</i> , <i>Philodendron</i> or different ferns like <i>Pteris</i> and many , <i>Nephrolepis</i> , <i>species of Peperomia</i> .

## VI. CONCLUSION

Vertical gardens are the most environmentally responsible way to generate green cover in a small space. Vertical gardening entails growing plants on vertical surfaces, such as a home's wall or a huge building's exterior. Vertical gardening isn't just for show; it can also help to cool and insulate buildings, lowering the need for and cost of air conditioning. Plants in the building serve to filter and improve air quality while also providing an environmental breeze to centrally conditioned businesses, households, and schools. Vertical gardening has little upkeep, but a vertical farm may want a little more attention, but it will pay off handsomely and does not require soil. It conserves water by lowering the need for irrigation and watering, both of which may be done with precision. Vertical garden reduces greenhouse gases such as carbon dioxide (CO<sub>2</sub>), carbon monoxide (CO), and nitrogen dioxide (NO<sub>2</sub>), and increases ecological values by creating habitats for birds and insects, as evidenced by history. Hence, it could be concluded that in urban concrete jungles, vertical gardens can help to soften the hard aspect of concrete. In India, if strategies with a long-term action plan are implemented, it could be possible to achieve a sustainable green environment within the urban areas.

## REFERENCES

- [1] Başdoğan, G., & Çığ, A. (2016). Ecological-social-economic impacts of vertical gardens in the sustainable city model. *Yüzyüncü Yıl Üniversitesi Tarım Bilimleri Dergisi*, 26(3), 430-438.
- [2] Blanc, P. (2008). *The vertical garden: From nature to the city*. WW Norton & Company.
- [3] El-Zoklah, M. S. (2016). Green Facades. *Int. J Sci Tech*, 2, 325-40.
- [4] Green, B. (2004). A guide to using plants on roofs, walls and pavements. *Mayor of London. Greater London Authority*.
- [5] Jain, R., & Janakiram, T. (2016). Vertical gardening: A new concept of modern era. *Commercial Horticulture. New Delhi, India: New India Publishing Agency*, 527-536.
- [6] Malakar, M., Acharyya, P., & Biswas, S. (2017). Vertical gardening for enlivening the ambiance. *Journal of Crop and Weed*, 13(3), 89-93.
- [7] Roofs, G. (2008). Introduction to Green Walls Technology, Benefits & Design. *Estados Unidos: Greenroofs org*.
- [8] Shaikh, A. F., Gunjal, P. K., & Chaple, N. V. (2015). A review on green walls technology benefits & design. *International Journal of Engineering Sciences & Research Technology*, 4(4), 312-322.
- [9] Sharp R, Sable J, Bertram F, Mohan E, Peck S. (2008). Introduction to Green Walls Technology, Benefits & Design. *Green Roofs for Healthy Cities*, Toronto, Canada.
- [10] Sheweka, S., & Magdy, A. N. (2011). The living walls as an approach for a healthy urban environment. *Energy Procedia*, 6, 592-599.
- [11] Thompson, J. W., & Sorvig, K. (2000). Sustainable landscape construction: a guide to green building outdoors.
- [12] Timur, Ö. B., & Karaca, E. (2013). *Vertical gardens*. IntechOpen. 587-622.
- [13] Urrestarazu, M., & Burés, S. (2012). Sustainable green walls in architecture. *J Food Agric Environ*, 10(1), 792-4.
- [14] Yeh, Y. P. (2010). Green Wall-The Creative Solution in Response to the Urban Heat Island Effect. *National Chung-Hsing University, Taiwan*.