

## Vertical Gardening

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Living green walls are panels of plants, grown vertically on structures that can be either free-standing or attached to walls. Living green walls are also referred to as vertical gardens, green walls, living walls or Eco walls. In 21 Century, one of the biggest challenges is to bring the nature into urban areas and perhaps, the most effective and spectacular resolution is the vertical garden.

Vertical Gardening is a special kind of urban gardening suitable to small spaces, particularly for decorating the walls and roofs in various styles. The construction of vertical gardens is recommended both in interiors and especially in the exterior of buildings. This is an alternative method for gardening by expanding the scope of growing plants in a vertical space. By applying these technologies, any kind of area can be used at its maximum capacity, benefit for environment and also human health. Environmental benefit are raising the vegetation, reduces the pollution effect. Vertical garden was invented by Stanley Hart White who patented a green wall system in the late 1930s.

A vertical garden also known as green wall or living wall are self-sufficient vertical gardens that are attached to exterior or interior walls of a building. They differ from green facades (ivy walls) as green walls have growing media supported on the face of the wall, while green facades have soil only at the base of the wall and support climbing plants on the face of the wall to create the green, or vegetated, facade. Green walls can absorb heated gas in the air and it will lower both indoor and outdoor temperature by providing a healthier indoor air quality as well as a more beautiful space. The plants receive water and nutrients from within the vertical support instead of from the ground. In vertical gardens, various types of modular panels can be used along with geotextile fabrics, growing media, irrigation systems, and plants.

- Having vertical garden can reduce indoor volatile organic compounds (VOCs) and other compounds linked to Sick Building Syndrome. (Butkovich *et al.*, 2008).

- In Switzerland, the idea of vertical nursery was first created. It was not regular in India, however now-a-days because of shortage of room it has been embraced in metro urban communities of the country. This is really a unique sort of nursery made with assistance of vertical structures and plants are developed in extraordinary way.

### Benefits of Vertical Gardening

- Vertical gardens can be fit into any kind of urban construction.
- Act a green wall.
- Effective greenery per unit area.
- Occupy less area.
- Add more aesthetic value.
- Require less water due to better substrate.

### Public / Private Benefits of Vertical Gardening

Area of impact	Description	Benefits
Reduce urban heat island effect	Temperature rise in urban areas caused by the replacement of natural vegetation by other structures	Promotes natural cooling and reduces temperature
Improved exterior air quality	Modern urban environments are having high concentration of air pollutants	Captures airborne pollutants and filters particulate matter
Aesthetic improvement	Studies have linked the presence of plants to improved human health and mental well being	Creates visual interest Increases property values Hides unsightly features
Building structure protection	Buildings are exposed to the weathering and	Protects exterior from UV radiation

	cause deterioration	and temperature fluctuations
Improved energy efficiency	Improves thermal insulation capacity through external temperature regulation	Reduces ambient temperature
Improved indoor air quality	Filter contaminants that are flushed out of buildings through traditional ventilation systems	Captures airborne pollutants such as dust and pollen

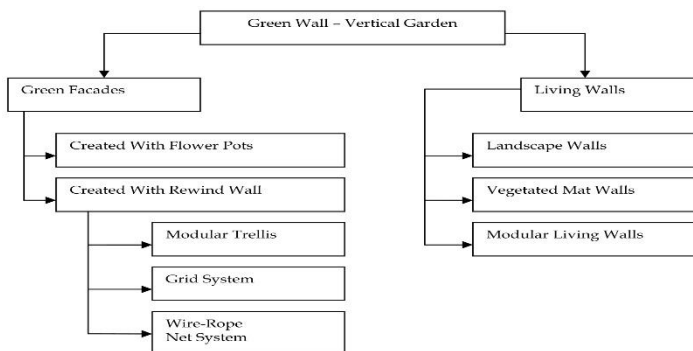
### Green Wall

A wall, either free-standing or part of a building, that is partially or completely covered with vegetation.

### Categories Of Green Walls

**Green Facades:** Growing climbing plants directly on a wall. Climbing vegetations are designed and trained to grow and cover a designated supporting structure. Metal frames, square panels, and cable systems are the options for the supporting structure. The purpose of these supporting frames is to keep the vegetation off the wall surface so that they will not damage the exterior and will provide easy access during building maintenance.

### Classification of Vertical Garden

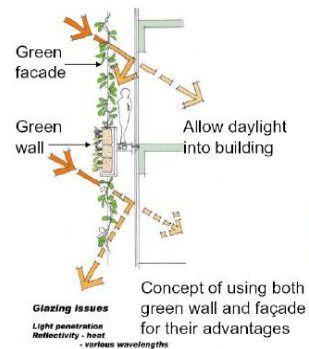


**Fig 1: Flowchart of classification of vertical garden**

**Living Walls:** The living wall is a kind of vertical garden in which vegetations are pre-planted onto panels. These panels are then installed vertically to a frame on a structure. This type of vertical garden allows a wider diversity of vegetations. (Lambertini, A., & Ciampi, M., 2007). These self-clinging vegetations can be rooted in the ground or in hanging planters. In this case, each supporting frame (each block), will be 1 m in width, 1 m in height, and 30 cm in depth, and the entire vertical garden will be

constructed with combination of blocks. In vertical gardens, various types of modular panels can be used along with geo-textile fabrics, growing media, irrigation systems, and plants.

### Hybrid System



- ❖ Reduced heating – by shading
- ❖ Reduced reflected heat to surrounding buildings
- ❖ Reduced Urban Heat Island effect
- ❖ Reduced Greenhouse Gases

### Choosing the plants for Vertical Garden

- Dense, Compact and Low growing plants.
- For Plants planted under sun - drought-tolerant plants, whereas a shady spot (pergola or verandah) will require a selection of shade lovers, such as ferns.

### Plants suitable for outdoor vertical garden

Peperomia, Syngoniums, Philodendron, Epipremnum, Begonia, Anthuriums, Nephrolepis, Chlorophytum, Lantana, Pilea, Rheo discolors, Cuphea, Fittonia, Spathiphyllum, Schefflera, Lavender, Geranium varieties, Carnation, *Rosmarinus officinalis* and *Thymus vulgaris*.

### Cooling effect of Ivy plants (Hedera) on a wall

- For Ivy covered wall, solar radiation is reflected by the leaves and some penetrates the leaf layer.
- Thus, reducing heat energy inside the building.
- The green wall reduces the heat gain by absorbing and reflecting heat energy.

### Planting

- The plants will be planted by hand in the rigid preformed containers with a maximum density of 32 plants/m<sup>2</sup>, above which there will be competition between the plants.
- The plants should be in 9 cm pots maximum so as not to break up the root balls when they are placed in the containers.

- The choice of green wall should be based on the environment's limiting factors (light, temperature, plant requirements, etc.)

### Growing media for Vertical Garden

Requirements are

1. Weightless media
2. High Water holding capacity
3. High Nutrient holding capacity
4. Good Porosity
5. Neutral pH
6. The growing medium should be specifically designed for use in a vertical position to limit constraints such as compaction, water retention, weight, drainage, etc.
7. Its composition will be organic-mineral (30% and 70%) and strictly composed of pozzolan, crushed clay balls, peat and water-retention agents (cross-linked polymers).
8. Fertilising the substrate must be carried out either by 'fertigation', using an automated watering system (strongly recommended) or using a slow-release fertiliser (such as Osmocote or equivalent).
9. Cocopeat, Perlite, Sphagnum moss, vermiculite, vermicompost, shredded bark and leaf molds are the common media combinations used.
10. Soil is not used since it increases the weight of the green walls.

### Irrigation

- Water is the main factor contributing to plant growth.

- Short but frequent watering periods, 2 to 5 minutes and 1 to 5 times a day, depending on seasons and regions.
- It allows the water to spread down through the module more slowly and to be absorbed by the growing medium, and avoids wastage.
- This keeps the substrate at a certain moisture level.
- It continues to absorb water easily thereby minimizing water run-off at the bottom of the green wall.
- For all these reasons we do not recommend manual watering as it is difficult to control.

### Challenges of vertical gardening

- Expense
- Heavy load
- Maintenance cost is high

### Conclusion of Vertical gardening

- Aesthetic effects
- Acts as natural insulation for hot and cold air and a save energy for building
- Reduces CO2 levels and increases oxygen and improved air quality
- Conserves water and watering takes less effort
- Sound absorption and noise absorption
- Improves thermal insulation and energy efficiency
- Provides protection to buildings from adverse temperature and hence improves the life expectancy of the buildings
- Mitigate urban island heat effect
- It holds rain water, providing food and shelter for wildlife

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