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Development and Application of Vertical Greening System

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(More information: www.hku.hk/bse/greenroof/)

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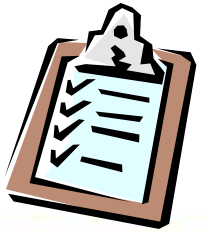
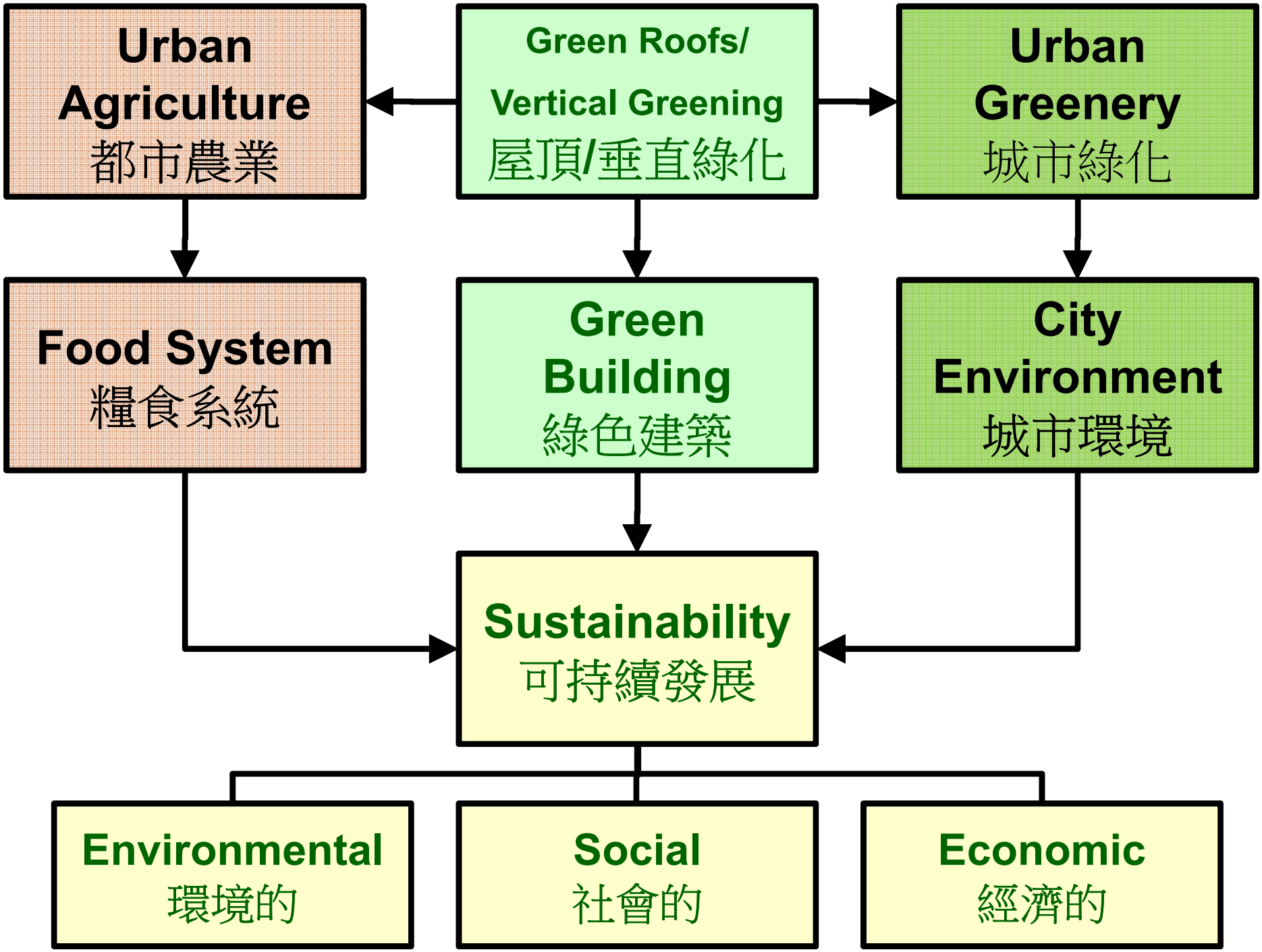


- The Need for Greenery
- Vertical Greening Systems
- Types and Classification
- Possible Benefits
- Key Considerations

The Need for Greenery

- Hong Kong 香港
  - Land area: 1,104 km^2
  - Population: 7.06 millions
  - Population density: 6,480 persons/ km^2
- High urban density to meet population growth
  - Urban heat island and lack of greenery space
  - Habitat loss, air pollution, climate change
- Promote green roofs and vertical greening to achieve ***urban sustainability***


Urban Agriculture
都市農業
Green Roofs/
Vertical Greening
屋頂/垂直綠化
Urban Greenery
城市綠化
Food System
糧食系統
Green Building
綠色建築
City Environment
城市環境
Sustainability
可持續發展
Environmental
環境的
Social
社會的
Economic
經濟的

The Need for Greenery

- Conventional greening methods
  - Tree planting and urban parks
- Greening initiatives in buildings
  - Roof gardens
  - Sky gardens
  - Green roofs
- How to maximise the greening effects?
  - Vertical greening on wall surfaces
  - Three dimensional greening

D.I.Y. vertical greening systems (Singapore HortiPark)

(Photo taken by Dr. Sam C. M. Hui)

Three dimensional greening (in Singapore)

(Photo taken by Dr. Sam C. M. Hui)

Vertical Greening Systems

- ***Vertical greening*** – descriptive terms
  - Green walls, living walls, bio-walls, living wall/ cladding, green facades, vertical green, vertical gardens, vegetated wall surfaces
- Possible applications:
  - 1. Building façades or outdoor vertical surfaces
  - 2. Interior walls or indoor vertical surfaces
  - 3. Noise barriers (e.g. along the roads)
  - 4. Slopes and site hoarding boards

An example of vertical greening 垂直綠化的一個例子

(Source: CityWalk, Tsuen Wan, 荃灣荃新天地, www.citywalk.com.hk)

A green wall in Central (restaurant) 中環的綠牆 (餐廳)

A green wall project in Kowloon Bay 在九龍灣一個綠化牆工程

(18 Kowloon East)

A green wall project in Wanchai 在灣仔一個綠化牆工程

(The Hennessy)

Green wall for exhibition function 用於展覽功能的綠牆

(Source: www.greening.gov.hk)

Government demonstration projects 政府示範項目

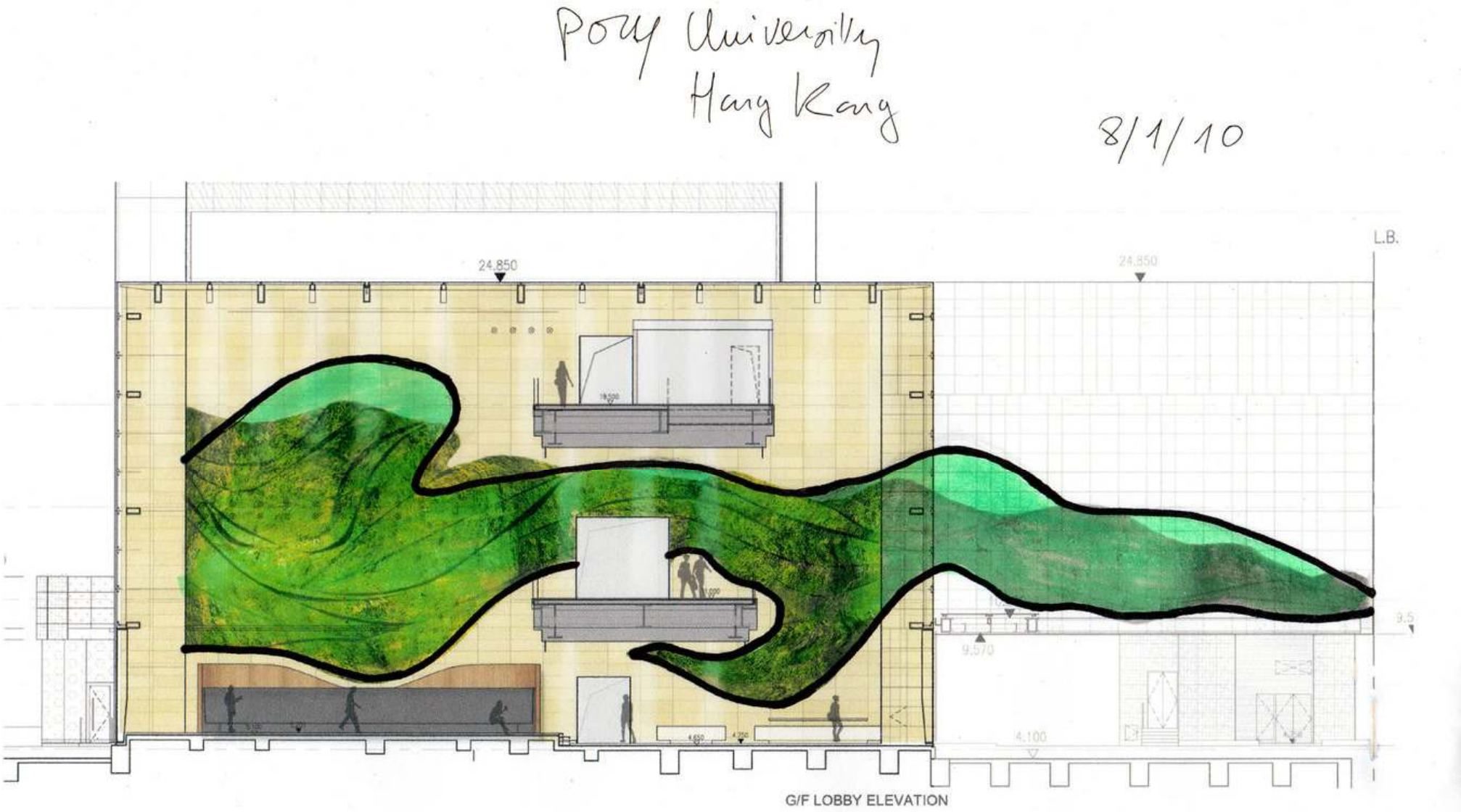
For a housing estate

For a school building

For a government building (EMSD Headquarters)

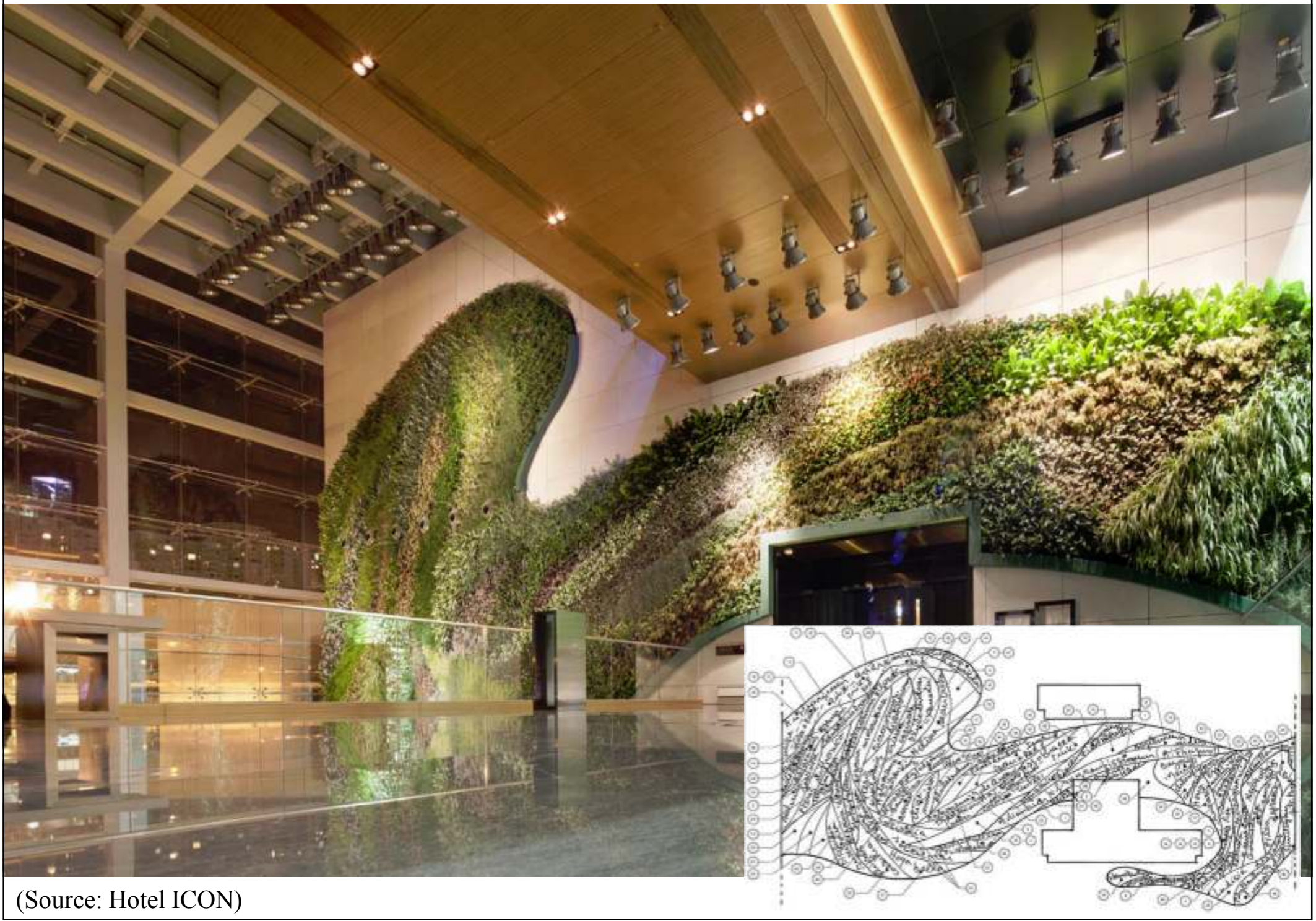
(Source: www.greening.gov.hk)

An example of indoor green wall in Hong Kong (at a hotel)



(Source: www.verticalgardenpatrickblanc.com)

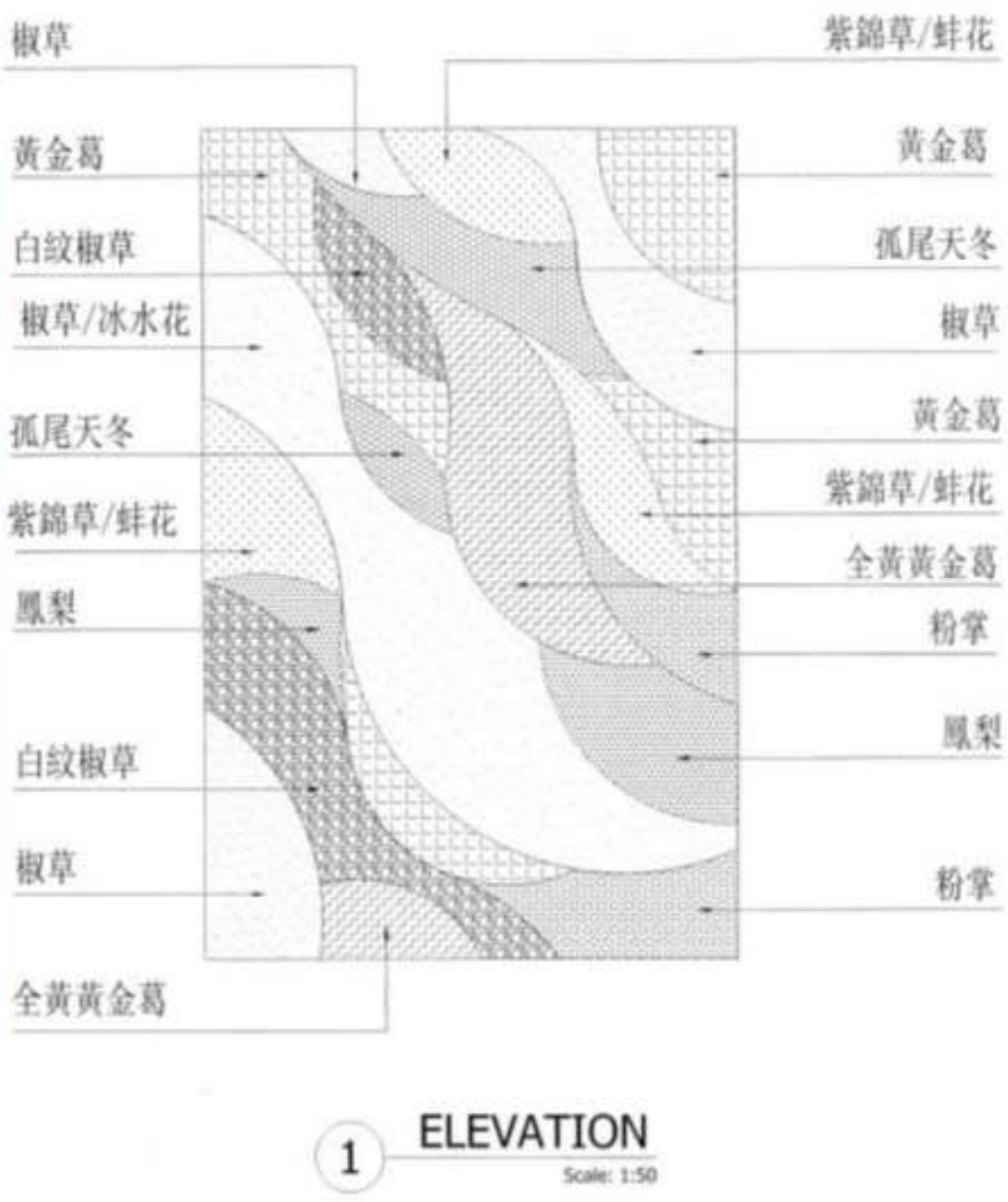
An indoor green wall in a hotel 在酒店的一個室內綠化牆



(Source: Hotel ICON)

Indoor green wall 室內綠化牆

Indoor green wall 室內綠化牆

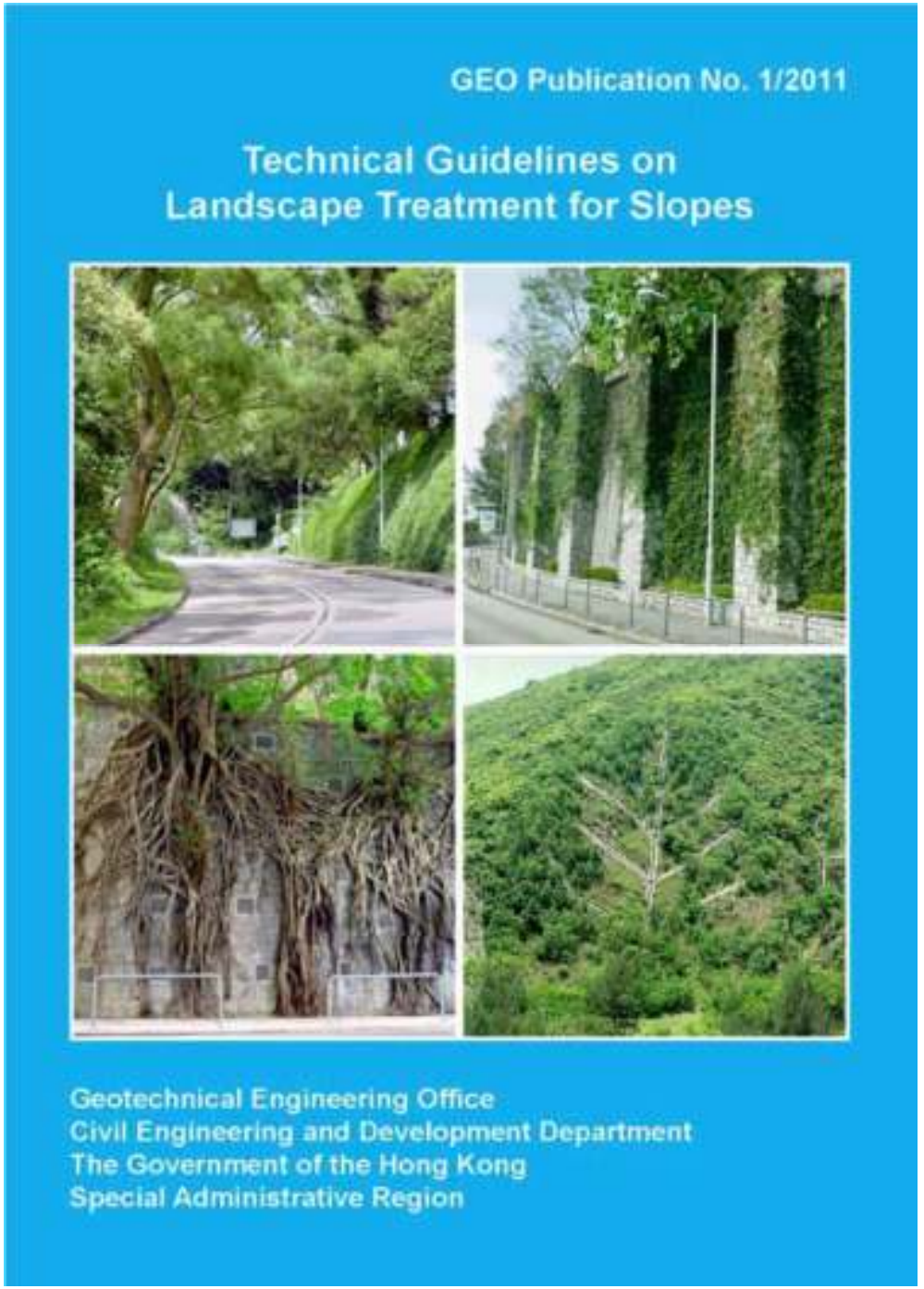


(CityWalk 2, Tsuen Wan)

Green noise barrier 綠色隔音屏障

(Source: Highway Department, HK)

Greening on slopes 綠化斜坡

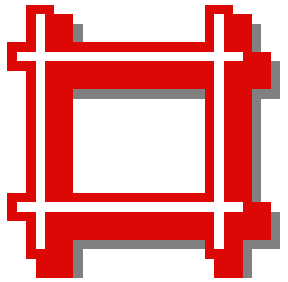


(Source: Civil Engineering and Development Department)

Greening on site hoarding boards (Taiwan) 綠化圍板（台灣）

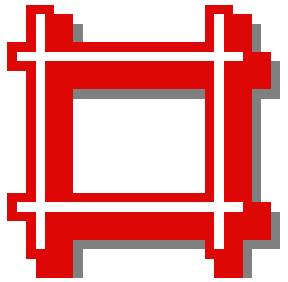
(Photo taken by Dr. Sam C. M. Hui)

Types and Classification



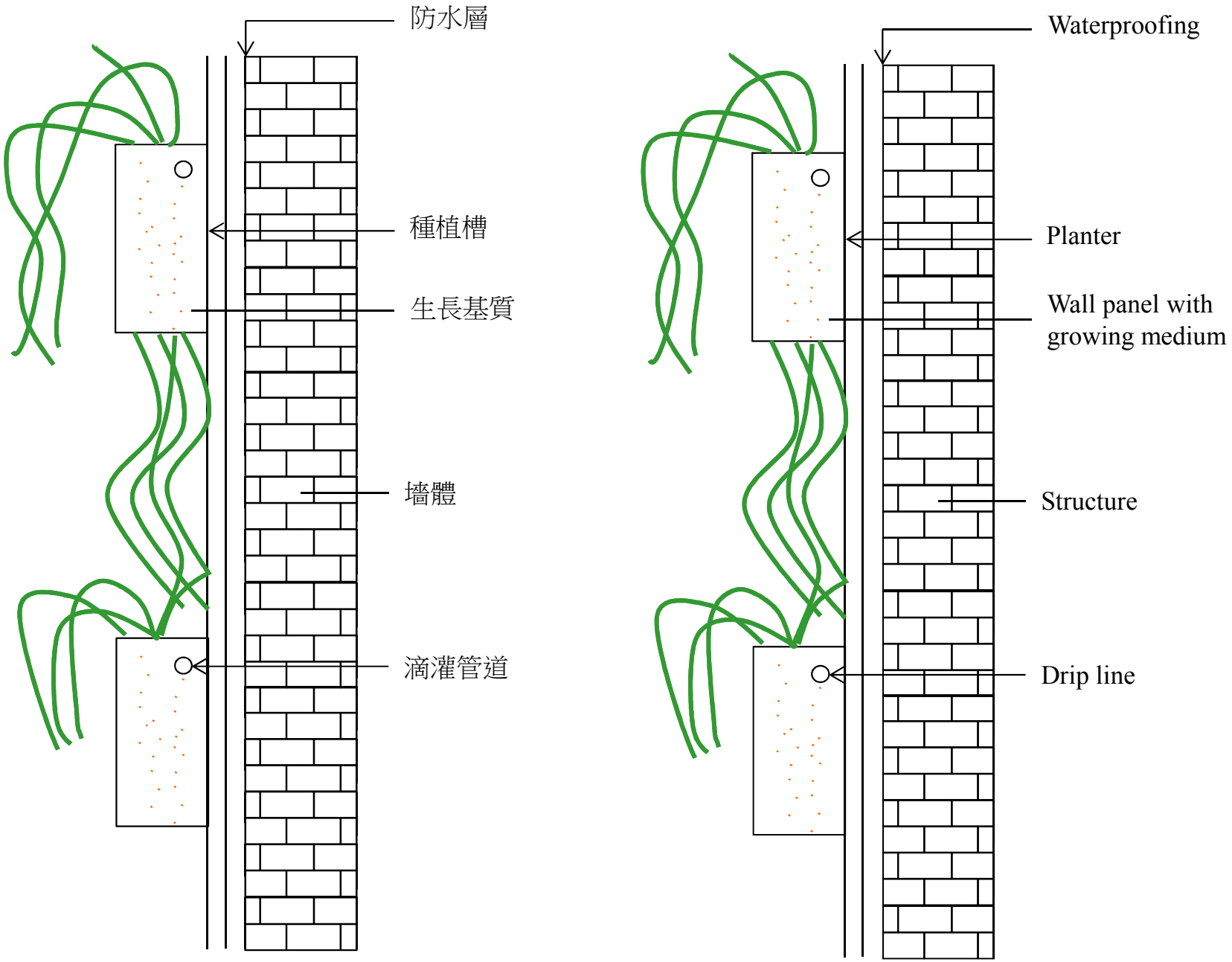
- Types of vertical greening systems:
  - 1. Green façades
    - Climbing plants, trellis systems, modular trellis panel system, cable and wire-rope net system
  - 2. Living/Green walls
    - Modular green wall, vegetated mat wall
    - Substrate-based or hydroponics
  - 3. Interior green walls
  - 4. Spontaneous living walls

Types and Classification



- 1. Green façades
  - Climbing plants or cascading ground covers are supported on specially designed structures
  - The plants are either grown in the ground or in elevated containers where they are watered and fertilised
  - The ‘sucker’ roots system of self-clinging plants that attaches to the wall can damage the wall surface

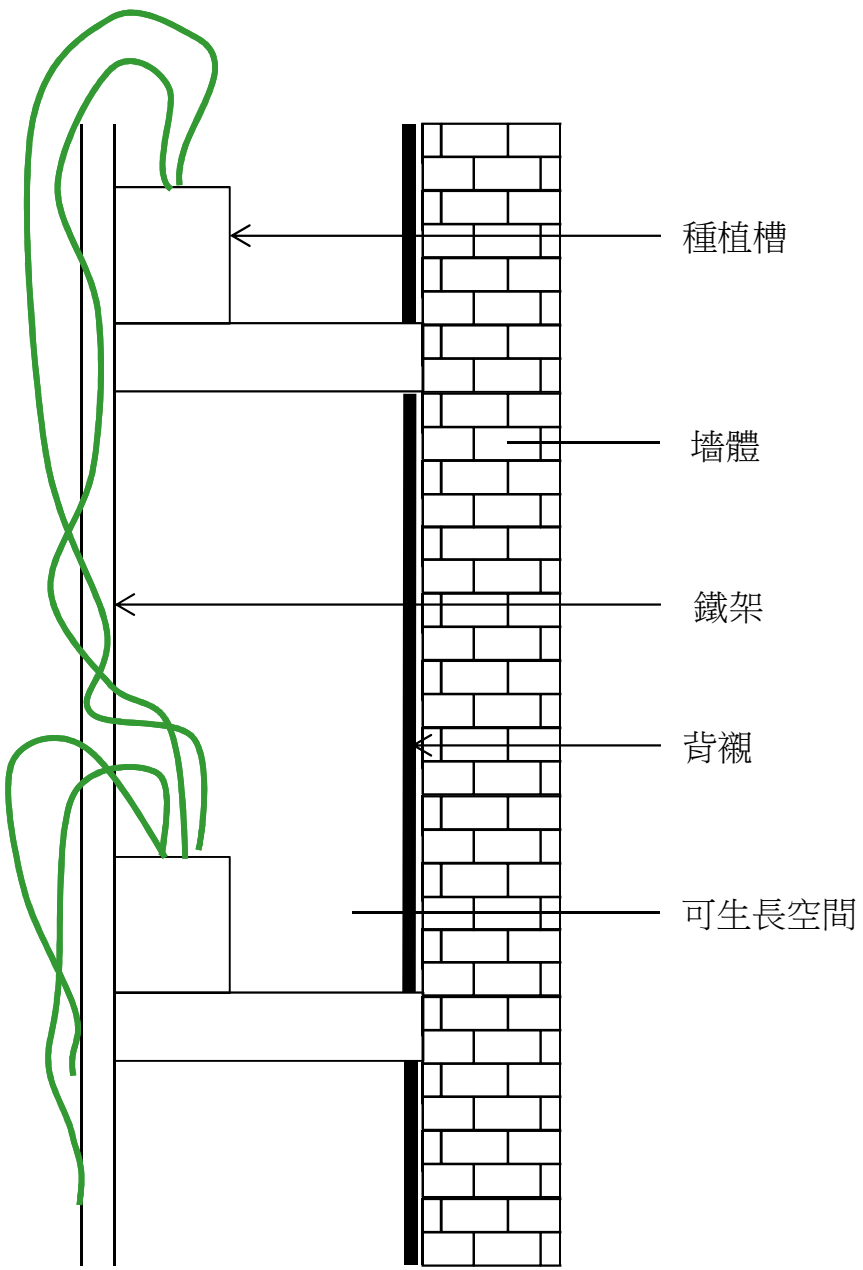
3. 攀爬或垂吊式/Climbing or Hanging System

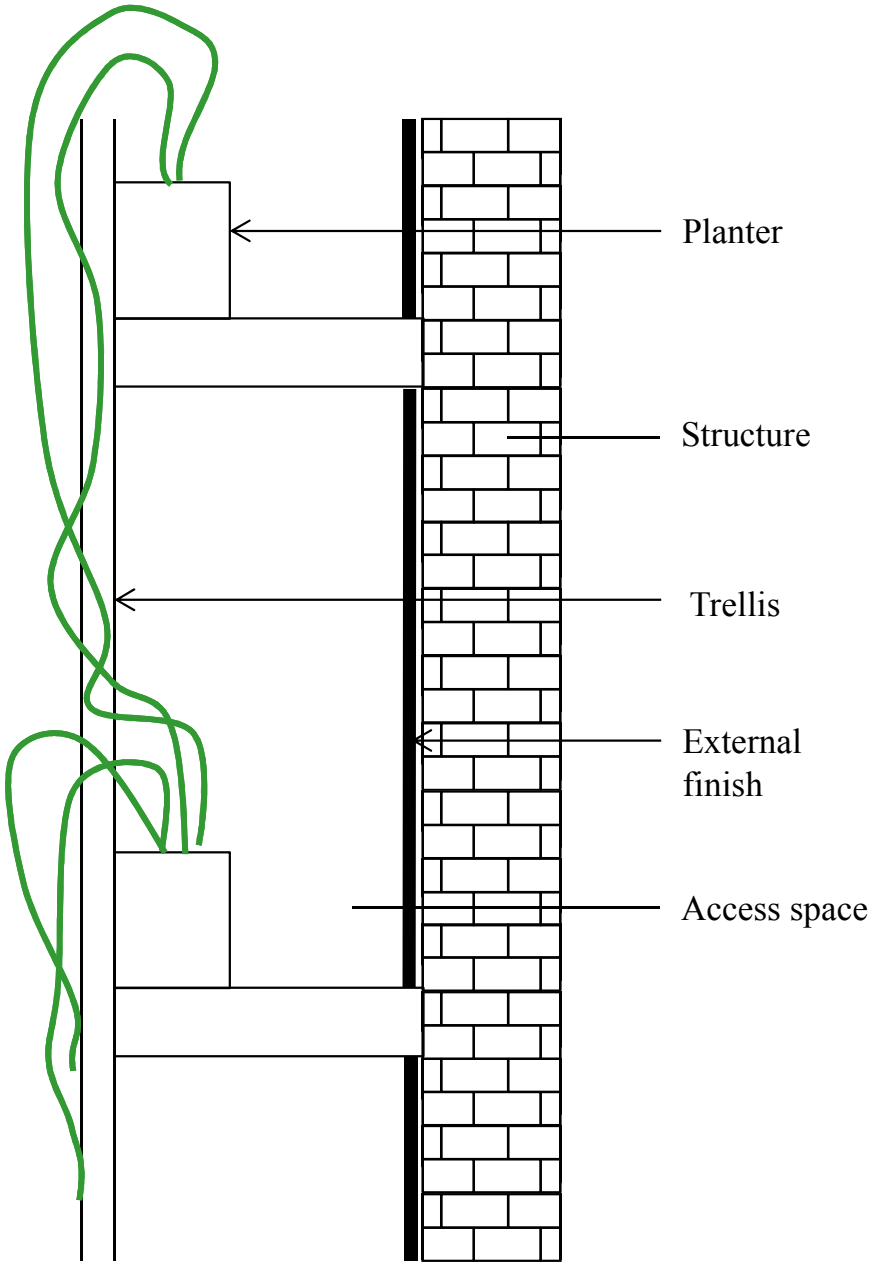


Types and Classification

- 1.1 Trellis systems
  - A series of wires or cables is attached to structure , allowing the climbing plants to grow up the cables to create a plant screen/wall
  - These structures can be attached to the building envelope or can be free standing

7. 鐵架攀爬或垂吊式/Climbing or Hanging System with Trellis

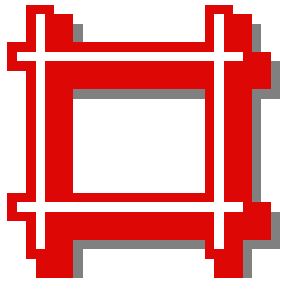




Types and Classification

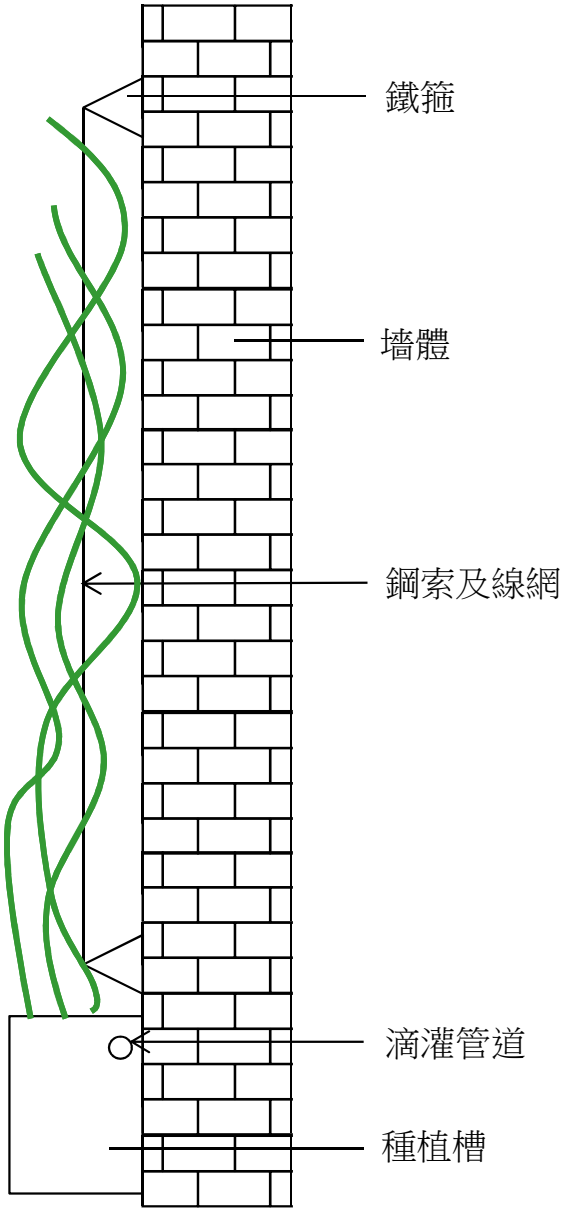
- 1.2 Modular trellis panel system
  - A rigid, light weight, three-dimensional panel made from welded steel that supports plants both on the face grid as well as the panel depth
  - This system is designed to keep the green facade off the wall surface so that the plant material cannot attach to the building

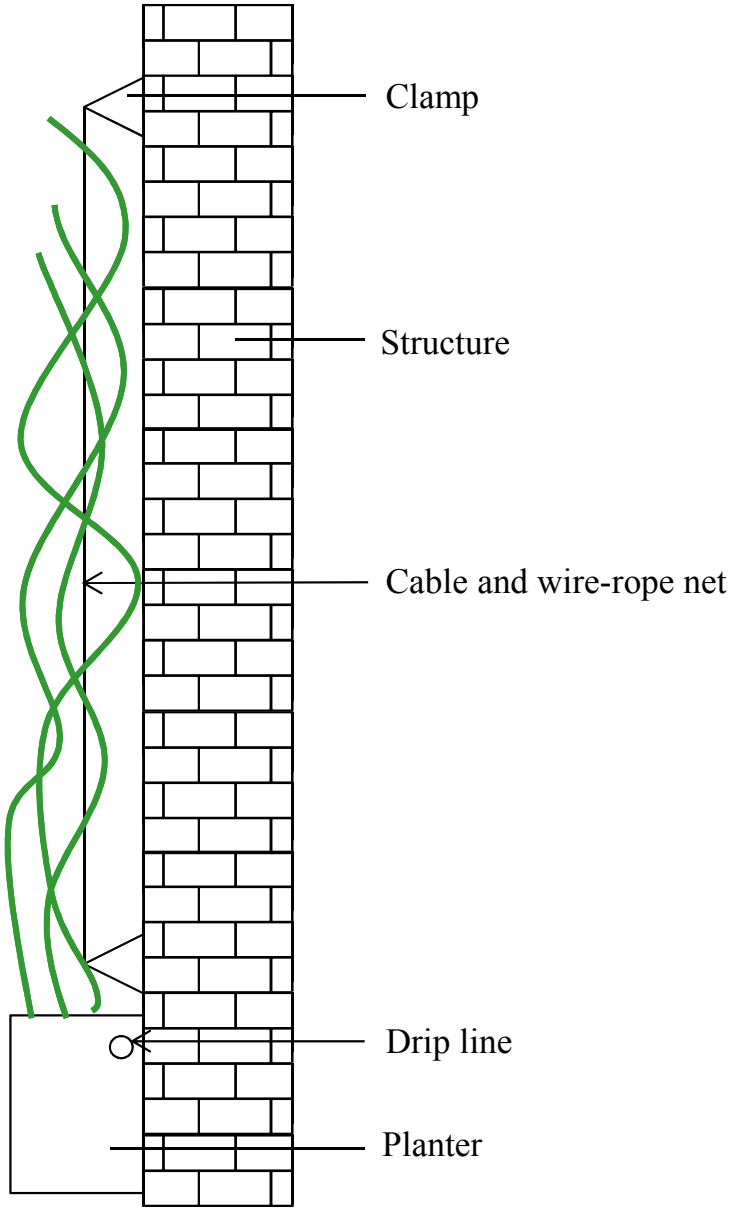
Types and Classification



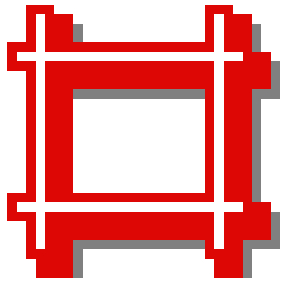
- 1.3 Cable and wire-rope net system
  - It uses either cables and/or wire net
  - Cables are usually designed for faster growing climbing plants, whereas wire-rope nets are used for supporting slower growing plants that need support at closer intervals
  - Both systems use high tensile steel cables, anchors and supplementary equipment

8. 鋼索及線網式/Cable and Wire-Rope Net System





Types and Classification



- 2. Living/Green walls
  - Constructed from pre-vegetated panels, vertical modules or planted blankets (vegetated mat wall) that are fixed to structural framework or to a wall
  - Made from steel framework, plastic, expanded polystyrene and synthetic fabric to support a variety of diversity and density of plant species
  - Tend to require more maintenance such as fertiliser and water than green facade systems that are planted into the ground

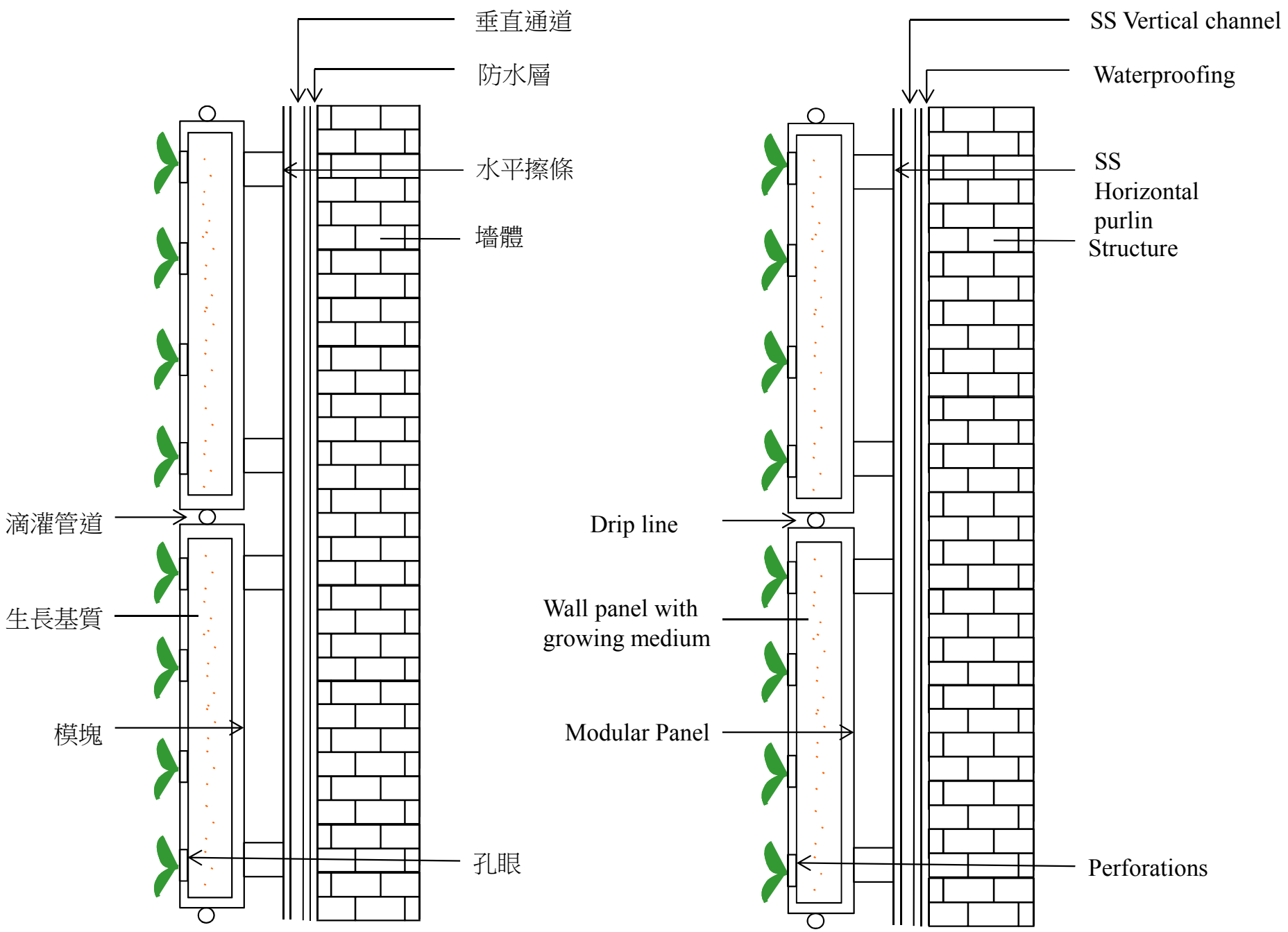
An example of living wall (Taipei)

(Source: www.sa-space.com)

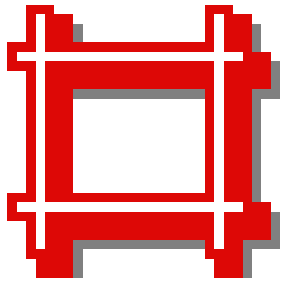
Types and Classification

- 2.1 Modular green wall
  - Consist of panels that hold growing media to support the plant material
  - Usually pre-grown, providing an instant effect after installation
  - Require irrigation at different levels along the wall using gravity to move the water through the growing media; similarly nutrient and fertilising is carried out through this method

1. 模塊式/Modular Panel System



Types and Classification

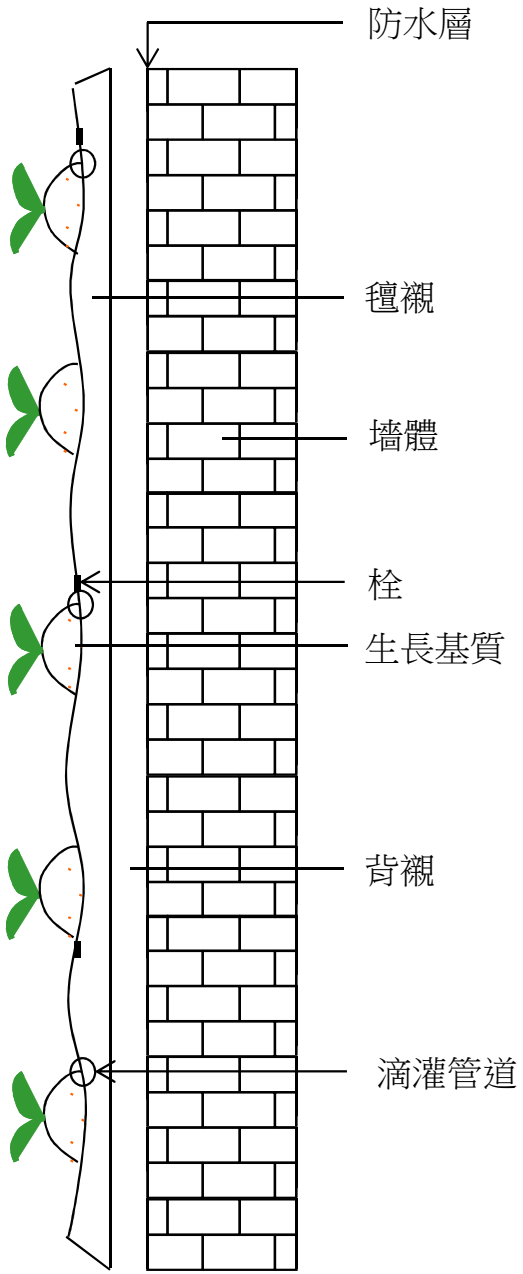


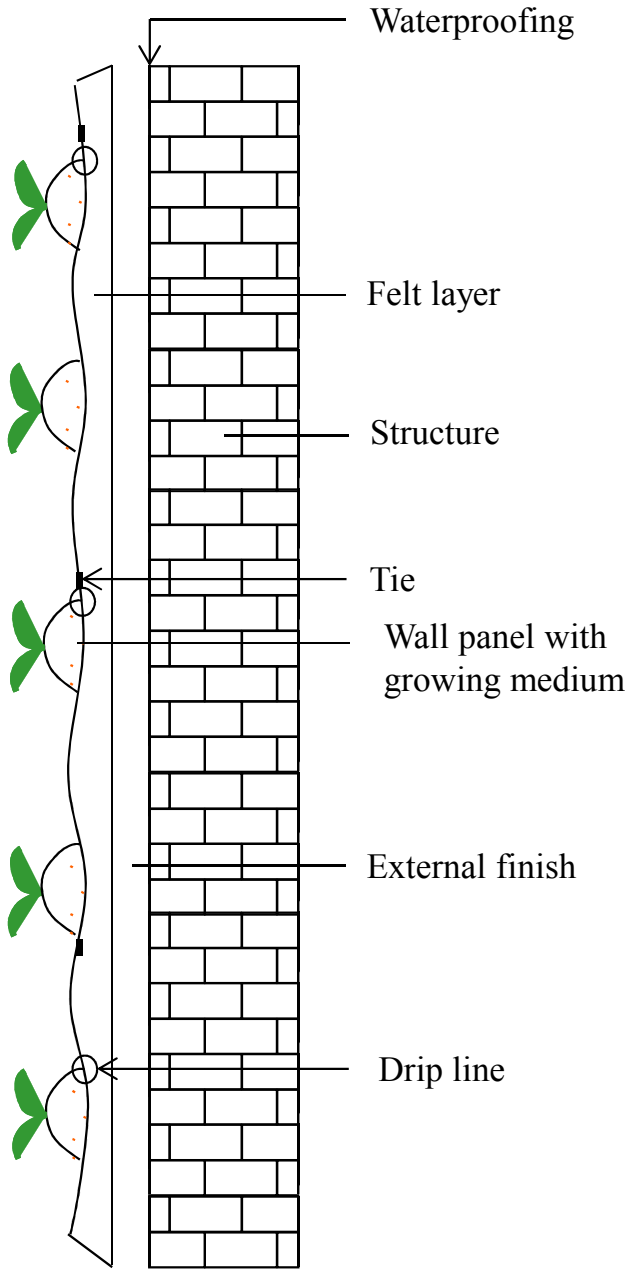
- 2.2 Vegetated mat wall
  - This system, pioneered by Patrick Blanc, is composed of two layers of synthetic fabric with pockets filled with the plants and growing media
  - The fabric walls are supported on a framework and backed by a waterproof membrane against the building wall
  - Nutrients and water are delivered through an irrigation system at the top of the wall

A living wall in a museum (Paris)

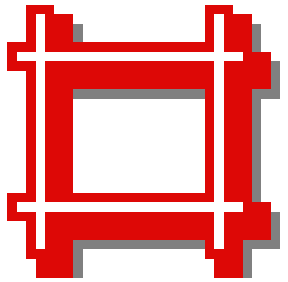
(Source: www.verticalgardenpatrickblanc.com)

5. 布袋式/Bag or Felt System





Types and Classification



- 3. Interior green walls
  - Interior living walls can be constructed from any of the previous systems
  - Designed for interior purposes, called the Biofiltration system (Bio-wall)
  - With indirect access to light and ventilation
  - Biophilic qualities that contribute to better health and air quality

Indoor green wall 室內綠化牆

(International Commerce Centre 國際貿易中心)

(Photos taken by Dr Sam C M Hui)

(International Finance Centre 國際金融中心)

Indoor green wall in a subway station (Taipei)

(Source: Mr. Eddie Tse)

Types and Classification

- 4. Spontaneous living walls
  - These are living walls that occur in the urban area where seeds germinate wherever they can and start growing, usually in hostile environments
  - These plants are often garden escapees or weeds that create a new urban habitat or environment to support greater biodiversity in the cities

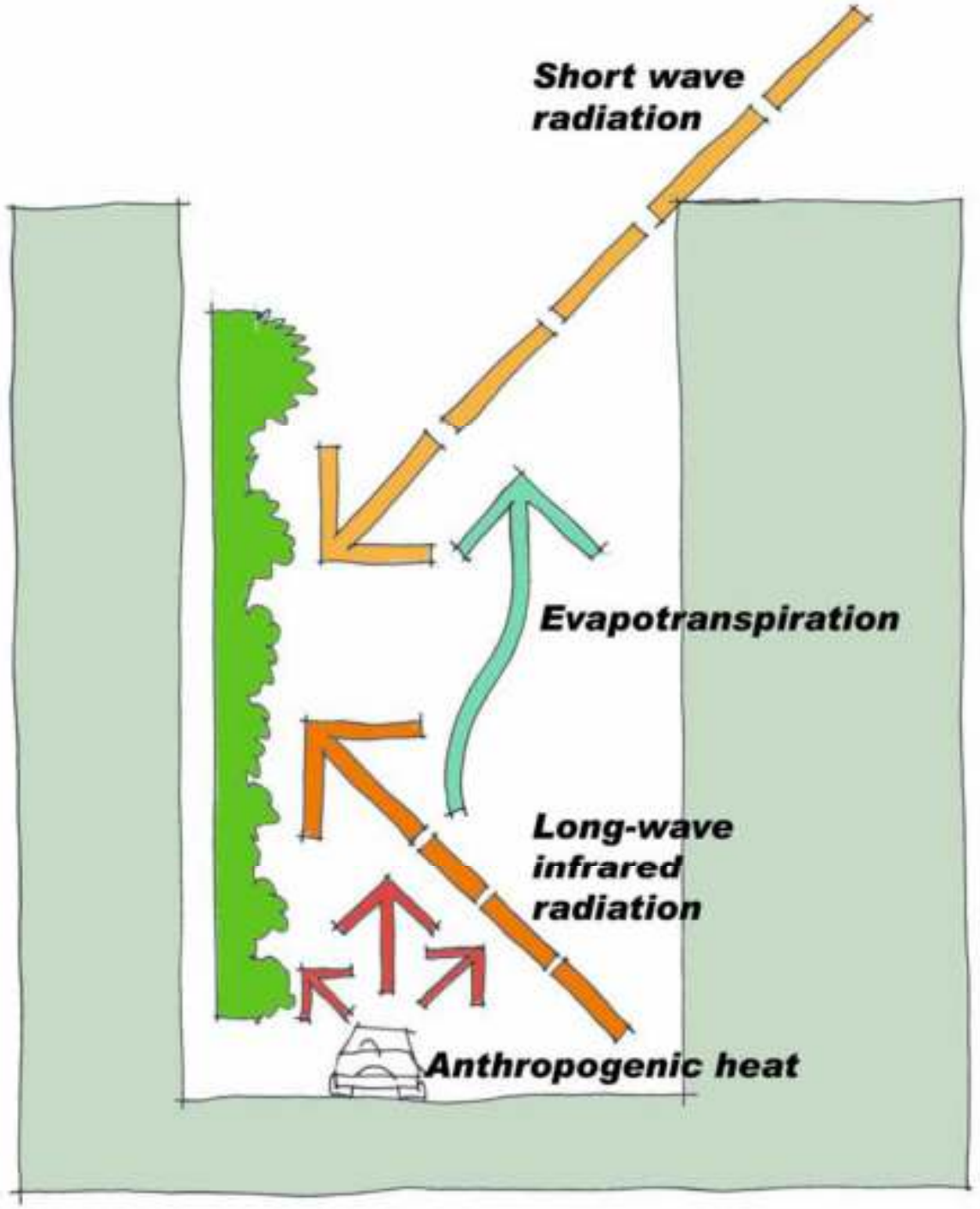
Possible Benefits

- Benefits of greenery in urban areas
  - Air temperature control
  - Air pollution
  - Biodiversity & habitat protection
  - Stormwater management
- Green roofs & vertical greening
  - Building integrated vegetation
  - Green infrastructure
  - Urban cityscape

Video: The Benefits of Living Green Walls (4:23)
http://www.youtube.com/watch?v=K7FQd7DXdWc

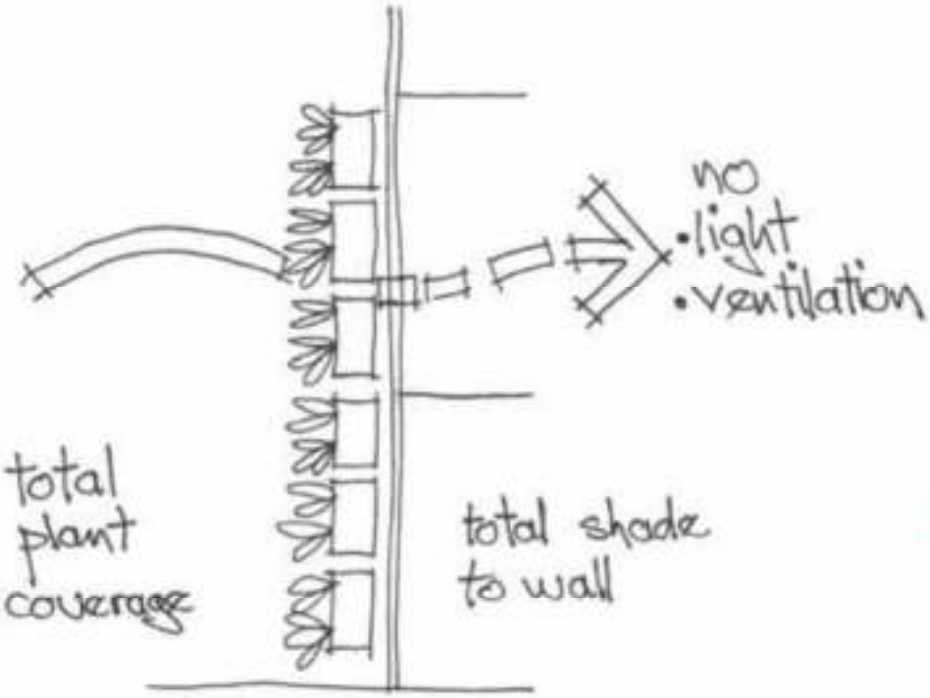
Possible Benefits

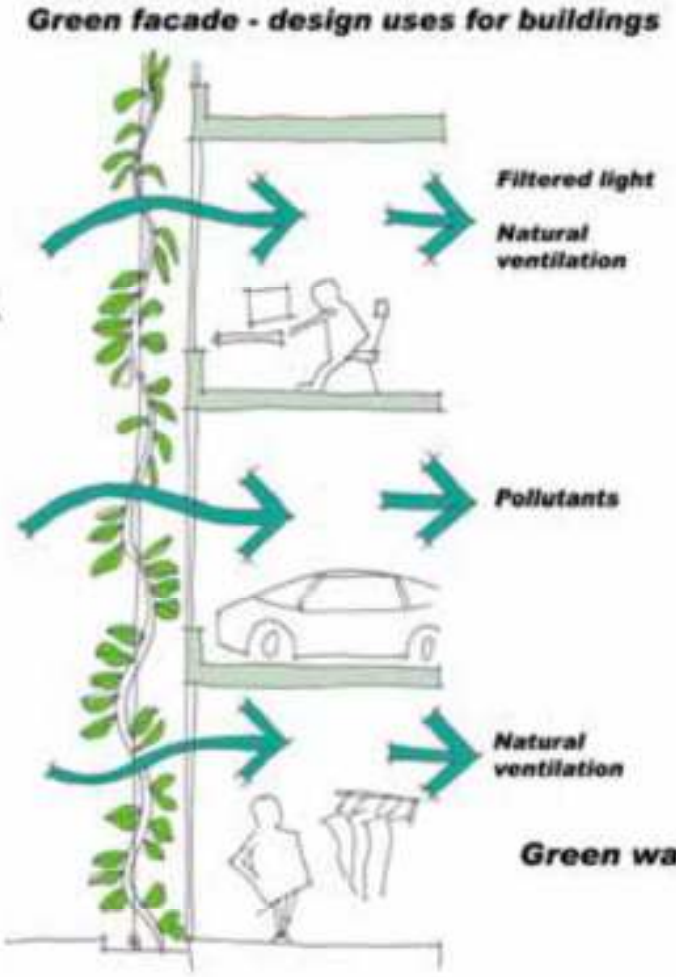
- Public benefits
  - Mitigate urban heat island (UHI)
  - Regulate microclimate & temperature
  - Improve exterior air quality
  - Urban aesthetic improvements
  - Provide ecological habitats
  - Increase biodiversity
  - Positive effects on hydrology
  - Possible urban food production

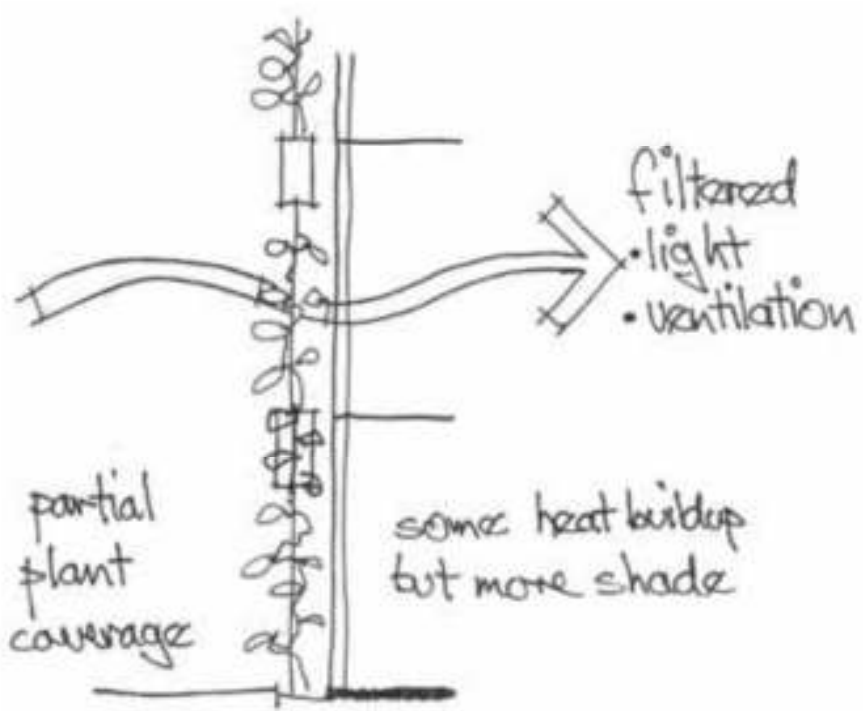


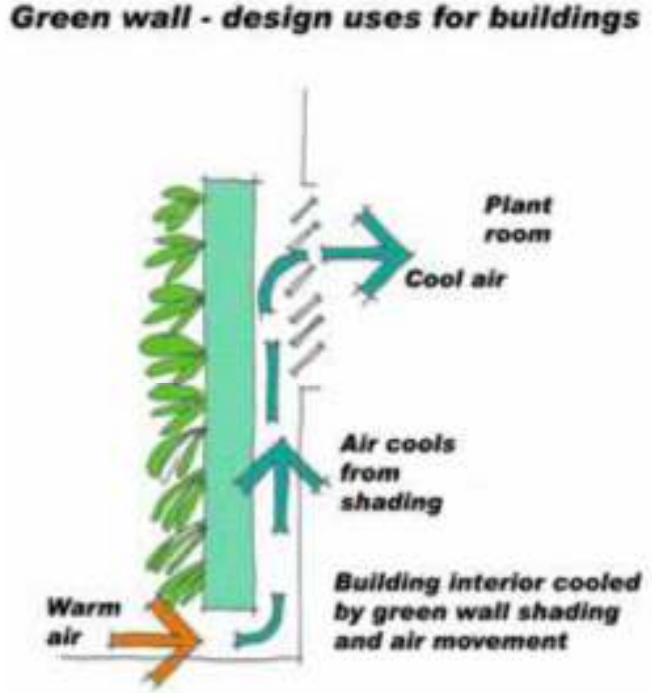
Urban canyon with living wall

(Source: University of Adelaide)



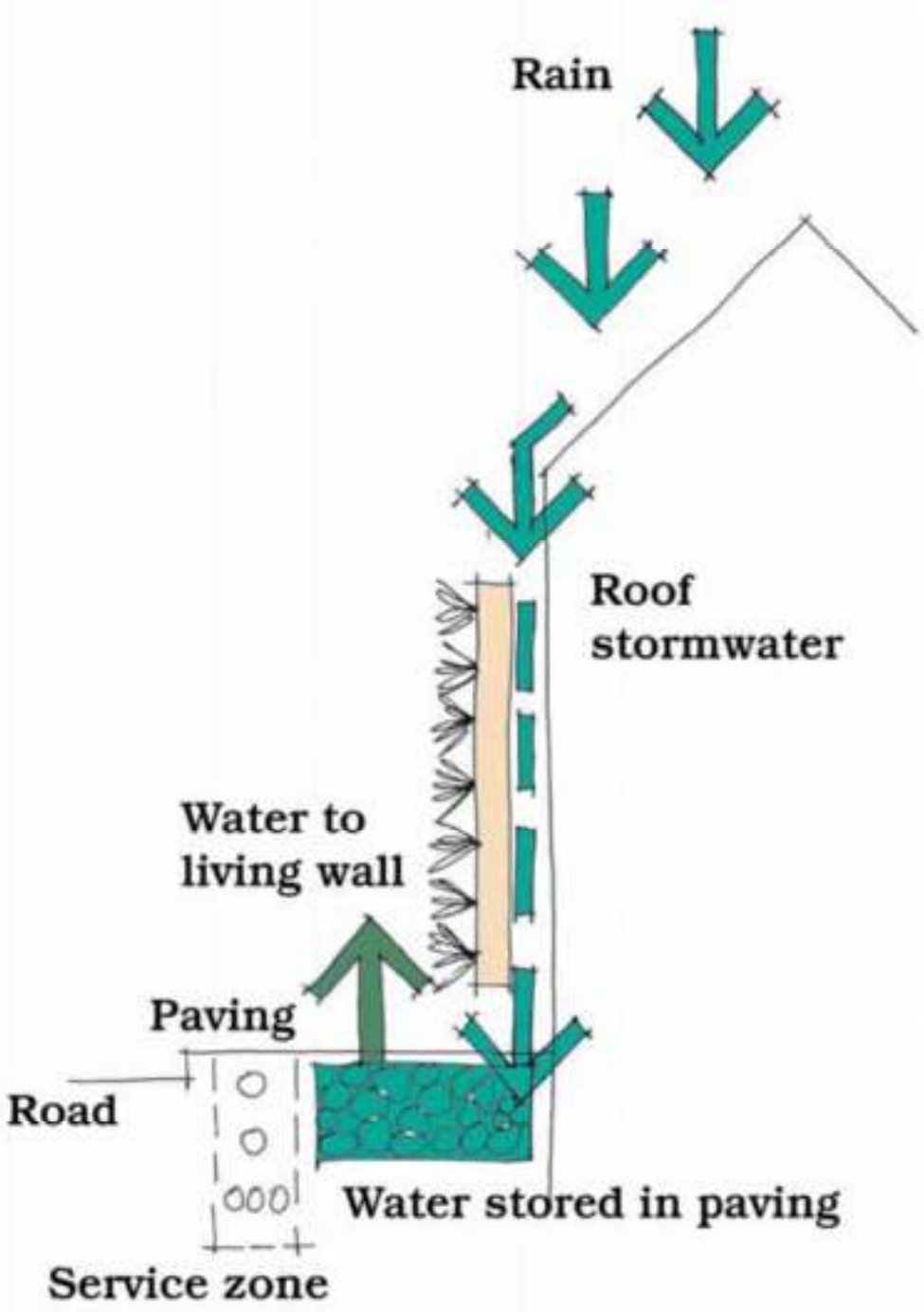


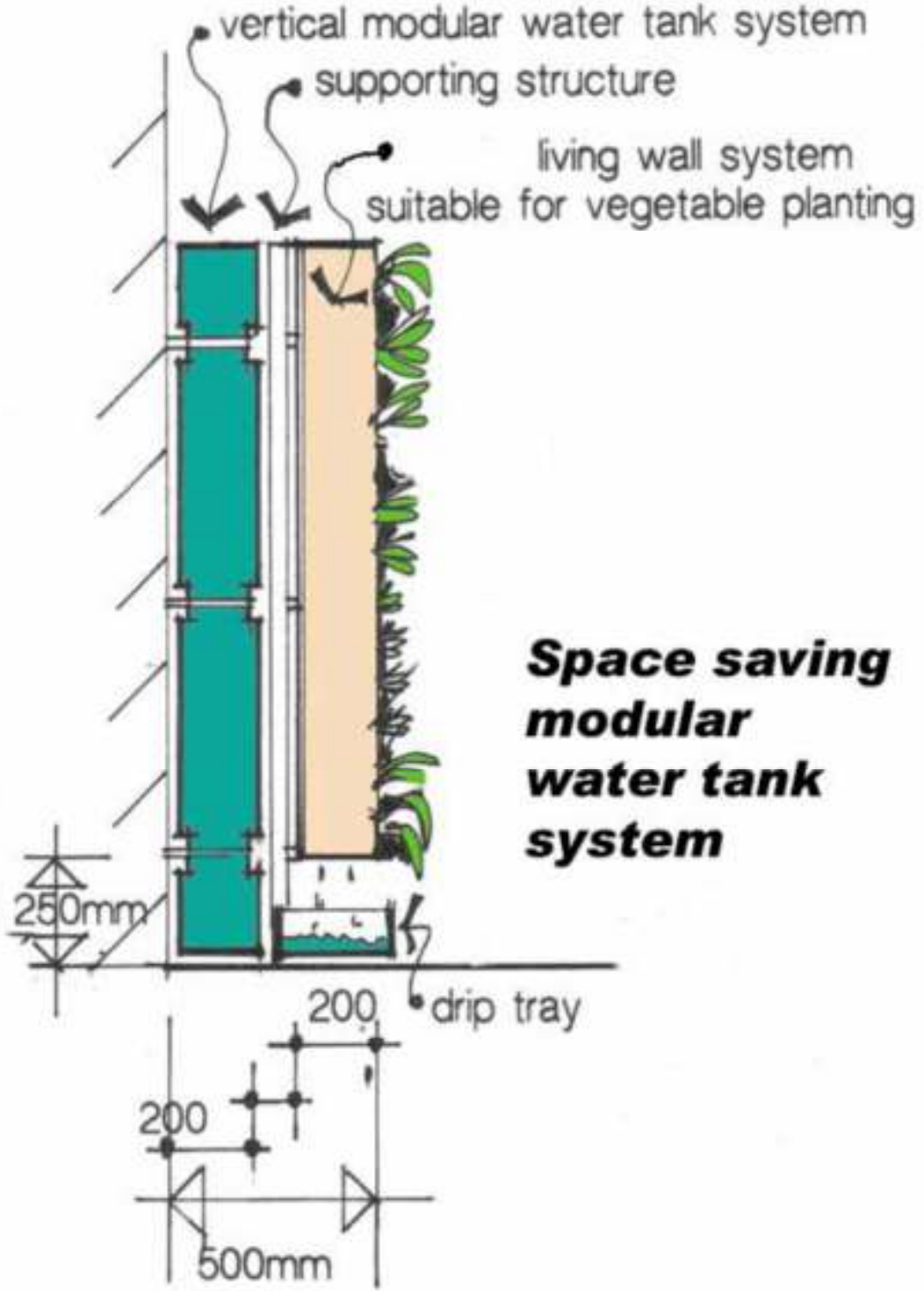




(Source: University of Adelaide)

Rainwater harvesting and storage





(Source: University of Adelaide)

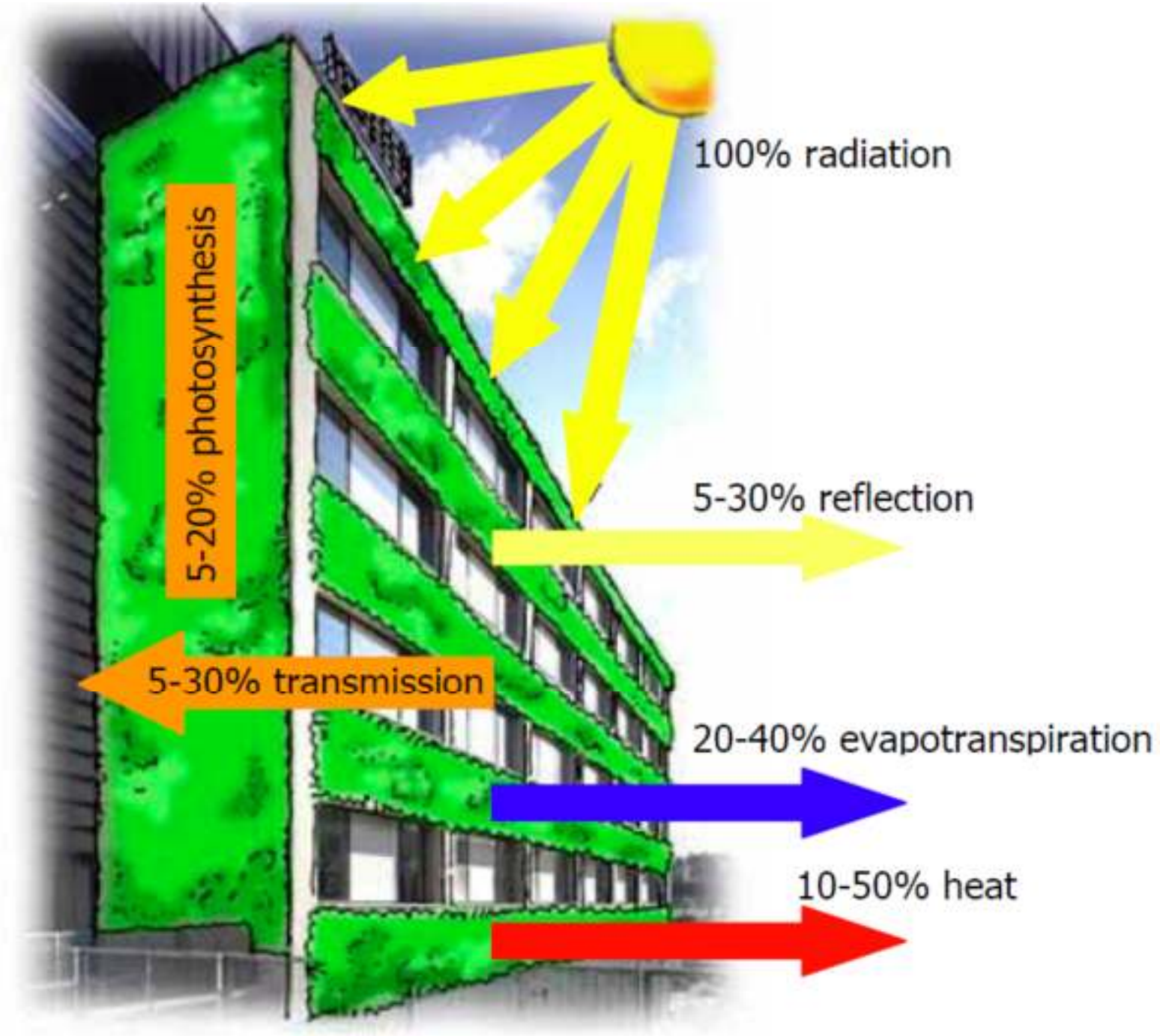
Edible vertical garden 食用垂直花園

(Source: www.lifeisagarden.com.au)

Possible Benefits

- Private benefits
  - Aesthetic effects & visual impact
  - Marketing & green image
  - Improved thermal insulation & energy efficiency
  - Reduce cooling energy
  - Protect against solar radiation & rain
  - Improved indoor air quality
  - Sound absorption & noise reduction
  - Credit points for green building assessment

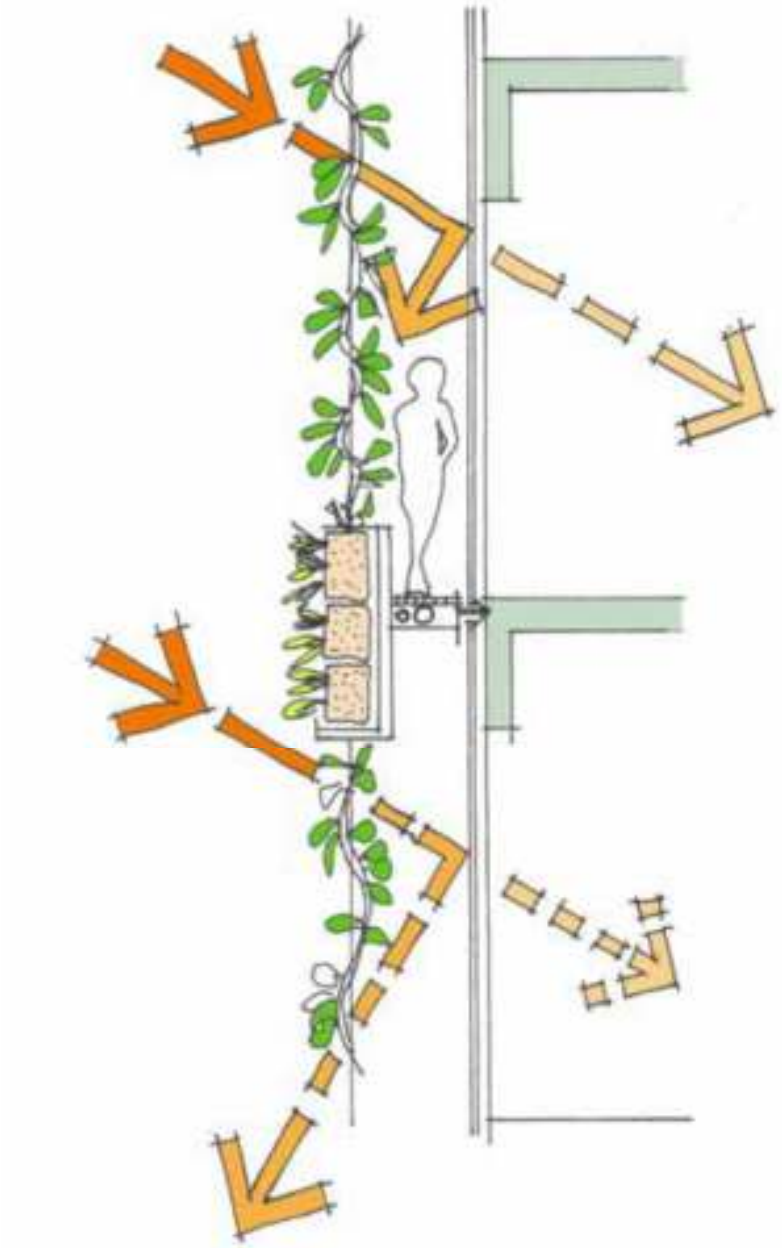
Energy balance for a green wall 綠牆的能量平衡



(Source: Ottelé, M., 2011. *The Green Building Envelope: Vertical Greening*, PhD Thesis, Technical University of Delft, The Netherlands.)

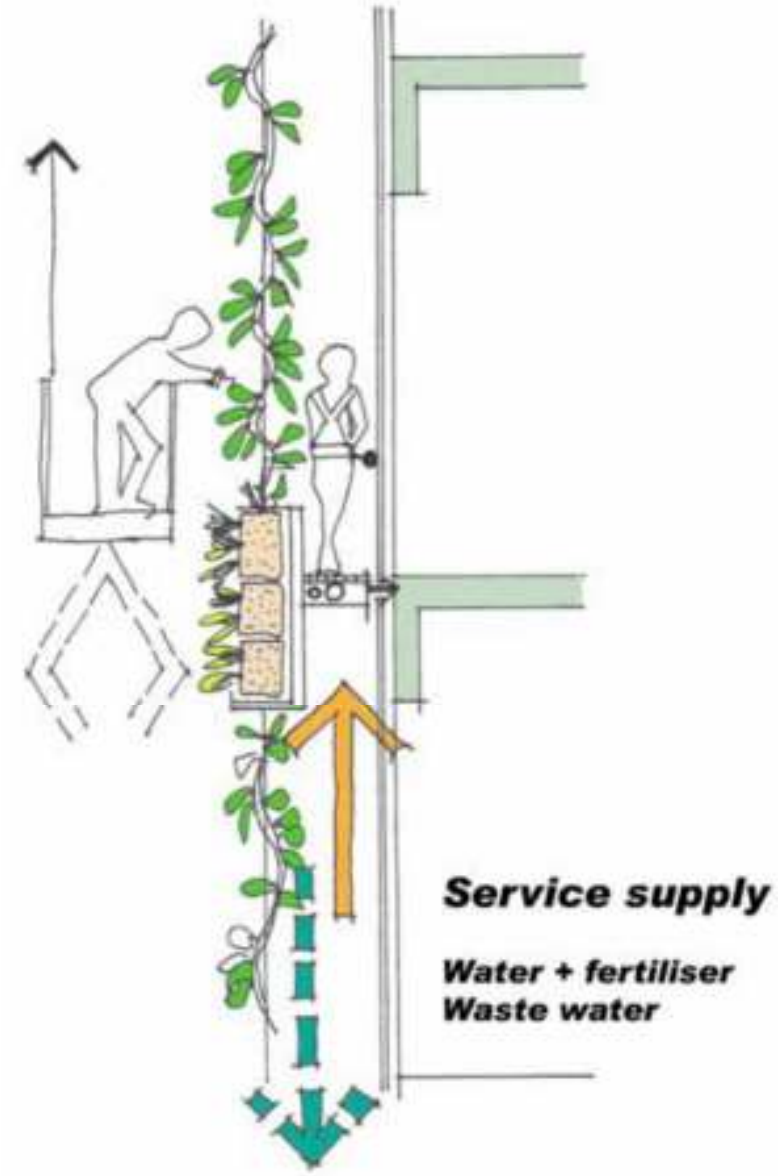
Key Considerations

- Design factors:
  - Orientation
  - Structural support and safety
  - Selection of plants and system
  - Irrigation and moisture issues
  - Damage to wall and deterioration
  - Maintenance requirements
  - Building design integration



Glazing issues

Light penetration
Reflectivity - heat
- various wavelengths



Maintenance issues

Methodology
Built in
External

(Source: University of Adelaide)

Key Considerations

- Implications
  - Increased capital & maintenance costs
  - Consideration for routine maintenance
  - Habitat for insects
  - Orientation & exposure
- Environmentalists' comments
  - Criticised vertical greening systems for excessive use of water, energy and chemicals for fertilisation
  - They can also be difficult to maintain

Key Considerations

- Factors for successful ***green façades***:
  - Attachment to building envelope
    - How the system will be secured to the building or freestanding structure
  - Calculation of structural loads
  - Plant selection for wind and light exposure, hardiness zones, and amenity context
  - Realistic expectations related to plant aesthetics and growth – some systems require 3 to 5 years

Key Considerations

- Factors for successful ***green façades***: (cont'd)
  - Plant maintenance and/or long term maintenance plan to secure the health of these living systems
  - Appropriate plant selection for the geographic region, correct plant spacing for desired coverage, and release from the temporary support structure used by the nursery

Key Considerations

- Factors for flourishing ***living walls***:
  - Irrigation (establish appropriate levels of watering and appropriate levels of nutrients)
  - Plants correctly specified for hardiness zone and geographic location
  - Consider the microclimates that may have different impacts on one part of a living wall relative to another (e.g. varying light, heat, humidity conditions)

Key Considerations

- Factors for flourishing ***living walls***: (cont'd)
  - Growing medium must be designed to sustain chosen plants and to provide the correct nutritional needs
  - Indoor applications need to determine correct light for plant survival
  - Check with manufacturers who may have registered or specially trained installers that will be able to complete the project successfully

THANK YOU 多謝 !!

(More information: www.hku.hk/bse/greenroof/)