Vertical Greenery as a Key element of Sustainability in the Urban Landscape

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SemesterII_ 2019-2020

ETSAB_UPC
Introduction

Nature is one of the most dynamic skills that we can use to build better, make houses more livable, sustainable, and create resilient urban suburbs.

Time is evolving, technology is moving as speed light, therefore the world of construction needs to get on board.

The entire world is facing global warming issues throughout the century. We can observe the consequences every year. What can we do to make things better and work faster?

Living in the Mediterranean country, especially in Barcelona, demonstrates that the town hall is always trying to find new strategies to improve the relationship between urban and natural surroundings.

Preserving, rescuing, creating and introducing new patterns about green spaces are the real challenge for the 21st century.

Shaping sustainable, resilient cities will necessitate the design qualities of compactness and density. About 54% of the world’s population now settles in cities, although it’s higher in European and American cities. For example in Barcelona it is estimated that more than 5 million live in the metropolitan area, which is the largest in the Mediterranean Sea. The city proper has a high population density of 16000 people per square kilometers. This make Barcelona one of Europe’s most densely populated cities.

The hanging gardens of Babylon was the first idea of green walls. Cities will need to take meaningful steps to enhance and regrow local and regional landscape.

Nature takes different forms in cities, it can be experienced in many ways; it can take the form of green rooftops, green balconies, vertical facades, and upward garden on high rise buildings. There are many options and solutions, but I will focus my investigation about vertical gardens, sustainability and their interactions with urban landscape architecture.

Is it possible today to live in a high rise tower in a dense vertical city and still find a way to connect with the natural world? I think so.

Is it enough to build vertical gardens to reduce pollution? Are they really sustainable? Furthermore, do they really help the city?
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Abstract

Nature and human have always coexisted over time. We learned to transform and adapt it to our way and according to our needs. Despite the incredible advances that we have been able to make within architecture, urban planning, technology, it seems that often the tools used go a little faster than our learning and the way to organize it with our surroundings.

Climate change is increasing and being more visible everyday around the world. With this work, it is intended to analyze within examples, one of the multiple methods developed to reduce our impact on the planet.

The majority of cities are fairly dense, there is no longer area on the ground for the creation of new green spaces. An alternative was the use of existing spaces, hence the green spaces in horizontal and vertical.

Vertical greenery system are taking up more spaces in the city. The progress towards their improvement is considerable, so that in the long term these elements can become sustainable and play a huge role in reducing CO2 in a city. Also help improve the life of the city’s habitant and contribute to the enrichment of the fauna and the flora of the places where they are built.

Keywords

Biophilic - Ecosystem services- Energy saving- Green facades- Green wall- Passive energy system
Objective

Since the last decades, the most challenging work is to find the best way to work along with nature and try to reduce as much as possible our carbon footprint in the world.

I’ve always loved nature. Coming from a Caribbean island, and having lived there for most of my life, I always thought that cities and nature should have a better and closer relationship. They should not be independent entities. And I also add that I never understand why urban space, parks, and streets have few trees and sometimes none. Nevertheless, the sun comes out year round. Why not use natural resources such as the sun for electric power.

Living in a Mediterranean city, I find myself once again close to nature. A city is regularly warmed by sun and winds off the Sahara. Locals are constantly looking for a way for temporary relief from the blistering sun.

Certainly, there are many things to revamp, but being able to enjoy the green space in the city is a plus. My curiosity by living here, is focused on the vertical gardens which are establishing themselves more and more, as a solution to counteract and reduce the rate of contamination.

My research will be based on the study of vertical gardens through examples outside and inside the city of Barcelona. I will also focused on the sustainability of these projects and their impact on the urban level and the growth that are being made better living and biodiversity within the city. I will also use drawings and plans to better explain and interpret the urban context and their surroundings contribution.

First and foremost, let us recall what is a vertical garden and its origin; the differentiations that exist between the established systems, presenting their advantages and disadvantages through concrete comparisons.
History of green wall

During the last decades, several researches proving that green walls can contribute to enhance and restore the urban environment and improve buildings performance.

Green walls, vertical gardens or living walls, are basically vertical structures that have greenery attached to them. The greenery is often planted in a growth medium consisting of soil, stone or water.

Greening systems, as green roofs and green walls, are frequently used as an aesthetical feature in buildings. However, the current technology involved in these systems can maximize the functional benefits of plants to buildings performance and make part of a sustainable strategy of urban rehabilitation and buildings retrofitting.

At a city scale, green roofs and walls contribute to the insertion of vegetation in the urban context without occupying any space at street level. Covering buildings with vegetation, when applied in a significant urban scale, can improve the urban environment by contributing to urban biodiversity, storm water management, air quality, temperature reduction and mitigation of the heat island effect.

At a building scale, green wall systems can be used as a passive design solution contributing to buildings sustainability performance. Vegetation has the potential to improve the microclimate both in winter (functioning as a complementary insulation layer) and in summer (providing shade and an evaporative cooling effect).

Considering the recent developments in green walls technology it is important to identify and classify all existing green wall systems, according to their construction techniques and main characteristics. Green wall is the common term to refer to all forms of vegetated wall surfaces, even though there’s different type of the making of a green wall.

The purpose is to review all types of green wall systems in order to identify and systematize their main characteristics and technologies involved. It is necessary to understand the differences between systems in terms of composition and construction methods. Most recent developments in green walls are mainly focused in systems design in order to achieve more efficient technical solutions and a better performance in all building phases.

In green walls, the growth medium is on the surface of the wall, whereas facades are rooted in the ground. The greenery of facades can take a long time to grow enough to cover an entire wall, while green walls may be pre-grown.
Smart and active green wall often look similar to conventional green walls, but serve more purposes due to the use of artificial intelligence and technology. In addition to the visual and biophilic benefits of all green walls, smart and active green walls can feature natural air purification and humidification thanks to the combination of enhanced air circulation, specialized growth medium and technology.

From left to right: green facade, green wall, smart and active green wall.

Fig.1. Different type of green wall

Living walls can make us happier and more productive. Bringing in natural elements to places where they can’t generally be seen lifts our mood, making us more alert and upbeat.

Regular passive green (plants alone) do not purify and naturalize air effectively enough for a noticeable difference. Smart and active green walls with active air circulation achieve this, as the wall, plants, and supporting technology are all designed for the purpose.

Outdoor green walls and facades have been found to be energy cost effective as their plants reduce the overall temperatures of buildings when exposed to the sun. The transpiration process of plants can slightly reduce temperatures indoors as well, thus also working as an energy cost effective solution and also amount of plant reduce noise levels.
Outdoor green walls are primarily visuals elements. They are mostly used to be greenery into urban landscapes. Their construction has restrictions in terms of the climate, as they have to endure their surrounding circumstances, which may sometimes take a rate on the structure and plants of the wall.

Smart and active green walls are only used indoors because their air purification efficiency would not be powerful enough to impact outdoor spaces. Moreover, the plants used in these green walls are tropical and would not survive in most conditions of the outside world when removed from their natural habitat.
Different types of vegetation’s can be used, however there are some restrictions depending on the type and purpose of the green wall.

Evergreens plants are usually preferred usually for indoor and outdoor walls due to their longevity and looks. They have to keep their leaves all year round. This limits the selection of plants available

For active green walls the process of selecting the right plant species is even more rigorous than passive green walls, this is due to the air circulation which can be quite taxing on the plants.

Water is vital for the survival of the plants, which is why most plant walls have integrated irrigation systems to make it easier to take care of the plants. The plants also need basic nutrients, which are usually received through irrigation.

The irrigation systems are typically either recirculating or direct systems.

The analysis of the most relevant systems in the field of green wall systems demonstrates that there is a significant evolution in this field.
Comparative study between green wall and green facades

Green walls can be subdivided in two main systems: green facades and living walls.

1) Green facades

They are based on the application of climbing or hanging plants along the wall. Plants can grow upwards or downward the vertical surface.

Green façade can be classified as direct or indirect;
- Direct: the ones in which plants are attached directly to the wall
- Indirect: include a supporting structure for vegetation

New solutions of green facades are usually indirect greening systems, which include a vertical support for climbing plants development. In these case, plants can be rooted directly in the ground or in planters, and be guided to develop along the support structure. Indirect greening systems include continuous and modular solutions. Continuous guides are based on a single support structure that directs the development of plants along the entire surface.

2) Living walls

They are quite recent area of innovation in the field of wall cladding. They emerged to allow the integration of green walls in high buildings.
Living walls allow a rapid coverage of large surfaces and a more uniform growth along the vertical surface, reaching higher areas and adapting to all kind of buildings. They also allow the integration of a wider variety of plant species.

Living wall systems (LWS) can be classified as continuous or modular, according to their application method.

- Continuous LWS are based on the application of lightweight and permeable screens in which plants are inserted individually

- Modular LWS are elements with a specific dimension, which include the growing media where plants can grow. Each element is supported by a complementary structure or fixed directly on the vertical surface.

- Systems requirements

Most recent developments in green walls are mainly focused in systems design and their elements (supporting elements, growing media, vegetation, irrigation and drainage) in order to achieve more efficient technical solutions and a better performance in all building phases (installation, maintenance and replacement)

- Supporting elements

Traditional or direct green facades usually have no support structure. They rely on the capacity of climbing plants to attach themselves to the vertical surface.

Indirect green facades function as double skin facades, creating an air gap between the building surface and vegetation. A support structure avoids vegetation to fall. Most support structures for indirect green facades includes continuous or modular guides, as cables, wires or trellis made of galvanized or stainless steel.

Steel structures and tensile cables can be used to hold climbing plants with denser foliage and to support their weight. Grids and wire-nets have smaller intervals and can be used for slow growing plants support.

Living walls usually include a frame to hold the elements and a support for plants.

Continuous LWS are based on the installation of a frame fixed to the wall, forming a void space between the system and the surface. This frame holds the base panel and protects the wall from humidity. The base panel supports the next layers. It is covered with layers of permeable, flexible and root proof screens, stapled to the base.

Modular LWS can take several forms (trays, vessels, planter tiles or flexible bags) requiring a different structure. Modular trays are usually composed of several interlocking parts, made of lightweight materials as plastics or metal sheets. The modular elements may also contain a front cover forming a grid to prevent plants to fall. Modular LWS can also take the form of elongated bags, filled with growing media, made of flexible polymeric materials which are cut to insert each plant.
Trays and vessels are usually fixed to a vertical and/or horizontal frame attached to the surface. The back surface can include hooks or mounting brackets for their suspension in the frame profiles connected to the vertical surface.

Modular vessels allow the installation of several plants in each element along the same row. They are commonly made with polymeric materials and due to their form have a significant visual impact on the building surface.

Growing media

In the context of green facades only modular systems require the selection of a growing media, which must be lightweight, considering that each element will be suspended and adapted to the selected plant species and environmental conditions.

In the field of living walls, continuous LWS also do not have substrate. They are commonly based on a hydroponic method, requiring a permanent supply of water and nutrients due to the lack of substrate.

Modular LWS are commonly filled with a growing media where roots. Most of modular LWS include a growing media based on a mixture of light substrate with a granular material, expanded or porous (coconut fiber or recycled fabric) in order to obtain a good water retention capacity.

Vegetation

The appropriate vegetation depends on climatic conditions, the building characteristics and the surrounding conditions, in which the green wall is inserted. The analyzed systems show some concerns with vegetation longevity.

Climbing plants are considered a cheap solution of vertical greening. These plants species can contain two main types of foliage, evergreen or deciduous. Evergreen plants maintain their leaves all year and deciduous plants lose their leaves during the fall.

Living wall systems allow the development of new aesthetical concepts of green walls, based on the creation of artistic solutions with plant species.

In order to fulfill sustainability goals, vegetation must have low irrigation needs, be adapted to local conditions of exposure and weather conditions. Recent examples of modular LWS include the option of using succulent carpets in green walls instead of perennials and shrubs. The use of drought tolerant plant species as succulents reduces the need of irrigation. These
plants species have also low maintenance and contribute to the minimization of the system weight.

![Modular living wall with edible plants](image)

**Fig.9.** Modular living wall with edible plants

Drainage

Excess fluid drainage in green walls takes place by gravity. Continuous and modular LWS use geotextiles that encourage drainage along the permeable membrane while preventing roots proliferation.

Modular trays take advantage of the overlap of modules and materials to improve drainage and water excess reuse to the modules below. Other examples as vessels mention to use of a filter material applied to the bottom of the module

Irrigation

The irrigation needs depend on the type of system, plants used and climatic conditions.

There’s some strategies for minimizing the consumption of treated water. There are strategies like rainwater recovery from the building roofs, reuse of the fluid collected in the drainage system and monitoring water supply needs through the installation of sensors that control the collecting water tank level, the irrigation time and weather conditions.

Other LWS, either modular or continuous also refer the installation of a gutter in the system base, recovering excess water storing it and reintroducing it into the irrigation system.

Installation and maintenance

Green facades, including climbing species, are more cost-effective during the installation process but have limitations in plants diversity. When there is the necessity of plants replacement, these systems show difficulties in ensuring vegetation continuity.

Modular trellises have advantages when compared to continuous guides on the installation and maintenance processes. The installation of plants at several heights decreases significantly the impact of the disperse growth of climbing plants along the surface and enables the substitution of unsuccessful plants.

Continuous LWS are commonly hydroponic systems, requiring a permanent supply of water and nutrients, which constitute a sustainability disadvantage

The selection of the most adequate system is directly related to the building characteristics (orientation, height, etc.) and climatic conditions (rainfall, wind exposure, etc.). It’s really important to understand their differences in composition and their main characteristics.
Environmental performance and costs

To better understand if green walls may be considered sustainable solutions.

Direct green facades are a more sustainable and economic solution. These systems have a small environmental burden considering that they have no materials involved and have low maintenance needs.

Analyzing the life cycle of some LWS, their sustainability may be questioned. Differences in the type of materials used, their durability, recycling potential, vegetation durability and water consumption can have a significant impact on the total environmental burden. The integration of stainless steel (shown by Ottelé et al.) as supporting system can have an impact 10 times higher than using other recycled materials (hard wood with FSC certificate or coated steel).

Nevertheless, green walls systems frequently use materials with high environmental impact. The cost of green wall systems can also be a variable with significant impact on the selection process. LWS are more expensive when compared to direct and indirect green facades. In LWS case, the cost are very dependent on the materials used and the system complexity.

The costs depends also on the application process and maintenance needs.

Improving the performance evaluation of recent green walls systems can lead to an increase of their application in buildings and therefore result in a reduction on their cost. Importantly, the decision of which green wall system is more appropriate to a certain project must depend not only on the construction and climatic restrictions but also on the environmental impact of its components and associated costs during its entire lifecycle.

![Diagram of different types of green walls](image_url)

*Fig.10.Difference type of vertical greenery system*
Experimental study of green facades Mediterranean continental climate (Lleida)

The main objective is to compare at real scale the thermal performance of two different vertical greenery systems implemented in experimental houses-like cubicles for both cooling and heating periods.

The use of green vertical system, well design and managed, can be a useful tool for thermal regulation for buildings with interest in energy saving.

There are basically four fundamental mechanisms that characterize green vertical systems as a passive system for energy savings:

- The interception of solar radiation by the effect of the shadow produced by the vegetation
- The thermal insulation provide by vegetation and substrate
- The evaporative cooling that occurs by evapotranspiration from the plants and the substrate
- The variation of the effect of the wind on the building

Finally, it is important to consider that for the efficient operation of these systems it is essential to know the behavior of the different species in local weather conditions, because the end result may differ greatly from one climate area to another, spoiling the expectations of energy savings that had been planned according to theoretical calculations for a given system.

The experimental site is located in Puigverd of Lleida, Spain, the climate condition defined as Csa (warm temperate, summer dry, hot summer), the winter is foggy, cold and humid.

Three house-like cubicles with identical walls and roofs construction systems. Their external dimensions are 3x3x3m (real scales experiments). A green wall and a double-skin green façade system were installed on the East, South and west of two identical cubicles oriented to the main cardinal points to compare and measure the thermal behavior and quantify the passive energy savings potential.

The substrate used was a mixture of universal substrate for kindergarten and topsoil. The choice of plant species was made from a previous list of climbers made for that climate. The resistance, height, adaptation to growth in modular trellis and availability in nurseries were considered. We had ivy (Hereda helix), honeysuckle (Lonicera japonica) as perennial plants, Virginia creeper (Parthenocissus quinquefolia) and clematis, as deciduous plants.

Plants that were best developed in height were the two perennials, (ivy and honeysuckle), but they left some areas with lower density of foliage. The Virginia creeper, provide greater density of foliage, but during the first year it had difficulty growing in height in the trellis structure. Finally clematis did show the worst growth.
In the field of construction, the shade factor is the fraction of solar radiation incident on an opening of the building that is not blocked by the presence of obstacles. The light transmission factor has to be considered as an approximation to this shade factor.

There’s more example that we could talk about regarding experimenting in green walls systems and try to make they passive systems.

In the use of green vertical systems (VGS) as passive systems for energy savings in buildings, one must consider the type of system, the parameters that influence their behavior, and finally it is essential to know the behavior of the different species in local weather conditions.

A simple metal trellis of 2 mm was installed using screws on East, South and West walls to build the double-skin GF. This system provides an air chamber of 25 cm thickness, according to the gardening and landscaping technical recommendations for VGS.

Studying and comparing the growth in a trellis modular shown:

- plants that are best developed in height were the two perennials (ivy and honeysuckle), but they leave some areas with lower density of foliage
- the Virginia creeper provided greater density of foliage, but during the first year it had difficulties growing in height in the trellis structure
- the value obtained for the light transmission factor is comparable to the best values of shadow factor that can be obtained by using artificial barriers for the south orientation.
Two different VGS (GW and GF) were evaluated as passive energy savings systems thorough summer and winter seasons of 2014-2015 and compared against a reference system in a real scale set-up under Mediterranean continental climate.

The overall electrical energy consumption tests confirm the high potential from both VGS to save energy in summer. The GW system provided the highest cooling performance achieving savings of 58.9%, while the GF presents a reduction of 33.8%, both of them compared to the reference cubicle with internal comfort conditions at 24°C.

Moreover, a direct relation between solar irradiation and energy savings was found indicating higher energy savings potential in climates with high solar irradiance.

Concerning the thermal performance by facade orientation in winter, GW registered the highest external wall temperature reductions on the South, achieving 16.5°C, whereas in East and West were 4.5°C and 6.5°C, respectively. That fact highlights the important solar gains through the southern orientation in comparison to the East and West. In addition to the shadow effect of VGS, there are three more effects that should be studied in depth to quantify the thermal performance of these systems.
International example

Example 1

One Central Park, Sydney, Australia (largest green facade)

New residential project by architect Ateliers Jean Nouvel in collaboration with French botanist Patrick Blanc.

Located in Sydney, One Central Park includes the tallest vertical garden in the world, 150 meters (almost 500ft) tall. The brief for Central Park combines a range of green infrastructure initiatives including green roofs, living facades, recycling demolished materials, adaptive re-use of buildings, sewer mining, water harvesting, etc. The construction includes 21 garden panel with 370 species of Australian flowers and plants that change seasonally. With 5000 shrubs and 11000 perennial plants, vegetation covers much of two high-rise residential towers.

Fig.14. Plan lower

One central Park is the largest green façade in Australia with considerable microclimatic challenges.

2700 linear planter boxes to balcony and loggia areas, creating around 7 linear kilometers of greenery around both towers wrapping all facades from level e to 33.
In an arduous process of research and plant selection, Blanc chose local species best suited to the climate and seasons. Facing strong wind, intense heat, dehydration, elevation and humidity and different levels of sun exposure, the native plants were also then tested for hardiness.

Water usage was a big issue as well as compliance to a 5 Green Star rating. It was necessary to irrigate using reclaimed and treated sewerage (black water) from the building itself. This sort of automated irrigation system at this scale has not been implemented previously.

The sunken courtyard includes a large planter set down into the structure for the trees with paving supported over. Air and water was provided to this planter using a system of aeration and irrigation pipes.

One Central Park is the most ambitious ‘living architecture’ project in Australia and has no precedent in this country. It is a combination of living walls and green façades (vines on supports with cascading plants). This is the first combination of these two systems in Australia.
Maintenance of the green façade is an ongoing issue due to the heights and exposure. The soil requirements for the planter boxes needed to ensure that soil would have as long a life span as possible. The soil mix, specially developed for the project, has similarities closer to hydroponics than conventional soil. The wind exposure and plant selections were tested in a wind tunnel to ensure suitability of the green wall system.

Climate adaptation and urban greening is a fundamental issue challenging designers of the built form. One Central Park can inspire future urban projects to also use urban greening to create more environmentally and socially sustainable cities. The landscape design of One Central Park needed to be sustainable from an economic perspective, in the selection of durable materials and planting, the reuse of waste water for irrigation and ease of maintenance.

Blanc’s design process meticulously considers a variety of functional factors. He reduces maintenance and energy cost with biodiversity. A high level of biodiversity both decreases nutrient and water consumption and prevents insect damage and disease. This eliminates the need for pesticides or chemicals.

To construct the vertical garden, he uses a growing medium of felt made from recycled clothes, which he uses to cover building faces that he intends to plant. It is purposefully non-
biodegradable and will not have to be replaced, overall, the vertical gardens will require maintenance only three times a year.

The green walls increase energy efficiency, serving as natural insulation for the building, as well as an air filtration system that transforms pollutants into useful plant fertilizers. Designing and building One Central Park has contributed valuable new knowledge and research to the growing collaborative fields of urban landscape architecture. Additionally, it will provide residents an unprecedented experience of natural living in an urban environment.

Fig.18. Exterior, one central park

Fig.19. Views of the façades, one central park
International example

Example 2

Caixa Forum, Madrid

Caixa Forum is located in the heart of the city’s cultural district, facing the paseo del Prado, close to the Reina Sofia and the Thyssen–Bornemisza museums.

The museum is housed in a converted 1899 power station. An insignificant gas station was demolished to create a mall plaza between the Paseo del Prado and the new Caixa Forum. The classified brick walls of the power station are reminiscences of the early industrial age in Madrid, while the gas station, a purely functional structure was clearly out of place.

The separation of the structure from the ground level created two worlds; one below and the other above the ground. The “underworld” buried beneath the topographically landscaped plaza provides space for a theater/auditorium, service rooms, and several parking spaces.

A 24 meter high vertical garden, designed in collaboration with the botanist Patrick Blanc, takes up on wall of the square.

Fig. 20. Vertical living wall, Madrid
The vertical garden resembles a piece of environmental graffiti as much as it is a botanical piece. The pattern of colors, is a fascinating combination of art, architecture and botany.

Splotches of greens, reds, yellows grow in tufts over the wall, in a mass of flowering plants, ivy and climbing shrubbery. The self-irrigating wall is kept green with drips of water that feed the plants and cast a cooling mist to visitors sitting around the reflecting pool below.

Blanc’s wall has a variety of plants, instead of the usual ferns and mosses, which were carefully chosen to flourish in the hot Madrid climate. Over 250 species are represented on the living wall in a mass of over 15,000 plants for the miniature oasis.

One can feel the drastic cooling effect of the wall when sitting next to it, with the temperature feeling several degrees cooler in its proximity. Blanc’s wall shows that green walls can grow in even the hottest and driest climates, and provide not just a lush landscape, but also relief from the heat.
The pattern of colors, along with its movements with the wind make the wall take on an anthropomorphic sculpture feel, blending art, architecture and nature.
National Examples

Example 1

La Plaça de les dones del 36 (district of Gracia)

Fig. 25. plan site geographic situation

Fig. 26. plan site Plaça de les Dones del 36
Access to the façade must be via Santa Àgata Street, which can be accessed from the street of Torrent de l’Olla. Once inside the city, access is well connected and it is very easy to get there, either by vehicle as on foot or by public transport.
The present project aims to remodel the dividing wall of the property located in the street of Santa Àgata 34. This dividing wall is one of the main façades of la Plaça de les Dones del 36.

The action consists of remodeling the dividing wall existing, improving its thermal behavior and integrating it into the environment through a primer architectural turn of the main façade, the installation of a vertical gabion garden, crowned for an installation of 31 photovoltaic panels and an area of slats. The vertical garden area or green wall, will also include an artistic mural.

The dividing wall, object of the action has a Southwest orientation and an area of 291 m² (3132.32 sq meters). It is divided in two parts, a plinth formed by a wall of concrete blocks between 9.84 (3.5m) and 13.12ft (4 m) high on the ground floor and an upper part that closes 3 floors plus a Catalan’s flat deck (Coberta plana a la catalana).

On the ground floor, in the horizontal plane, there is currently a parterre finished with sauló that contains vegetation shrub and three trees.

Below the square, there is a three-floor underground car park that is limited by the shape of the square with a 40cm thick concrete screen walls.

The building has a ground floor and three floors, reaching a height of 15 meters (49.21 ft) from the street Santa Àgata, and a buildable depth of 18 meters (59.05 ft). The building dates from 1895 according to the cadastre.

The structure of the building is with masonry load-bearing walls and wooden beams with Catalan’s rear arch (revoltó de volta a la catalana) in the slabs.

The main façade does not have heritage protection, although it has great artistic value and historical.

![Fig.29. Main façade](image)
Currently, the dividing wall is covered by prefabricated panels that again form a rain barrier. These panels have an approximate size of 60x120cm, with a total thickness of 6cm.

By the face inside, we find 4cm of expanded polystyrene, and on the outside, 2cm of finishing mortar and painted with mallatex. These panels are fastened by a system of galvanized steel profiles of the type dry construction. The vertical profiles are 9cm thick, and are fixed on top of the block wall with a horizontal U-shaped guide and on the dividing wall with arms about every 2m.

Behind this partition, we find a 30cm thick ventilated chamber, and finally, the dividing wall of the building, a 15cm thick solid brick masonry wall with 30cm needles. This masonry wall is currently protected with a projected thermal insulation of about 2 cm thick.

The proposal consists of a mixed composition that integrates, in a single set, a vertical garden of the green wall type, photovoltaic panels that will provide electricity to the grid and a mural blade base.

The town of Gràcia is characterized by its own urban fabric, inherited from the old independent town in Barcelona, which one day was. This nature is reflected in several aspects, one of which, the reduced width of the plots.

The proposal attempts to transmit this urban grain and tidy up the photovoltaic panels at the top of the dividing wall creating a "skyline" or backdrop that divides into three parts the rest of the surface where act. The design will follow the artistic technique called “halftones”.

Fig. 30. Proposal façade
Fig. 31. Example of vegetal composition with slats

Design criteria:
- Increase the presence of green in the square to help promote temperature and humidity conditions, both in the square and in the houses bordering the dividing wall.
- Incorporate a clean and sustainable energy production system, thus expanding energy production photovoltaics of the city.
- To give a new facade, with urban character, to a public square.
- Generate a composition that is familiar with the neighborhood.
- Vegetation planting with low water consumption.
- Use of recyclable materials and machined joints for easy assembly and low maintenance.
- Maintenance system compatible with the district's media.
The green wall is made with gabions of 100x50x12cm that hang from their own substructure. They consist of gabions of stainless steel bars, which contain substrates where it will take root vegetation. Vegetation consists of plants with low water consumption and high resilience. The plantation is composed of different species, thus achieving a variation of texture and color.

The slats that enclose the composition, both on the ground floor and in the mural area, materialize with a panel composed of Trespa resins, which is formed from a core of resins with a finishing layer.

This material is suitable for machining and being able to execute the drawing of the mural, and withstands high discharges well temperatures to which it will be exposed.

![Diagram of mural proposal_ Halftones technique](image)

The mural will capture an image with the technique called "Halftones". The slats that form it, they will give a glimpse of the vegetation of the vertical wall located at its back.

The area of photovoltaic panels placed horizontally, are grouped into three sectors, forming one set of 31 units. The plates will be black, both the glass and the profiles.

Vertical garden

The vertical garden consists of 230 gabions of 100x50x15cm, made of stainless steel bars. These gabions are hung on vertical guides located every 102.5 cm by means of hooks welded to the guides. At the same time, the gabion guides hang from the main structure.
The weight of the gabion in moisture of the 100% is expected to be between 30 and 35kg. These guides will also be used to hold the slat system in the right sector of the dividing wall.

The gabions are filled with anti-root mesh bags filled with plant substrate. The plantation it consists of a composition of different plants, achieving variation of texture and hue.

The plantation is divided into two sectors. Sector 1, is made up of 90 gabions located behind the slats, sector 2, consists of 140 gabions and is located in the area without slats (see landscaping plans).

The gabions will arrive at the site with a pre-cultivation of 3 months to allow a good rooting of the plantation.

Fig.33. fastening structure of gabions, photovoltaics and slats
Fig. 3.4. Scaffolding plan
Fig. 35. Details of the gabions

Fig. 36. Vegetation detail
Photomontage and picture of the completed work of the green wall in the square de les Dones del 36

Fig. 37. Proposal Façade

Fig. 38. Proposal Façade
Current pictures and review of the project

Fig. 39. current pictures

When I went to the place to visit the vertical wall, the first impression I had was how isolated the project was from the rest of the space. Certainly it was a place with trees but I had a clear impression, I suppose from the way it was integrated into the space that something removed them instead of joining them. The wall itself is quite impressive and creates a pretty pleasant visual impact but as I said previously, its integration with the rest of the place could have been done in a more suitable way to create a united and not isolated space.
National Example

Example 2

Jardín modular Betevé (district Sant Martí)

Fig. 40. plan site

Fig. 41. Main Façade
The action is carried out on one of the facades of the Betevé building, which faces the Tisner square. This plot is an empty building plot, where is situated the main access, and in the area where the modular vertical structure is placed, there is currently an outdoor parking

![Image of Betevé building facade]

This plot is an empty building plot, where is situated the main access, and in the area where the modular vertical structure is placed, there is currently an outdoor parking

The object of the current project is the punctual remodeling of the blind facade to which later a support structure of a vertical modular garden will be adapted.

This project was born from the idea of making a replicable vertical garden. That is why one has been designed modular structure that serves as a support for the vertical garden and can be adapted, with the addition or subtraction of elements, in any place or dividing wall of the city, adapting in height and length to the support or building contiguous.

This is a performance in an existing building. In the eight levels in height (ground floor and seven levels above in a section and ground floor and a level in the other section), planters with direct access are placed that make their maintenance much easier.

Garden vegetable soil is sifted gardening soil, consisting mainly of plant debris decomposed and stabilized. It is the standard soil for planting vegetables.

The purpose is to describe and justify all the different elements that form the structure of the modular garden that will cover the blind façade of the building of Betevé, projected within the plan of remodeling of partition walls.

The modular system that makes up the garden is a framework of metal structure composed of modules of 2.20m x 2.20m and a depth of 1.0m between axes of structure. This framework supports planters with vegetation, bird nests, and solar panels. Some interior stairs as well metal walkways make it easy to maintain. On the other hand, there is one on the top floor viewpoint accessed from the roof of the existing building by a metal staircase of new construction.

The total height of the modular garden is 8 floors, corresponding to 17.61m. The width of these 8 plants is 8 modules the first two floors (equivalent to 17.60m.), and 4 modules the rest of upper floors (equivalent to 8.80m.)
The structure is all made of galvanized steel, and is resolved with round, rectangular tubular profiles, and squares. In order to minimize the effect of the wind, the structure is anchored at specific points in the gables existing in the blind façade of Betevé, which is supposed to be already dimensioned to absorb these thrusts, as wind actions are present there without the intended new structure build.

The foundations are solved by means of micropylons with steel beams. Steel bridge beams save the existing facilities on the site, without affecting them have to move. A 10cm thick floor is built on top of them. Before to execute the foundation it will be necessary to verify exactly where the facilities pass, to confirm that micropylons and bridge beams can be run where intended.

In recent years, the use of rainwater as a substitute source of supply for mains drinking water, this water is mainly used for irrigating garden areas, though which also include other uses such as the use for filling cisterns toilets, cleaning tasks and other uses where drinking water quality is not required.

The Betevé building has a 790 m² gravel roof that collects rainwater runoff through 2 downspouts. It is proposed to take advantage of the drainage runoff of one of the two downspouts.

At an aesthetic or formal level, we have a flat and blind façade, very large but at the same time empty of elements, which give it a friendly and organic character. In the vertical garden solution will be given to this facade one new aesthetics, closer and changing, thanks to the
vegetation that will evolve over time and the seasons, with different phases of flowering and growth.

Fig. 44. Roof of the Betevé building. In green, rainwater collection surface

Fig. 45. Plan of “enderroc” and disassembly _ancient construction
Fig. 46. Plan of the new construction

Fig. 47. Proposal
In the eight levels in height (ground floor and seven levels above in a section and ground floor and a level in the other section), planters with direct access are placed that make their maintenance much easier. The uprights of the modular structure fulfill the functions of closure and vertical protection at the same time they serve as support for the growth of vegetation. A forklift pulley hung from the structure of covered plant facilitates the tasks of maintenance and the transport of tools and material to each plant.

![Diagram](image)

Fig. 48. Proposal

Garden vegetable soil is sifted gardening soil, consisting mainly of plant debris decomposed and stabilized. It is the standard soil for planting vegetables. An expanded clay (arlita) base will be fixed on which a felt or geotextile will be located. On this the planters with the substrate indicated above, a height of 40 centimeters and the planting will be carried out of the vegetation of the planters.
Fig. 41. Gardening details

Fig. 42. Gardening
Current pictures and review of the project

Betevé's project is a project in the process of execution. As for the previous project, (Plaça de les dones del 36). This project is in a slightly different context.

State a project not yet built, at first glance, it seems to be more integrated into the space that surrounds it.

And we can already see the structure that will have to support the plants.

In fact, we are awaiting the final result of this new project and hope that in the long run, it can be an important ecological contribution at the urban level in this district and in the city.
National example

Example 3

Plaça dels drets dels infants (Trinitat Vella)

Fig. 44. plan site _geographic situation

Fig. 45. plan site

The object of the present project consists in remodeling an existent partition to be the base of a vertical garden which will be placed on a metal structure
It is a building with a façade on two streets, with 4 floors above ground and one floor semi-underground, where the neighbors have access to the staircase, considered the ground floor, in the street of la Foradada.

This partition is a load-bearing wall made with a wall of 15 brick wall, clad and protected by a rain partition with good condition. In the semi-underground part, there is a wall of stone also with a pluvial. The orientation of the façade is south.

Fig.46.Current state, plan and section

On an aesthetic or formal level, we have a flat, blind partition, empty of elements that give it a friendly and organic character, as it is a raincoat without coatings. In the solution of vertical garden will give to this façade a new aesthetic, closer and changing, thanks to the vegetation that will go evolving over time and seasons, with different phases of flowering and growth.

The work of adapting the partition consists of providing thermal insulation in this façade plan. Which will be exposed in the future, with the injection of polyurethane foam. In the visible area of the median, a Sate type finish will be given.

In the design process of the vertical garden and its elements, it was detected that the dividing wall is formed by a ceramic wall of openwork brick or brick, which could not guarantee that it would be able to support the vertical garden. Therefore, a self-supporting structure has been designed.
The chosen vertical garden system will be a modular system, which allows adaptation to the geometry, low water consumption, low maintenance and the possibility of creating a three-dimensional carpet with the great variety of vegetation that the system allows

Fig. 47. System details

BIOFIVER vertical gardening modules formed by the union of two three-dimensional structures of polypropylene cells. One of the structures is filled with soil or substrate for cultivation and the other remains empty generating an empty space for air circulation. A fabric is placed between the two layers hydrophilic for the correct distribution of irrigation water.

The outer cell is made of stabilized soil and allows good root development. The roots are develop throughout the substrate and end up colliding with the air from behind. This fact favors the biofiltration.

This system has an exudation irrigation network that allows the entire garden area created with these modules have the same amount of irrigation at any point

The modular system allows the adaptation of vertical gardens to any surface and without limit in terms of width and height.

It also allows subsequent modifications to the gardens without affecting the rest of the structure
Table of characteristics of the plants proposed by the Vertical Garden type BIOFIVER.

Fig.48. flower selection

The system chosen for the vertical garden in Plaça de la Foradada in Barcelona, belongs to the group of gardens non-hydroponic verticals with organic substrate, this makes it more resilient to point problems in the water distribution. Hydroponic systems need a constant flow of fertilized water and whatever supply problem or pumping can irreversibly damage the garden.
The BIOFIVER system consumes an average of 4 l / day / m² and 90% takes advantage of this consumption. Compared with hydroponic systems it consumes 70% less water and can withstand for several days without water supply.

The system with substrate makes there a lower dependence on fertilizers, as it is based on the natural process of absorption and decomposition, to obtain the necessary nutrients for the plant development. Due to this natural balance, the plant has a bit of development slower, which reduces the need for maintenance and makes the vertical garden more stable.

Systems developed on natural substrates maintain a balance in nutrition with balanced and controlled development of plants. Pruning is limited to once or twice a year.

Thus the maintenance costs are similar to those of any other garden.

A NASA study has shown that the rhizosphere, (part of the roots that surrounds the root system younger plants) plays an important role in purifying certain air pollutants. In this rhizosphere is generally inhabited symbiotically by certain microorganisms capable of absorbing substances harmful to health.

Fig.49. Proposal_plan and section
Proposal for improvements

Aware of emergencies, by changing their lifestyles on a daily basis, more and more citizens aspire to become actors in the ecological transformation of society.

The city and the habitat were never really thought of for this purpose, so much so that to apply some basic ecological gestures today is a real feat.

Very positive developments in a number of operations thanks to the voluntarism of town planners, architects and municipal teams politically motivated for the construction of a sustainable city. However, there are too many operations, improperly qualified as "Sustainable", by adding a solar water heater, wood cladding or prefix “eco”, mask the depth of the transformations to be undertaken.

Sustainable development requires the consideration of a whole host of interconnected elements, such as the reduction of energy demand and water consumption, minimizing waste and pollution and providing efficient public transport.

In that sustainable construction approach, the closing of materials and water cycles, and the reduction of energy consumption are priority objectives.

Maybe we can consider as an example the biophilic city.

Biophilic city, its emphasis on both the natural world and living (bio) and the connections with and love of nature (philia). In these days we need more than nature that serves as infrastructure, we need to connect more with nature for our own sick and well-being (scientific evidence).

Biophilic cities captures the importance of urban nature in a way. Nature is not an option, but an essential quality of modern urban life.

The concept of biophilia was originally coined by the German social psychologist Erich Fromm, Harvard entomologist E.O. Wilson.

Wilson famously defines biophilia as the innately emotional affiliation of human beings to other living organism.

Green space close to home appeared to be more important than green space further away.

Biophilic cities should consider nature at all levels, form the microscopic to the bioregional and continental.

Biophilic urbanism is expressed in the many ways that buildings and built environments can integrate new green elements or features.

It is increasingly evident that exposure to nature helps us to be better, more caring and compassionate human beings.

About responding effectively to the immense global environmental challenges, it seems that having nature all around us will likely result in the most generous, cooperative and creative responses possible.
The growth and development of cities has had a profound effect in altering the natural landscape in which they are situated. Study shows that there are new and different assemblages of plants and animals that are adapting to and thriving in the urban conditions of cities. Nature in cities is dynamic and changing.

I also think if we keep searching for new recycled materials more for the structure support of the vertical garden, we can gain a lot.

Maps of the current existing green space (forest, mountain, park…) and their relationship with the public transport.

Fig.50. Current green spaces in Barcelona
Fig. 51. Public transport without the bus network

Fig. 52. Green spaces
Fig. 53. Overlap
1-A nivel estructural, el material en muchos de los casos escogido no es biodegradable, es por tema del coste, por posibles problemas constructivos o no se había realmente planteado?

M.M: Los materiales biodegradables en construcción tienen el problema que si están situados a la intemperie se degradan, precisamente por ser biodegradables. Esto implica que su mantenimiento es muy complejo y costoso. La experiencia que tenemos en Barcelona con la madera en el exterior es mala, y cuando se coloca en pavimentos exteriores ya se prevé que antes de 10 años deberá ser substituida. En pavimentos, y en acabados en general, es asumible la sustitución porque se puede entender una capa de protección de la estructura, pero en el caso de los jardines verticales, están desprovistos de este acabado de protección, estando la estructura directamente a la intemperie.

Se utiliza la construcción de la estructura en acero básicamente por dos motivos:

a- Es ligera, no solo en peso, sino también en aspecto. Esto permite que el jardín coja más relevancia, escondiendo la estructura.

b- La estructura en acero es adaptable. Pocas veces la construcción de la medianera es capaz de soportar la nueva estructura, lo que implica hacer cimientos para soportar la estructura. Es importante considerar que las medianeras que se cubren con jardines verticales normalmente dan directamente a la acera, por donde pasan servicios de agua, luz gas, comunicaciones... Solo la flexibilidad de la construcción en acero permite adaptarse a una cimentación irregular y precaria.

Sí que nos hemos planteado utilizar materiales cerámicos o pétreos, que aunque no son biodegradables, sí que son inertes. Pero la concepción de jardín vertical cambia radicalmente porque cambiamos de construcción ligera a pesada.

2-A veces los nutrientes para nutrir las plantas contienen otros productos que no son naturales, existe otra solución o en el futuro habrá otro tipo de nutrientes que ayudan las plantas a crecer bien y que no dañarán el entorno al nivel de la contaminación?

M.M: Desde el año 2018, el servicio de mantenimiento de la vegetación de Barcelona está eliminando progresivamente los productos químicos que no sean de origen natural. De esta manera se está consiguiendo fortalecer las plantas autóctonas y mejor adaptadas al clima de Barcelona. Además, con la disminución de químicos se fomenta la biodiversidad de la ciudad, no sólo de vegetales, sino también de insectos y pájaros.

Pero hay que tener en cuenta que los jardines verticales difícilmente crecerán en las medianeras de forma espontánea y natural. Así, que de momento y hasta que no se encuentre los productos de origen natural idóneos, efectivamente se utilizan químicos para facilitar la adaptación de las especies vegetales a esta situación artificial.
Se están haciendo pruebas con especies enredaderas plantadas en el suelo (no solo en fachadas, también en pérgolas vegetales) y los resultados son satisfactorios. El problema es que tardan años en cubrir toda la superficie. Son un ejemplo la medianera de la avenida de Roma o la pérgola de los jardines de María Mercè Marçal.

En los equipos que proyectan los jardines verticales, además del arquitecto, también es imprescindible contar con un paisajista con experiencia (ingeniero agrónomo o biólogo). El ayuntamiento está abierto a propuestas que éstos profesionales hagan en la disminución de productos de químicos de origen no natural.

3-Hay un plano futuro y interés a escoger cuidadosamente los materiales para hacer más jardines verticales en la ciudad para que realmente funcionan como elementos sostenibles (hay un ejemplo en donde se utilizó el foam que es un material que pollua mucho el aire)?

M.M: En el año 2015 se aprobó una Instrucción de alcaldía para la ambientalización de las obras. Éste obliga a plantearse desde la fase de proyecto la huella ecológica de la ejecución de las obras. Además, todos los proyectos deben pasar por l'Agencia de l'Energía, que certifica sus instalaciones y exige generación solar de energía.

Así que los proyectos redactados a partir de esta fecha deben tener una memoria ambiental que justifica la utilización de ciertos materiales, y las razones por la que no se utilizan otros más sostenibles. Además, obliga a hacer el cálculo de CO2 que emitirá la construcción de ésta obra.

Creo que a medida que la técnica de construcción avance en sostenibilidad, el ayuntamiento será de los promotores de la ciudad que antes los aplicará. En este sentido, la instalación de placas solares de generación fotovoltaica en la fachada de Betevé demuestra que se está mejorando en este sentido.

4-Hay esperanza que un día Barcelona (aunque es cierto tiene muchos espacios verdes pero más concentrados como Collserola, Montjuic, etc.) que el ratio de los espacios verdes por habitantes será suficiente y podrá funcionar conjuntamente con lo existente como espacios que mejoran el aire, la bien estar de las personas?

M.M: Es necesario diferenciar los Distritos. Hay Distritos que por su geografía o historia tienen un porcentaje de verde adecuado a su población, como por ejemplo Sants en relación con Montjuic. Pero esta relación es un porcentaje, que poco tiene que ver con el desarrollo cotidiano de los vecinos. Son espacios verdes muy grandes, pero lejos de las escuelas, residencias, centros de trabajo.

En Distritos extensos como Sant Martí, Horta, Nou Barris... aún quedan solares y fábricas por transformar. Todos estos son oportunidades que generan espacios verdes cercanos.
El déficit de espacios verdes cercanos es peor en l'Eixample y Ciutat Vella, dónde los porcentajes aún son más bajos. Estos dos distritos están muy consolidados y tienen pocas oportunidades de crear espacios con vegetación. Por este motivo transformamos las calles en zonas peatonales aumentando significativamente la vegetación. El esfuerzo es muy grande, ya que frecuentemente, debajo de estos jardines hay parkings y servicios urbanos que impiden plantaciones. Además, estamos atentos a los ámbitos pendientes de ejecución de planeamiento, ya que son oportunidades para la creación de parques o jardines verticales.

Interview with Marc Miguel Baños, landscape and urban planning architect in the department of manteniment i obra at the headquarters of the Ensanche district,

Barcelona July 5, 2020
Interview with Alícia Soler, structuralist of Betevé’s green wall project

1-A nivel estructural sé que el material escogido no es biodegradable, entonces quería preguntar sabiendo que se podría utilizar la madera (un tipo adecuado para exterior y en contacto constante con el agua) otro material no fueron escogidos, es por algún tema de construcción, coste o?

En los jardines verticales se ha utilizado acero básicamente por un tema de mantenimiento, y para reducir al máximo las secciones de los perfiles.

Referente al mantenimiento, si bien el acero se oxida, al ser galvanizado, su resistencia a un exterior expuesto es mayor que la resistencia al exterior de la madera, la cual necesita mayor mantenimiento. También a este efecto, y tal vez más referido a la durabilidad, la estructura de acero se prevé que, si es desmontada, pueda ser aprovechada tal cual en otro emplazamiento.

Referente a la reducción de las secciones al máximo, esto es necesario porque, al ser un proyecto que puede repetirse en diferentes partes, era premisa de diseño que el ancho total del jardín tuviera la mínima profundidad posible. En esta profundidad deben caber las jardineras, las instalaciones, y las personas de mantenimiento, por lo que pasar de un pilar de acero de 8cm, a un pilar de madera que podría ser de 15cm, aunque parezca poco, nos haría incrementar la profundidad de la estructura, y hacer la estructura inviable en alguna ubicación.

En el caso de los jardines verticales, el proceso ejecutivo que se propone es construir módulos enteros en taller, galvanizarlos, y, en obra, únicamente apilarlos y atornillarlos. Esto reduce también los tiempos de ejecución y los transportes, ya que lo único que se traslada son los módulos y las piezas de unión entre ellos.
Conclusions

Most recent developments in green walls are mainly focused in systems design in order to achieve more efficient technical solutions and a better performance in all building phases. Yet, green wall systems must evolve to become more sustainable. Continuing to evaluate the contribution of recent green wall systems to improve buildings performance and comparing the environmental impact of these systems with other construction solutions can lead to an increase of their application in buildings and reduce the systems cost.

The decision of which green wall is more appropriate to a certain project must depend not only on the construction and climatic restrictions but also on the environmental impact of its components and associated cost during its entire lifecycle.

These systems encourage the fruition of urban areas. They have a therapeutic effect of inducing a psychological wellbeing through the presence of vegetation. They improve city images and functions as a complementary thermal and acoustic protection.

Most systems are designed to be applied in the vertical plan allowing in some cases their application in inclined plans with some restrictions. Therefore, green walls must evolve and adapt to different surface forms and inclinations (curved, vertical, horizontal) with the convenient adaptations.

Considering the analysis of different types of green wall systems, it can be understood that innovation is mostly centered in the improvement of their design to achieve a better performance during the installation, usage, or maintenance processes. Yet, green walls must evolve to become more sustainable, through the use of materials with less incorporated energy and CO₂ emissions and the application of climate adapted plant species with less irrigation needs.

Some examples already show sustainability concerns by using natural or recycled materials and native plants, integrating water recovery systems and sensors for water and nutrients minimization.

The city and the habitat were never really thought for this purpose, so much so that to apply some basic ecological gestures today is a real feat. Sustainability it's an attitude that requires an honest, thoughtful analysis of how we live our lives today in order to create a better world tomorrow.

Of course, sustainability is not just about embracing the latest green technologies. It’s about creating environments that stand the test of time, and neighborhoods that fulfill our desire to live, work, and play close to the city, thereby reducing our reliance on cars.

Vertical greenery systems for the last decade are increasing their presence in building designs providing several urban ecosystem services. These contemporary design criteria provide a new social conception of the building sector.

Moreover, they also enhance the quality of the next generation of buildings by introducing environmental concepts that consider the whole life of the materials, energy and water consumed throughout the construction.
Conclusions

I am happy to have chosen my topic because it has helped me discover so many other issues that I had not even thought of.

As I made progress with my research, I realized that the subject in itself was much more complex. Vertical walls and their different systems are a whole world in their own right.

Certainly, all these new forms of green space added to the existing one brings a plus in the reduction of our consumption of CO2 in the city; however the materials used in the construction are not 100% sustainable.

I could say that in the end that I was a little disappointed; I did not expect to find myself at such a large wall. By deepening my research, this has completely changed my perception of vertical walls in the city of Barcelona and everywhere else. I was able to realize that creating a horizontal or vertical green space does not only imply the choice of plants or the final visual aspect that it will have on its surroundings, but the choice of materials and the different elements used. They are points that are very important on the ecological impact that we want to bring as a change in the world of construction.

Accordingly, I was able to find examples that reduce the consumption of CO2 to zero and that were also auto sufficient. I am firm in my belief that we can do better in the future.

It is our duty as a builder and creator of new spaces in a city to succeed in shaping better urban spaces for the well-being of all, especially that of the planet.

We must also contribute to the change we want to see in the world of construction. Therefore we have to be flexible and find new ways to build up on our skills and improve what we thought was right before. Perhaps, by choosing, experimenting and, creating new methods we can come to encompass the idea of the concept of a sustainable city.
Bibliography

Links and websites

https://worldpopulationreview.com/world-cities/barcelona-population
https://www.researchgate.net/publication/266078897_Green_wall_systems_A_review_of_their_characteristics
https://lh3.googleusercontent.com/proxy/RBDZgH2WH9uxNGni290qvZcJunr2QP2TXnXmdlr8sJ2bW5Q36lEIRbyv2SU0elZHCRRvuDzzDz37QQpfnDzTnt1ajiG5xD6lloZEQNdrlrOogTdl8rIDl6NJe5MUeKw2RsLcE0r
https://iwan.com/portfolio/caixa-forum-herzog-de-meuron/
https://www.naava.io/editorial/what-are-green-walls#:~:text=Green%20walls%20are%20vertical%20structures,feature%20built%2Din%20irrigation%20systems.
https://www.researchgate.net/publication/266078897_Green_wall_systems_A_review_of_their_characteristics
https://urbannext.net/one-central-park#:~:text=One%20Central%20Park%20has%20achieved,is%20a%20way%20of%20life.
https://www.centralparksydney.com/explore/a-sustainable-habitat
https://urbannext.net/one-central-park#:~:text=One%20Central%20Park%20has%20achieved,is%20a%20way%20of%20life.
https://urbannext.net/one-central-park#:~:text=One%20Central%20Park%20has%20achieved,is%20a%20way%20of%20life.
Bibliography

Links and websites

https://books.google.es/books?id=4V_ECwAAQBAJ&pg=PA158&lpg=PA158&dq=debut+of+the+green+wall+in+the+world&source=bl&ots=Ug5R5ITBZV&sig=ACfU3U0kU4EZhS11E1oTfL0DKdi2BGXR8w&hl=fr&sa=X&ved=2ahUKEwiPgruo4vvpAhXNDmMBHZAoCHwQ6AEwCXoECAcAQ&v=onepage&q=debut%20of%20the%20green%20wall%20in%20the%20world&f=false

https://www.academia.edu/32598621/VILLE_DURABLE_et_Ecoquartiers?email_work_card=reading-history

https://www.tdx.cat/bitstream/handle/10803/399726/Tjca1de1.pdf?sequence=5

pequeño manual del Proyecto sostenible by Francoise-Hélène Jourda, editorial Gustavo Gili
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International example

One central park, Sydney, Australia

Information and details

ENERGY

Central Park will have its own low-carbon natural gas power plant, producing thermal energy for its residents and workers.

In the first stage of its development, a two-megawatt (MW) tri-generation energy plant, run on natural gas, will produce low-carbon thermal energy, providing heating and cooling for 3,000 residences and 65,000 sqm of retail and commercial space in 14 buildings at Central Park. The stage one tri-generation energy center will also supply low-carbon electricity to the heritage County Clare Hotel and the mixed-use Brewery Yard building.

Tri-generation is twice as energy efficient as a coal-fired power plant. Environmental consultants and design engineers WSP have forecast that Central Park’s two-megawatt plant could reduce greenhouse gas emissions by as much as 190,000 tonnes over the 25 year design life of the plant. This has the same effect on greenhouse gas emissions as removing 2,500 cars off the roads every year for 25 years.

Central Park’s tri-generation plant has been funded by a $26.5 million Environmental Upgrade Agreement (and EUA) - a new type of low-cost, long-term funding for green infrastructure. EUA is a voluntary agreement between a building owner, a finance provider and a local council, made possible by changes to the Local Government Act in 2011 to encourage building upgrades. Frasers Property and Sekisui House entered into an EUA with the City of Sydney in March 2013.
A key element of Central Park's sustainable infrastructure is the recycled water network. Central Park Water will be the biggest Membrane Bioreactor (MBR) recycled water facility in the world built in the basement of a residential building. Central Park Water is wholly owned by Flow Systems and will service approximately 4,000 residents and more than 15,000 workers and visitors daily.

Central Park Water will own, operate and maintain all water related infrastructure within Central Park – effectively taking over the management of the water cycle within the precinct. Thanks to Central Park Water, residents will use between 40 and 50 per cent less drinking water, saving money and precious drinking water supplies.

Multiple sustainable pipelines within the precinct enable the delivery of differing water qualities. Given households use only 10 to 20% of water for drinking/cooling and another 20 to 30% for cleaning, Central Park Water is enabling households and businesses to use recycled water for the 50 to 70% of other activities such as toilet flushing, washing machine use, irrigation, green-wall watering and air cooling.

The recycled water Centre will be built over four basement levels. It uses MBR and Reverse Osmosis (RO) technologies, designed to simplify operational management and minimize maintenance.

Importantly the technology can be completely controlled remotely, it requires minimal space and does not smell or make any disturbing noise. Central Park Water will bill customers directly and is subject to the same licensing requirements as Sydney Water. IPART and the Minister for Natural Resources, Lands and Water oversees the administration and operation.
of private water licenses.

Our recycled water network harnesses multiple water sources with varying qualities and creates multiple water supplies, covering all the water requirements of the community.

The seven water sources include:
· Rainwater from roofs
· Storm water from impermeable surfaces/planter box drainage
· Groundwater from basement drainage systems
· Sewage from an adjacent public sewer
· Sewage from all buildings within the Central Park community
· Irrigation water from all green walls
· Drinking water from the public water main

For more on Central Park Water, visit www.centralparkwater.com.au
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Caixa forum
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Jardín modular Betevé

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