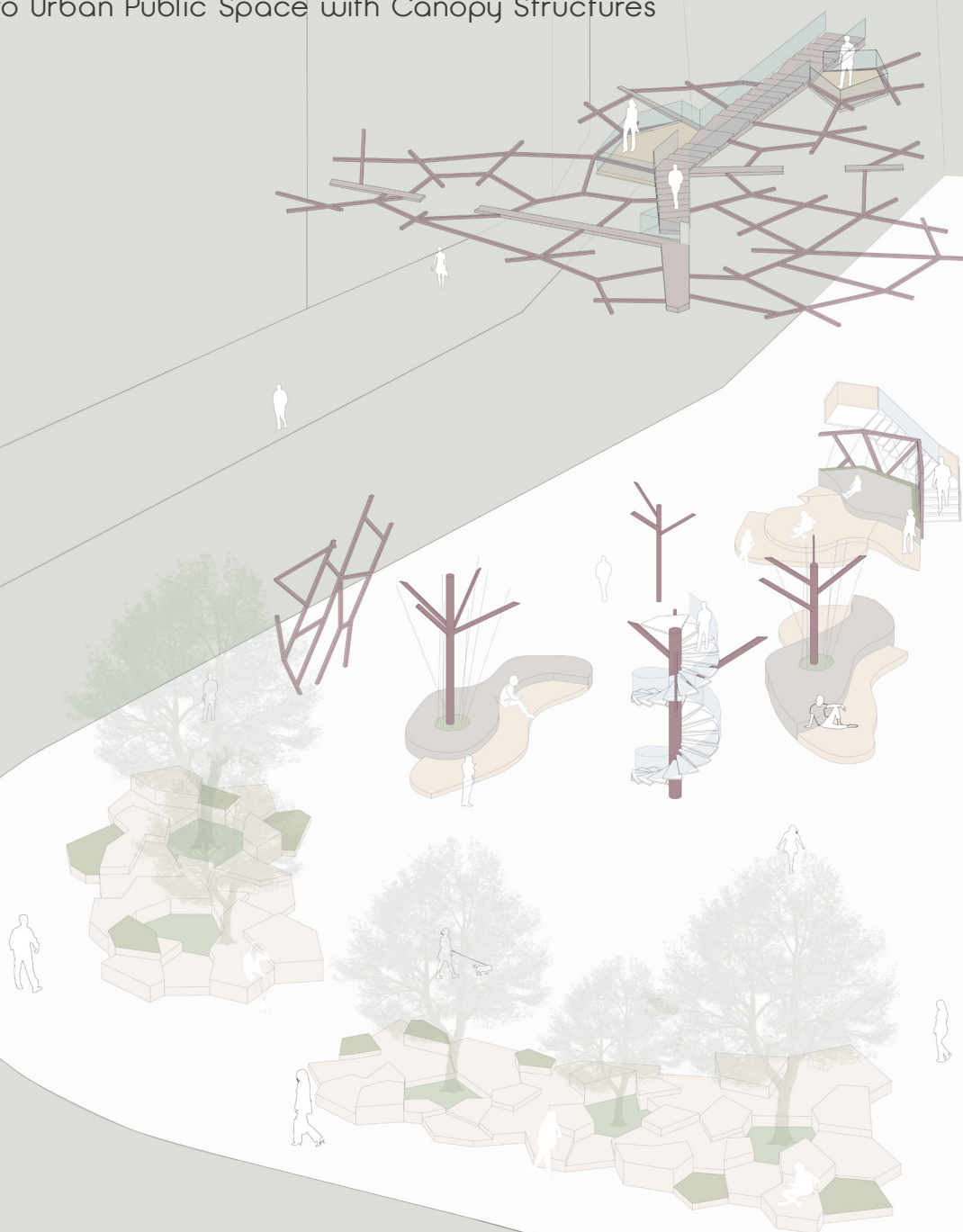


# Living Canopy

Integrating Greenery into Urban Public Space with Canopy Structures



by Prince Aboagye  
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# Living Canopy

Integrating Greenery into Urban Public Space with Canopy Structures

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# Abstract

Today large number of people leave in urban areas and it is estimated that over 68 percent of people in the world will be living in cities ten years to come. Increasing population in urban areas tends to reduce the amount of green spaces due to new buildings and infrastructures that accommodates new inhabitants. There has been ongoing reduction in green areas urbanites enjoy in public spaces, being it for leisure or play. Although urban structures serves as a vital role in our everyday life either for shelter or work, it could also be used as a tool to maximize green areas in public spaces.

Green surroundings are known to foster social interaction, engage people in physical activities or serve as a place for relaxation. This spaces largely connect the general public and helps to creates dynamic engagement between people and the environment. Integration of greenery in the public realm comes with a great benefits for it users and generally improves the microclimate, it serves as a buffer for noise and purifies the surrounding air. These spaces also enhance and support biodiversity in our built environment. In addition it helps to boost the economic value of spaces and bridges the social gap in communities. Other researches has also proven the health benefit of being in a green surroundings.

The purpose of the thesis is to critically look into ways of densifying urban public space with greenery through the use of canopy structure systems. The study tends to look into various design iteration of canopy structure systems that can support and integrate greenery for public benefit. The research will further look into urban horticulture, focusing on vertical greening systems and vertical gardens as a subject of interest and it support for biodiversity.

Keywords: green densification, canopy structure, public space, urban horticulture, biodiversity.

# Acknowledgments

Am grateful to be part of the 2021 master thesis class. It has been a fruitful and adventurous journey with my master thesis project and I like to extend appreciation to the people who made it possible. My first appreciation goes to God for giving me the strength and the desire to carry out this project from the initial stage till now. I also like to extend my sincere gratitude to my supervisor Emilio Da Cruz Brandao for his most appreciated supervision and knowledge of the subject matter. Further thanks goes to my examiner Joaquim Tarraso for his guidance and positive impact on my thesis work. Last but not the least I like to thank my family for their support and encouragement throughout my entire master degree programme. Lastly many thanks goes to my architecture colleges for their advice, suggestion and critics on my work.

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## About the author

I previously worked as an architect trainee at the office Alessandro Ripellino Arkitektkontor in Stockholm, where I mainly worked with planning schemes and also part of the visualization team. As an architect, I like to work with nature and sustainability in all my project concepts.

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Sustainable architectural design  
Residential healthcare  
Local context

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Kwame Nkrumah University of Science and Technology, Ghana.  
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### 2009

National Institute of Information Technology.  
Program software application



# 1

## Introduction



## Purpose

Green space can be term as a combined area that is made up of natural and artificial green area providing benefits to various group of people. Due to urbanization in cities, the amount of good quality green space is likely to reduce unless effort and design measures are put in place to increase it. Therefore finding innovative ways to densify our urban green landscape is beneficial to us and the climate in general. The thesis is to create awareness and the importance of public green space and why we need to introduce more greenery in the cities. The final design outcome will see to the integration of greenery in it design and spaces created will be aimed in inviting the general public. It is also meant to teach and to showcase hi-tech horticultural planting approach both for leafy vegetables and ornamental plants.

## Research question

How can greenery be integrated with canopy structures in urban public spaces?

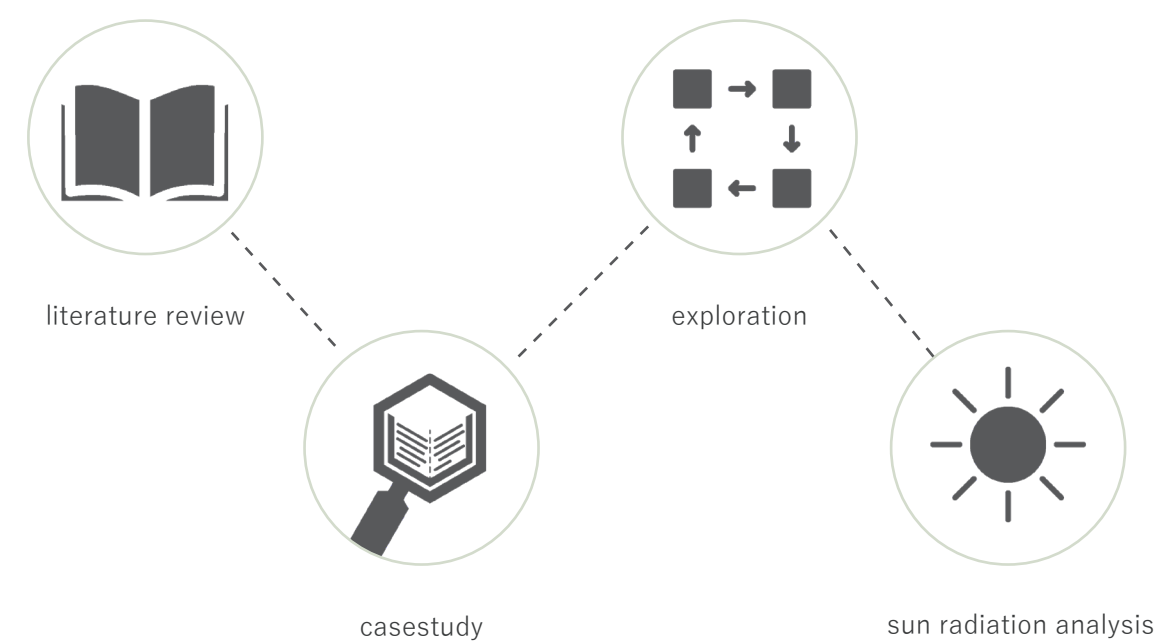
## Background

Urbanization and the growing population in cities means a huge portion of green spaces in urban areas are also going through tremendous change whether being it a space for building infrastructures or parking lots. New development in the cities tend to reduce the amount of greenery compare to the ones that are add after development. Most green areas in the cities are meant for recreational purposes to enhance the social cohesion, attachment to the place and to promote outdoor activities as this positively affect the quality of life. Dense communities has often being linked with poor social contacts due to lack of green spaces. Urbanization in Gothenburg has been on the raise in recent years and the current 2050 development plan aims to urbanize the city more than before.

# Method

The main approach of the thesis is research by design. The methods used in gathering useful data were literature and case studies on the related subject. Further exploration of biomimicry concepts and design iteration were carried out. The literature focused on urban green infrastructure and technological green system. The cases study focused on analyzing similar case projects and further exploration were done to end up with the right design solutions.

Radiation analysis as a tool was also used in analysis the site and the canopy to allow enough light into the space.



# Relevance

Now a days architects are not solely responsible for designing physical building structures for living and working but are also required to design quality green outdoor public spaces that the general public can enjoy and benefit from. Because public green spaces are the lungs of the cities, architects must put pressure on cities to plan for more green public spaces in dense urban centers and help increase it awareness. Urban environment and the role of greening must be part of a future approach for architects and planners when designing cities.

## Sustainability

Green spaces are perceived as a great compliment to the built environment and are seen as the natural healing space for it users. Communities with more green areas become a place of choice to live or work by most inhabitants as it support our daily social life and existence. Therefore exposure to green spaces are essential to human health and well-being such as reducing the exposure to noise, air pollution, heat, stress and engaging people in healthy activities. Creating such spaces tend to fulfill the need of a quality life.

Today social sustainability is one of the topic under discussion and finding solutions to increase greenery in the urban realm, to foster social interaction and activities is the way forward. Designing green spaces promote social contacts, enhance the sense togetherness and belonging, other studies has also shown that green space encourages familiarity, aid skill development and reduce loneliness.

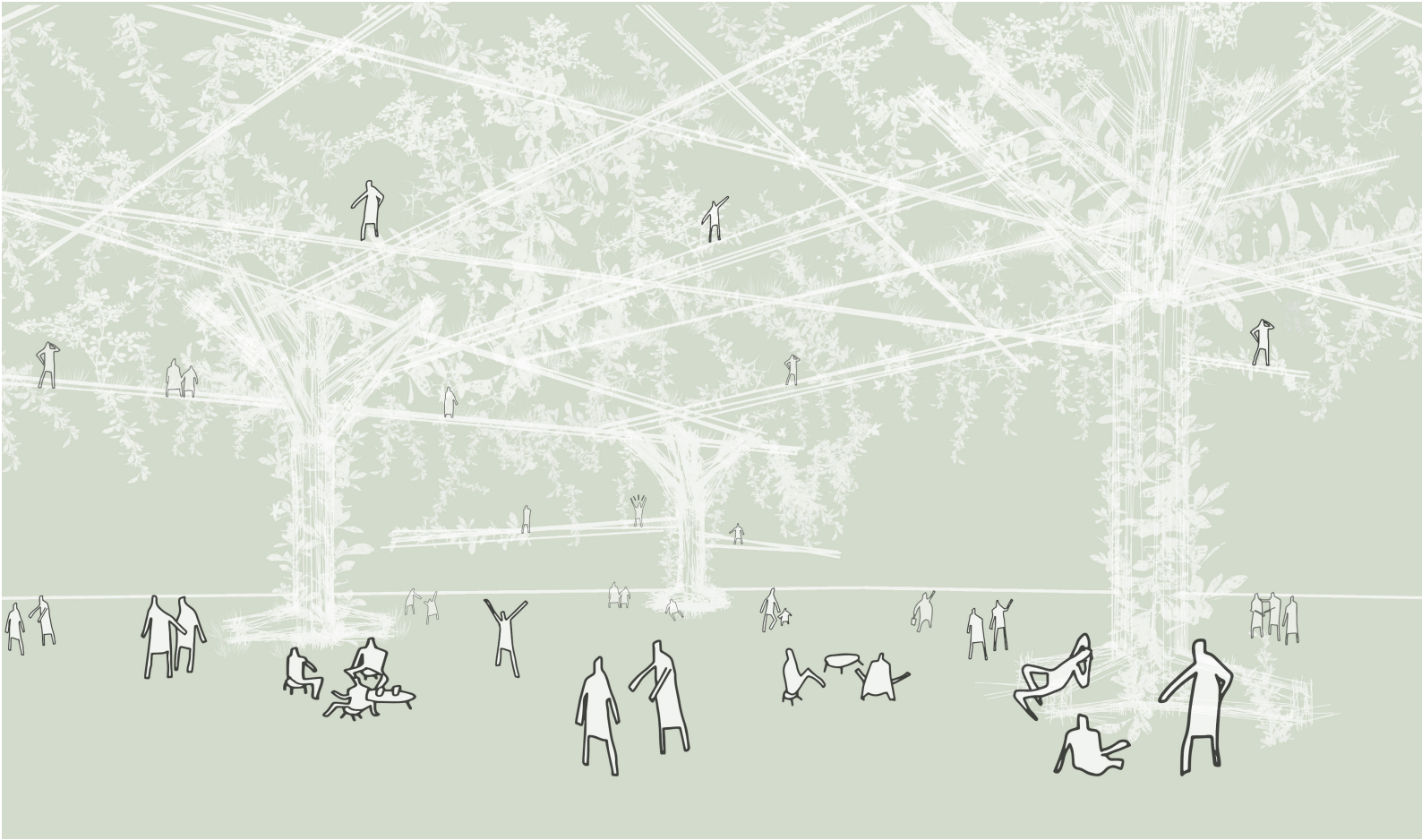


# Manifesto

Our surroundings has a great impact on our lives as people and how we interact with our surrounding says a lot about us as humans. In designing for the future it's also importance to thinks about social sustainability and how our green spaces can play a vital role. There is need to look into other alternative solutions to introduce greenery in our dense urban public spaces through innovative designs. Integration can be exlored with both new and old structures to densify green growth and peoples experiences.

Green space strengthens social bond in neighborhoods and communities by creating opportunities to facilitate social engagements. Researche as shown that green spaces encourage physical exercises and serve as a therapy for its users. Urban structures and green space can leave together by integration rather than creating a space just for one.

# Graphical manifesto

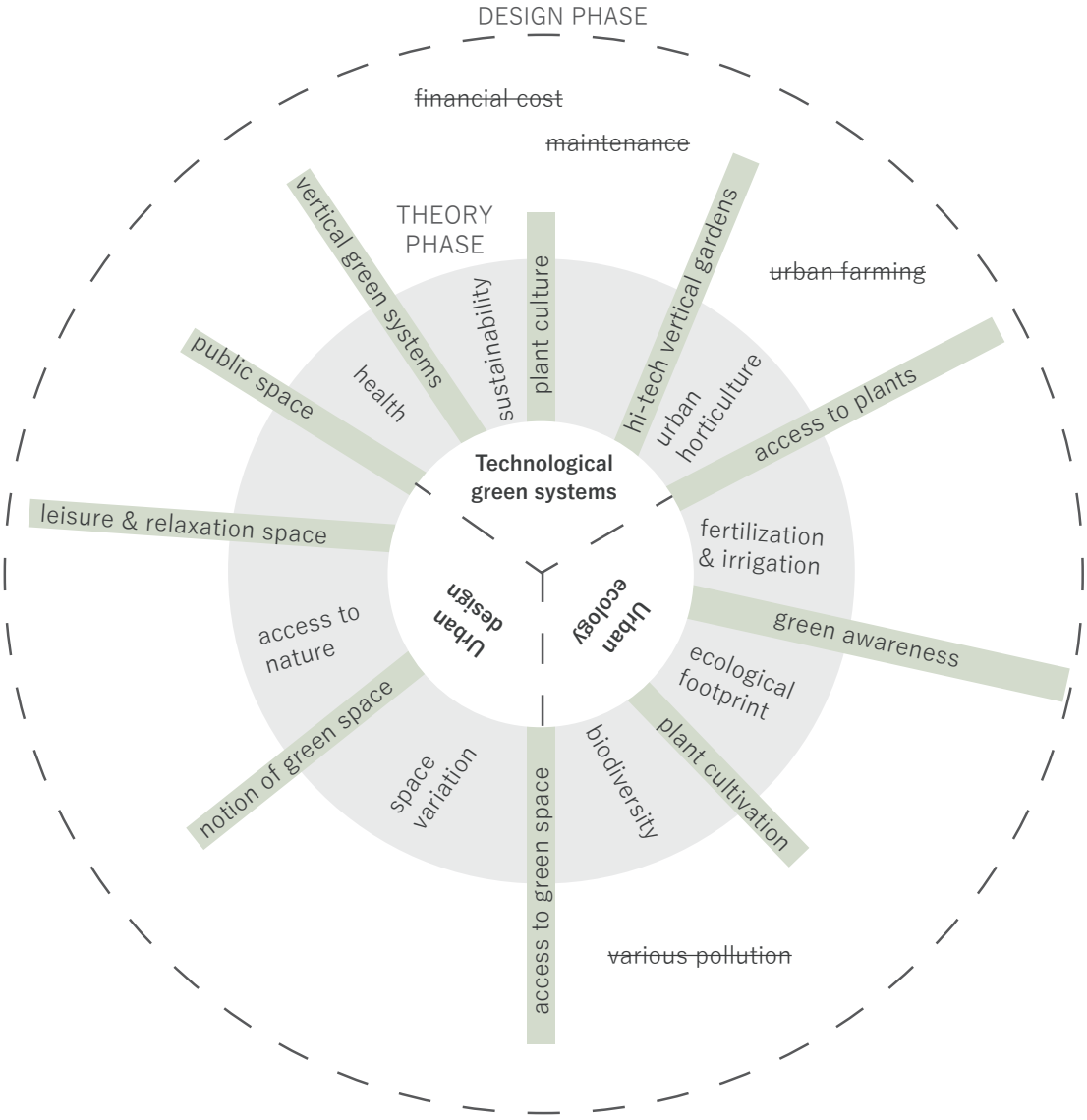




# Delimitation

The study focused on canopy structure design elements that can support plant growth and densification. It also focused on urban horticulture practices including; vertical greening systems and vertical garden practices as means to aid plant cultivation and densification. On the theory phase the thesis also highlighted on some of the benefits and similar case examples.

The research did not take into consideration the various pollution in the dense urban areas and its impact on plants. The project is not considered as an urban farming scheme but to create awareness of the importance of having green spaces in dense urban areas. Maintenance and cost of the design outcome would not be also discussed.

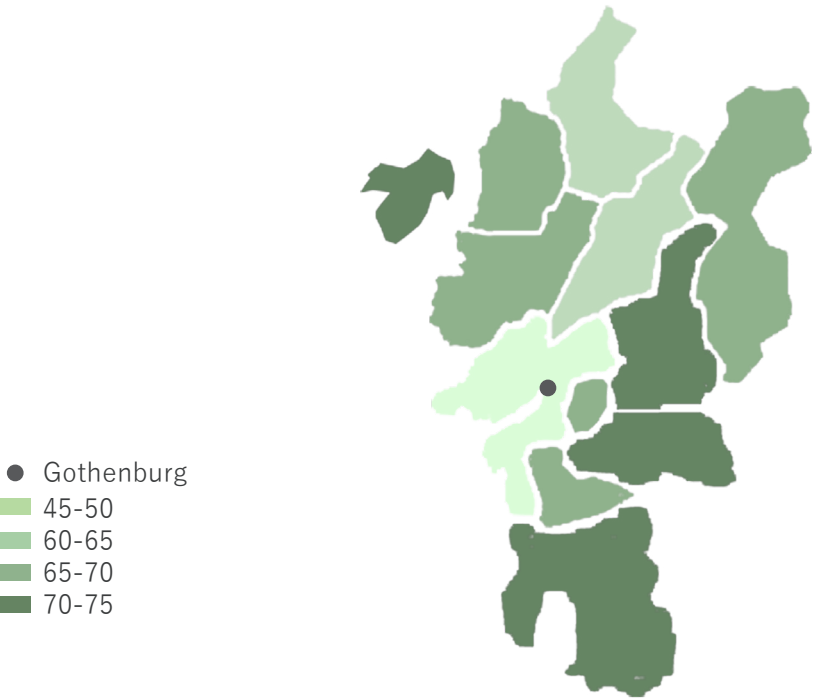


## Urban green & technological systems

2

# Urban green structures

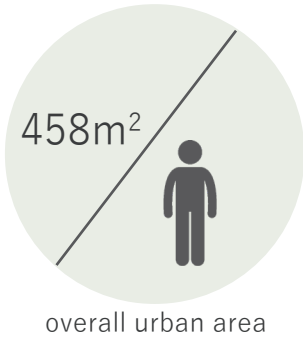
In urban cites the balance between green structures to urban dwellers is a great challenge. In many urban cities there is a vision to create dense green areas especially in the public realm. Green structures are essential part of the built environment as it contribute to the well-being of it users and improves biodiversity, it also serves as a home for different plants and animal species. Greenery itself aids in the regulation of hot temperatures in dense urban areas and has a great social perspective. In Västra Gotland region green areas tends to decrease towards dense urban areas.



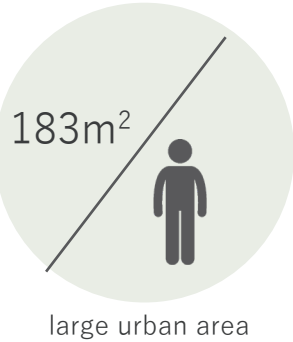
Västra Gotland green ratio

In the global level the relevance of green structures as an urban sustainable development goal has been heightened by the United Nation as one of its 2030 agenda goal 11 “make cities and human settlements inclusive, safe and sustainable”. In an ecological view point it is crucial for the survival and the increment of different species while as in the recreational view it a bit tricky whether people have access to green spaces especially in dense urban areas.

The facts remain the same as the measurement of green structure has some level of relevance in the larger urban areas. In small urban areas it is not much of importance because of the presence of abundant green areas. According to Sweden Central Bureau of statistics, 63 percent of urban areas consist of greenery which included both small and large urban areas but there is a linear correlation as the amount of green areas reduces toward the larger dense urban areas.

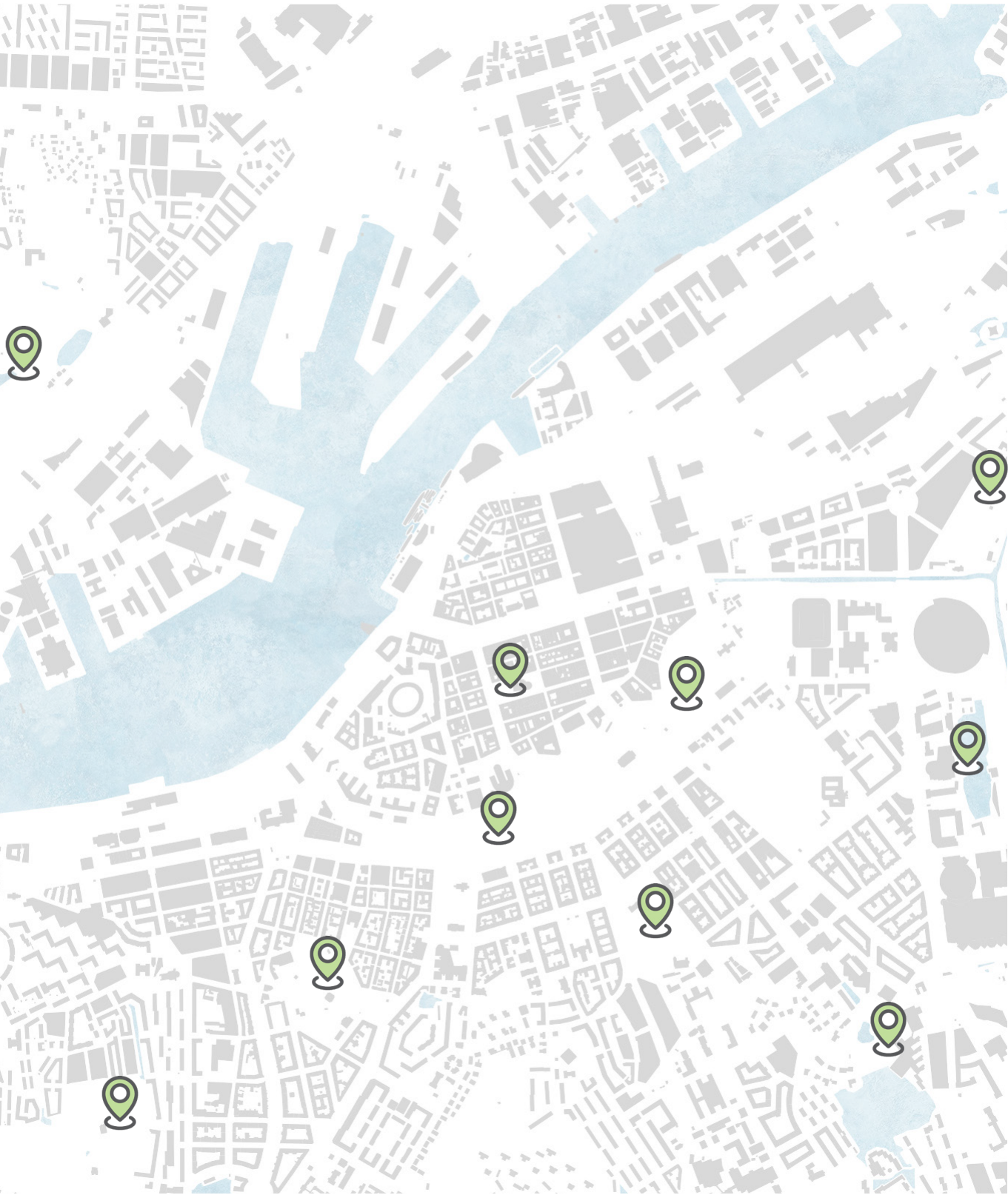


On the average the urban population has 458m² of green space per person in Sweden



In the very large urban population like Gothenburg, green space per person is 183m²

# Public green space



Map of dense central gothenburg, known public green spaces

The overall green area includes all green element in the urban domain whether private or public but the public green space are the ones available for the public to access regardless of the time of year. On the average 40 percent of urban areas both small and large consist of publicly available green space, but it tends to reduce in dense populated areas making the difference noticeable.

Green areas cannot be discussed without hard lands which is the absence of green areas. Hard lands includes buildings or may be covered with hard materials such as concrete, asphalt, gravel pitches and artificial turf. About a third of urban areas are covered with building and infrastructure accounting for averagely over 30 percent with the remaining 7 percent consisting of industrial lands and parking spaces. This percentages increases in larger urban areas.



large urban area

In the large urban areas, the population has 127m² per person of public available green space



small urban area

Small urban population has 1,151m² per person of public available green space, which is 10 times compare to dense urban areas

# Urban horticulture

Growing population in large urban areas comes with its own challenges including food shortages and the lack of open green spaces to enjoy by urbanites. Urban horticulture which involves the production of herbs, vegetables, medicine and ornamental plants has been a relevant approach in resolving these challenges. Urban horticulture in other terms can be said to be a part of agriculture which involves the growing of plants for food, medicine and it beauty. It can also be defined as the cultivation of plants.

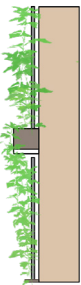
Urbanization which is the result of movement of people from the rural areas into the city has an effect on agriculture in terms of how certain kinds of vegetables, fruits and how other foods are produce. It also has challenges associated with the opportunity of people to get accessible to enough green space or nature. Vertical greening system and gardening is an ongoing approach to help introduce greenery into the dense urban areas with limited land space. These hi-tech systems is to aid cultivate plants effectively in small public spaces in dense urban areas, giving ubanites the opportunity to experience and interact with these system thereby improving the hard landscapes and quality of life.

# Vertical greening systems

It comprises of vertical structures that aids in spreading vegetation that may be attached to a building facade or internal wall. There are several green wall typologies ranging from simple to complex configuration.

## Green facade

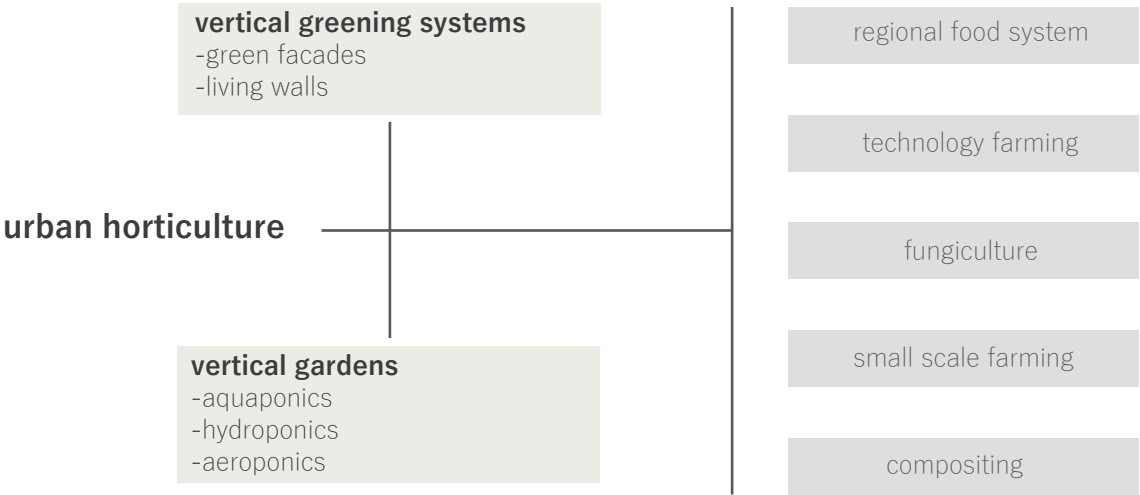
It uses climbing or hanging plants to cover a vertical surface, it often comprises of a supporting frame with rooted plants in the soil close to the frame or in plant boxes. Soil containers can be placed on the ground for plants to grow upwards or at the top for plant to grow downwards. It can be attached directly or indirectly to a vertical surface.



green facade system



Fig.1 (Elizabethminchilli, 2016)  
Elizabeth Minchilli, Monti, Italy



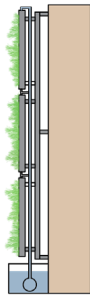
## Living wall system

Living wall approach uses different technology that enable many plant species to growth directly on a vertical surface. Usually a waterproof back space is required to solve damping related problems, it also serve as a gap for providing irrigation and plant nutrients. This method is similar to hydroponic system way of plant cultivation.



## Hi-tech vertical garden

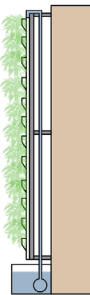
Vertical method of farming started has a method of scaling up plant production and also a means to introduce farming in the dense cities with limited land use space. This involves the growing of plants and animals for food, beauty and other purposes, artificially aligning them in a vertical position and there is no need for soil. The design of the plant holders can also be stacked on top and interlocking each other, the method is reusable and can be used in indoors or outdoors.



panel system



Fig.2 (Butong, 2016). Bjorns vertical garden, Stockholm



cloth system



Fig.3 (Nandwani, 2018). Patrick Blanc's green wall Musée Du Quai Branly in Paris



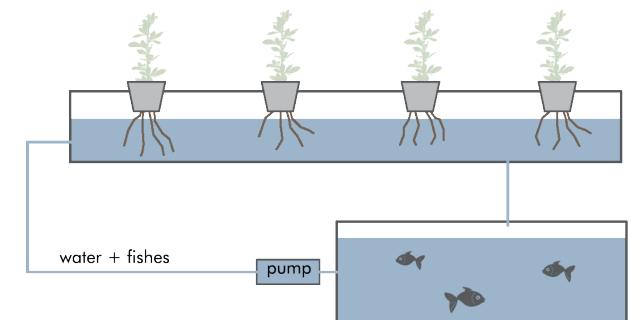
active system



Fig.4 (LiveWall, 2018). Appleton International Airport, Greenville, Wisconsin

## Aquaponics

It combines hydroponics and aquaculture in its cultivation. Byproduct of water in fish farming are drawn through the plants as nutrients for growth then recycled back and reused by the fish.



### Advantages

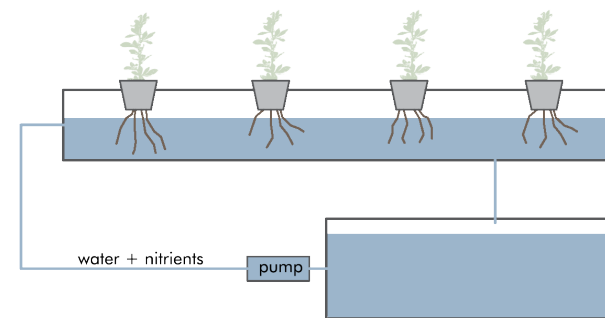
- No need for fertilizers
- 95% less water usage than conventional farming.

### Disadvantage

- Expensive to manage
- High level of knowledge is required
- Requires attention

## Hydroponics

It is a growing approach without soil, where plants are suspended in floating water with mineral nutrients added. It's best done in a controlled indoor environment which enable it to be accessible in the winter months.



### Advantages

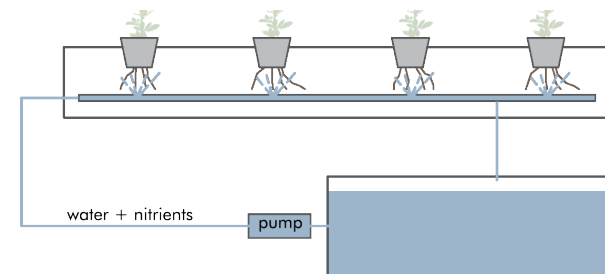
- Soil-less and no nutrients pollution
- High nutrients level and 90% less water usage than convention farming.
- Nutrient solution can be reused
- Can be cultivated anywhere

### Disadvantage

- Requires attention

## Aeroponics

The system is made up a base and a planter attached to the base, the planter section is hollow in the inner part and has a plant holder along it. The plant holders are might to receive the plants and the base holder is attached to a nutrient distributor which then supplies nutrient to all the plants attached to the plant holder. It usually requires sunshine or LED lights.



### Advantages

- Soil-less and 90% less water usage compare to hydroponics
- Higher nutrients quality and absorption.
- Less demanding in terms of automation.
- Highly beneficial for a limited space.

### Disadvantage

- Regular maintenance
- High technical knowledge is required
- High cost to run

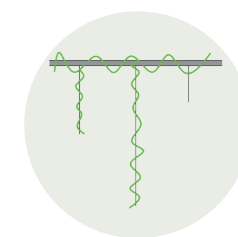
## Plant movement and species

Plant behavior can be term as what plants do. Animals can do things or perform tasks without any change in their body structure but with plants any action taken leads to it growth or discarding of it parts which involves a change in size or form which results in movement of plants. Plants stay at one place but it's their parts that move, bend, twist. Trellis are supports systems that facilitate plant movement and directions thereby aiding in plant densification. It usually attached to walls and other structures to help the densification of plants.

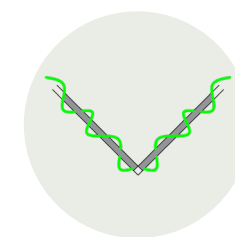


Fig.5 (ClipArtETC, 2021)  
Directional movement

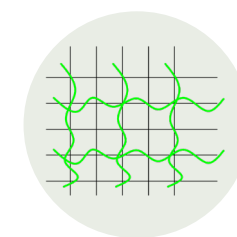
## Plant and trellis



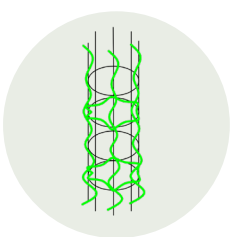
horizontal/vertical  
movement



diagonal  
movement

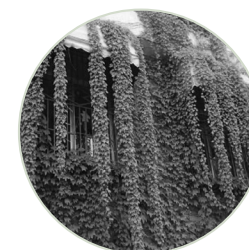


grid mesh  
movement



cylindrical  
movement

## Evergreen climbers



Boston Ivy



Clematis armandii



Aristolochia durior



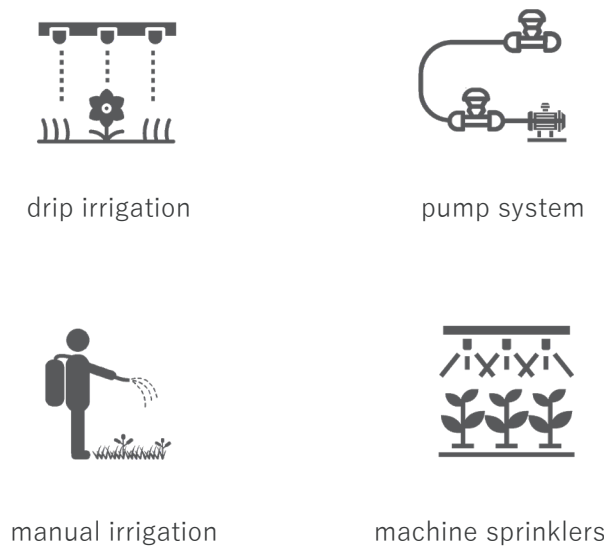
Common Ivy

Fig.6 (Ebertsgreenhouse, 2021)



Nutrient supply

As edible plants like vegetable may require water once or twice a day, ornamental plants can grow with less availability of water. Application of water can be done manually or mechanically. Sprinkler systems can be used directly on top of the plants. Drip irrigation system is another form of water application with 20 percent conservation of water. The pump system is the most commonly used method in vertical garden such as hydroponic system. It enables the circulation of liquid plant nutrients in a loop.



Leafy vegetables

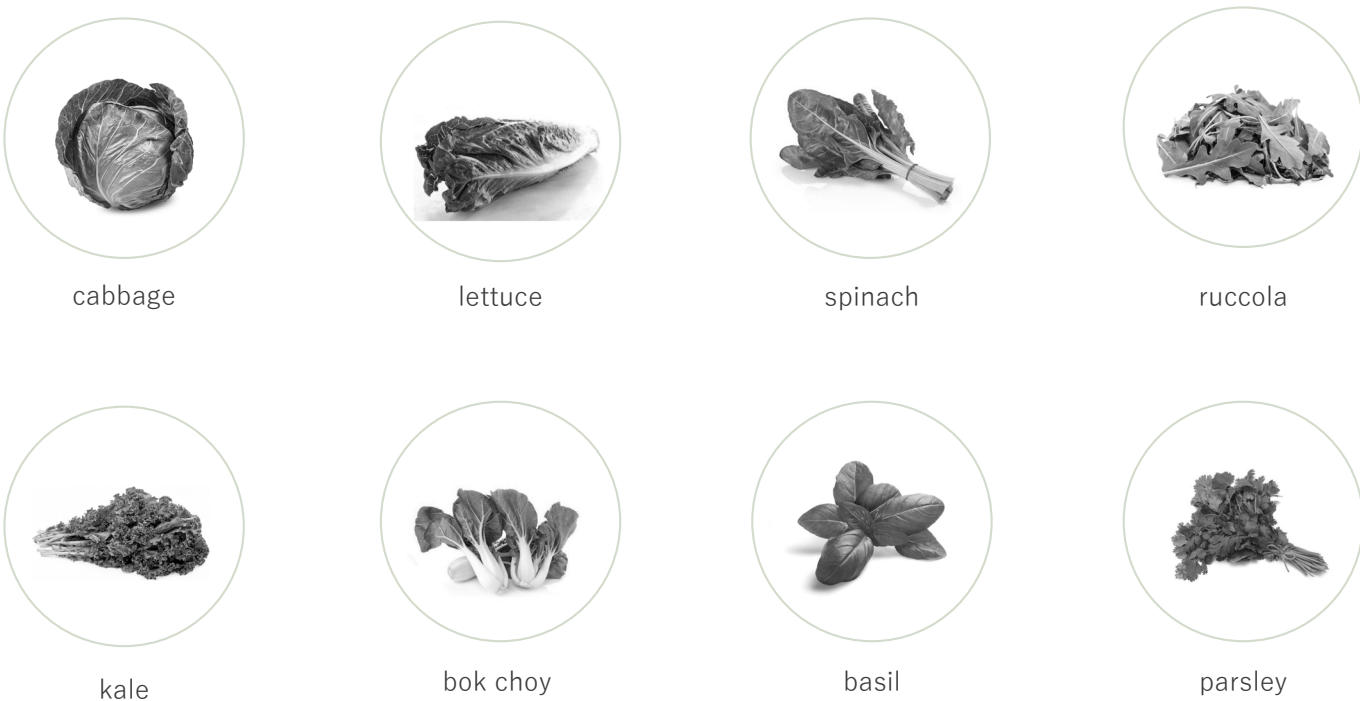


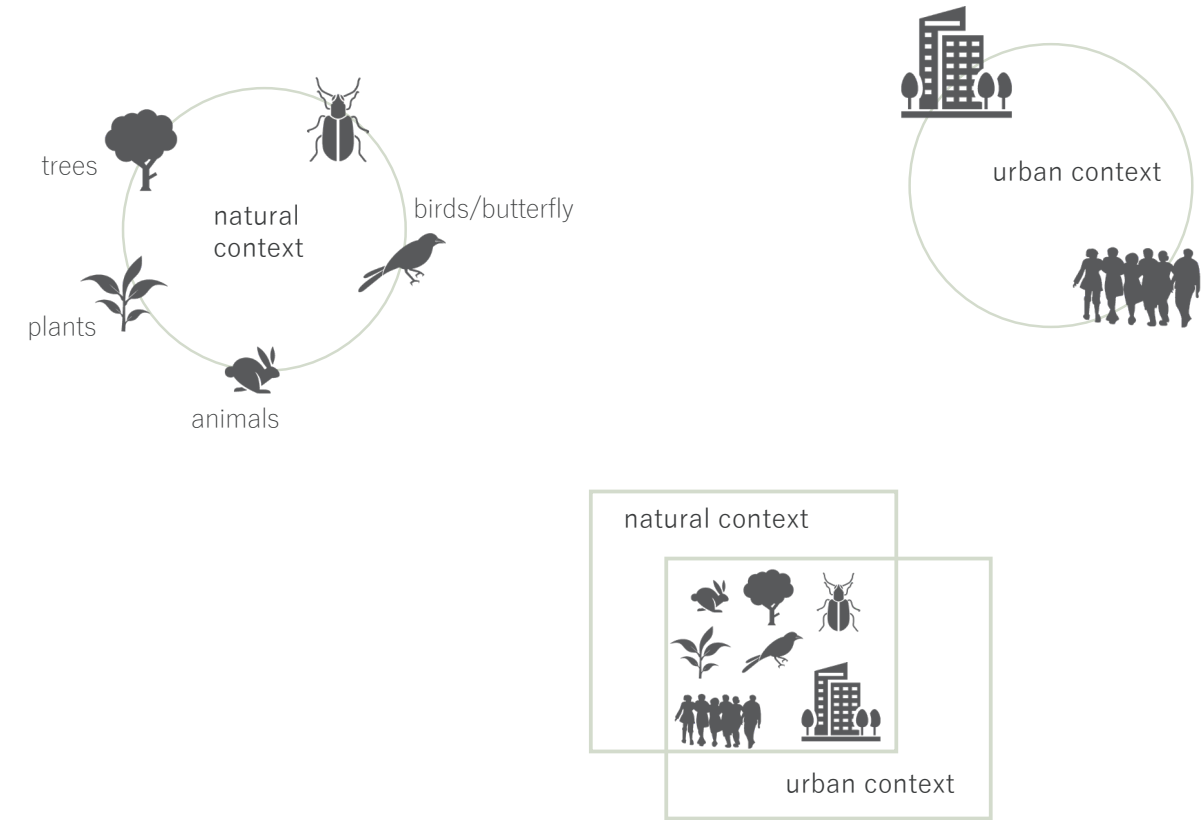
Fig.7 (Specialtyproduce, 2017)

Biodiversity

Dense urban society faces major ecological problem of biodiversity loss, there is a valid relation between the loss of species and urbanization as green space that provides home for various species are replace with building and other infrastructures. Biodiversity is crucial for the ecosystem as it provides as with food, oxygen, water and medicine which are essential for human survival. There is a need to create more biodiverse space in the urban areas with the introduction of green spaces to invite different species as well as people. Integration of the natural and urban context through shared space will provide benefits to it users.



Fig.8 (The Conversation, 2012). Biodiversity sensitive urban design approach, RMIT school of architecture and design



Biodiversity in nature has various connectivity such as physical connectivity, the relation between plant and animal species and how does this relation occur in dense urban areas of Gothenburg. Numerous urban cities around the world for several decades have tried to create green connections in urban areas to help facilitate this notion of making urban areas more biodiverse.



Fig.9 (Arboristnow, 2016) Naturally bird species creates their own nest in serene space if provided for them.

**Bird species in the area**



black redstart



common redstart



marsh warbler



wheatear



little ringed plover



reed warbler



reed bunting



whitethroat

Fig.10 ( RSPB, 2020)

**Conclusion**

Hydroponic system way of planting was adopted because of it efficiency and reliability, it also uses less water as compare to traditional farming. In a hydroponic system, plants pockets that holds the plants and carries the nutrients could be made narrower as compare to the rest of the system. In terms of irrigation a pump approach is the most efficient and common way in circulating water and nutrients. Nutrient circulation is done in a continuous manner to avoid it from freezing in winter periods. Plant pockets and trellis are design elements that aid plants to move and densify in all direction. According to the study plants species that are used for canopy structure densification are mostly climbers due to its ability to spread and densify easily. Small scale leafy vegetable cultivation which adopts hydroponic system was incorporated in the structure to allow public viewing and to create awareness on how these system works.

**hydroponic  
system**

**trellis  
&  
Plant pocket**

**climbing plants  
&  
leafy vegetable**



## case study of canopy structures

3

# Orchideorama

The concept of Orchideorama design was to create a relation between architecture and living organisms. In the bigger scale the structure gives the perception of an extension of the surrounding nature or a shadow garden. The structure can be seen as a shed with gathering of different gardens and plant species.

## Structure and scale

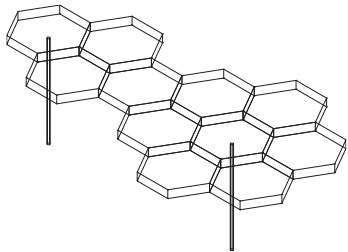
The structure adopts the famous hexagon shape as its base form. It's seen as a flower with seven different hexagon shapes which makes up a single flower, with the central hexagon been used as a patio. Orchideorama composes of 10 flowers. It also has its vertical support from the central point to the ground. It has additional technical facilities which are integrated in the structural columns such as lighting works and water collection. The scale of the structure adopts the height of the surrounding forest.

## Biodiversity

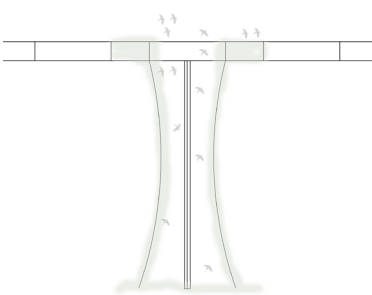
The structure is also a home to smaller animals such as birds and insects. Some of the patios are designed for feeding birds and others serve as a place for breeding butterflies.



Orchideorama is a green public space in Medellín, Colombia, it was designed by Plan:b arquitectos + JPRCR Architects in 2006. Fig.11 (UrbanNext, 2005).



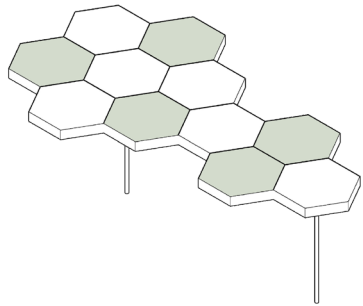
vertical support system



birds and butterfly breeding

## Plant support

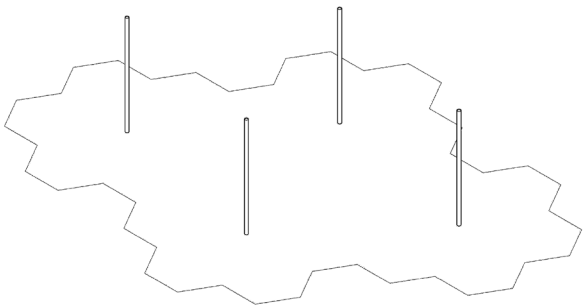
The main structure doesn't have plants woven into it but it has a different way of integrating plants. Each flower, which is made up of seven different hexagonal shapes, has a specific function dedicated to it. Some areas of the patio are used for small temporal gardens and other areas are dedicated to flowers such as orchids, exotic and tropical flowers. The ground level has its share of decorative gardens.



plant support on structure

## Spatial composition

The design of the supporting columns creates a spacious area for various activities such as birds and plant exhibition. The space created also enhances social engagements as the area accommodates weddings, fashion shows, concerts and festivals.



useable space form



# MFO park

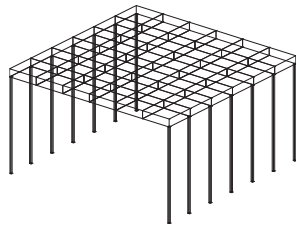
The concept of MFO park design was to densify public spaces in the urban center with greenery and can be seen as the relation between architecture and living plants. In the large scale the structure gives the perception of an extension of the surrounding buildings but as a green and social space. The structure can be perceived as a canopy accommodating different types of plant species and garden.



MFO Park is a green urban public space in Zurich, Switzerland, It was design by Raderschallpartner Architects in 2002. Fig.12 (UrbanNext, 2002).

## Structure and scale

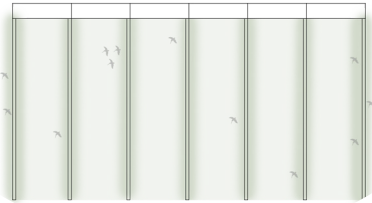
The structure takes a square-like grid form. It is covered with wire mesh on it three side, this wire mesh serves as a support and direction on which the plants grows. The grid system makes the structural configuration easy and simple. In the central space, series of wire mesh from the main grid descends down embodied with dense plants creeping all over it. The structure is vertically supported by small steel columns creating various floor levels which maxims the spatial usage. Technical facilities such as lighting and water collection are along the columns.



vertical level compotion

## Biodiversity

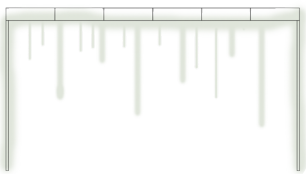
The MFO Park did not address biodiversity directly but space with green plants tend to attract different kinds of birds and insects. The grid mesh structure could be conducive for birds to take a rest on. The linear mesh cluster creates an atmosphere for butteries.



bird breeding

## Plant support

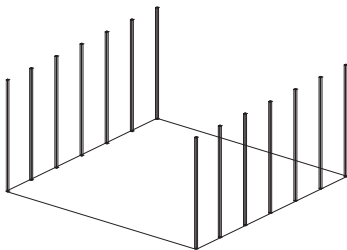
The main structure has plant woven into it in a well-planned manner. The use of grid mesh and linear wire gives the plants the opportunity to be part of the structure itself. The ground level also accommodate various plants but also serves as a green and social space. The structure can be perceived as a canopy accommodating different types of plant species and garden.



trellis systems

## Spatial composition

The main supports at the edges of the structure creates an uninterrupted space at the central part making room for various social activities such as sports, games, meeting spaces, concerts, film screening and theater performance .The double wall system at the facades creates space for stairs, walkways and cantilevered decks. The top of the roof is used as a sun deck.



useable space form

# Vermilion sands

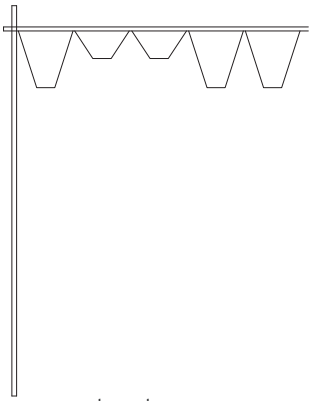
Its a temporal pavillion for art festival during the summer periods in west Vancouvers waterfront. The pavilion creates a unique use of hydro-seeding, which is a seed planting approach general use in large area planting. This was used to create a living canopy.



Green Wall Living Canopy was designed by Matthew Soules Architecture. Fig.13 (Archdaily, 2014).

## Structure and scale

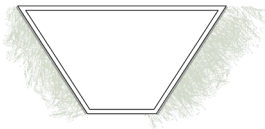
The structure is made up of horizontal and vertical supporting systems, the vertical coulms are smaller in size and many in number to be able to carry the plants.



structure

## Plant support

The structure support plant by integrating the plants to a pyramid shaped wooven mesh which is attached to the main canopy structure.

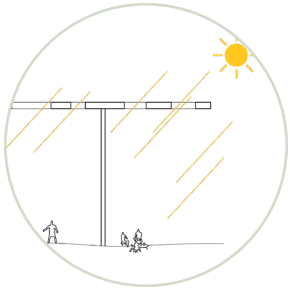


plant support

# Conclusion

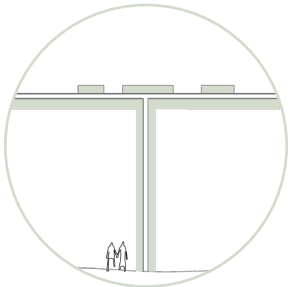
## Structure

The higher the canopy structure the more light can reach underneath, openings in the structure also provide extra light where it's needed on the ground.



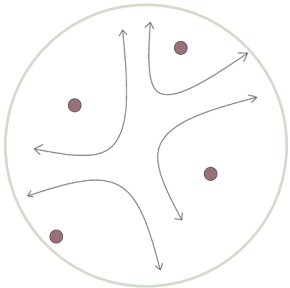
## Plant support

The canopy adopt the use of trellis and plant pockets as a form of support and movement for densification. Trellis can be shaped in different form and direction.



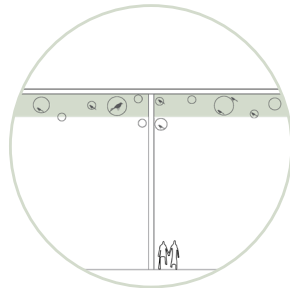
## Spatial composition

Boundaries of the ground space is mostly defined by the shape of the canopy structure. Open space with less vertical coulms interactions allows easy flow.



## Biodiversity

In the canopy, spaces created for birds and insects are mostly located in areas with less human activities to avoid unwanted human interaction, these places are mostly just underneath the canopy structure.





# canopy structure concept

4

## Tree analogy concept

Naturally humans are in some form attached to their natural surroundings, people generally visit the forest or green space to get closer to nature. Under the canopies of a forest, trees gives a serene atmosphere that people enjoy whiles engaging in various activities. The structure of the canopies makes these spaces very spacious both horizontally and vertically. Because of the diversity nature of the forest humans also gain the exposure to different types of plants and animals such as birds, insects and butterflies.

In the quest of introduce and integrate greenery into dense urban areas this idea can be adopted. This will aid utilize small urban public spaces efficiently in terms of green integration. The tree canopy structure as we know creates shelter for humans and provides a home for animals and insects. The canopy structures can be merge with vertical greening systems to create a forest like atmosphere in the urban areas.





# Biomimicry

The notion that nature does it better can be noticed in our everyday life when it comes to architecture. In a nutshell biomimicry is the imitating of natural forms, processes and ecosystem to generate a more sustainable design.

## Tree analogy

The concept is to analysis the different part of a trees as the basis for the vertical support for the canopy structure. The base as the support on the ground and the upper portion of the tree being the support at the upper level. The biological process of the whole trees system serving a medium for nutrients transportation would be also adopted as an approach to carry plant nutrients to the different part of the structure.

the upper branches serves as a support for the leaves and a transport medium.

the truck serve as a transport medium to the upper part of the tree.

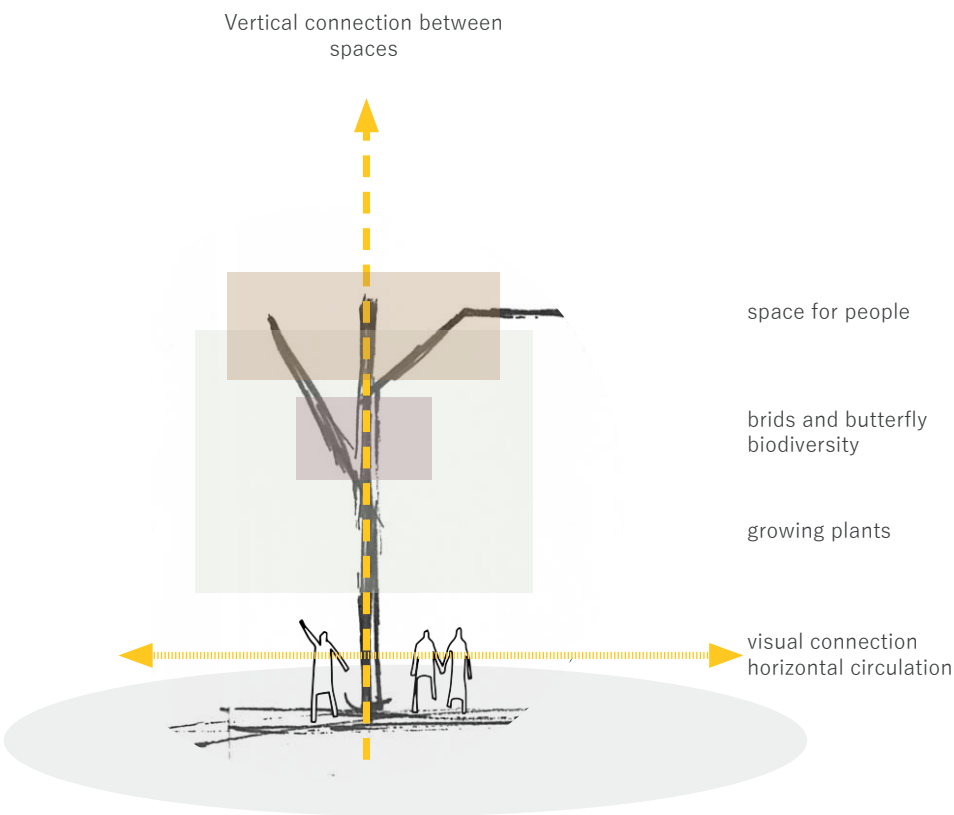
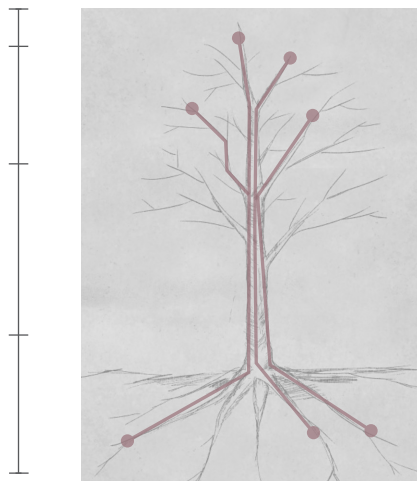
the root of a tree serves as a form of support that keeps the tree standing firm. It also stores nutrients that are used by the tree later.



Fig.14 (Archdaily, 2012)  
Black tree



Fig.15 (Archdaily, 2016)  
Elytra filament pavilion



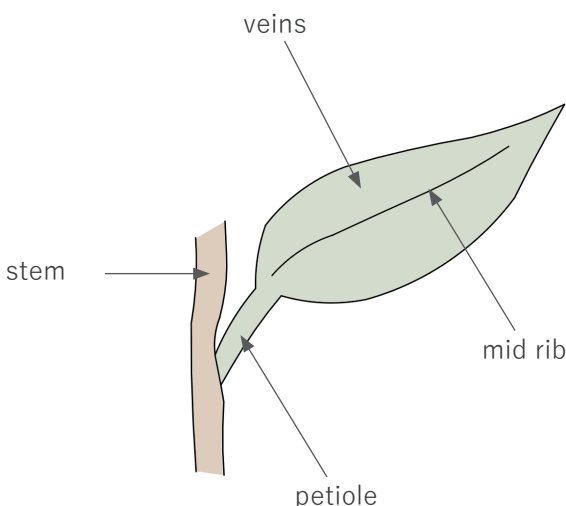
canopy vertical space configuration

The concept allows easily movement at the lower level spaces with more human interaction activities. The mid level is dedicated to plants cultivation, birds and insect and can be percieved as more biodiverse zone. The upper level is dedicate for people. This analogy will give a diverse ways for people to experience the different height levels of urban public spaces.

# Biomimicry

## Leaf Structure

All leaves are made up of basic structures such as mid rib, veins and petiole. The mid rib provides structural strength throughout the leaves and keeps it upright and sturdy. The veins serve as a transport medium and the petiole holds the leaf attached to the stem.



## Venation

Venation is simply the arrangement of veins in leaves and the wings of insects. Venation as a structural and aesthetic concept has been adopted for various canopy designs. Leaves are made up of different pattern arrangements such as parallel, radial and net-like structures and this facilitates the transport of plant nutrients to the different parts of the leaves.



Fig.17 (Quora, 2018)

## Reticulate vein pattern

The smaller network patterns of the reticulate enhance distribution of nutrients to different parts of the leaves.

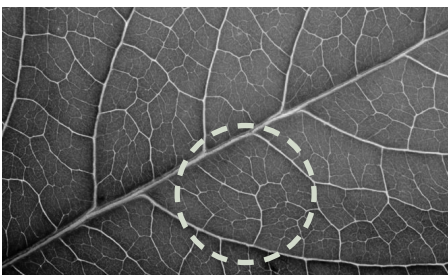
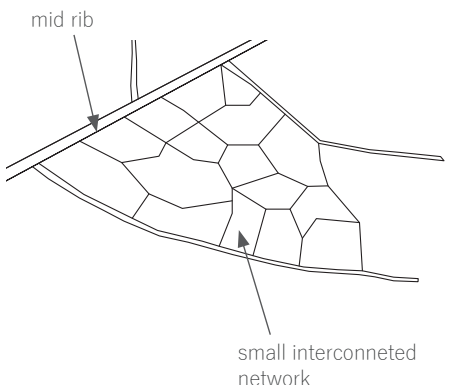
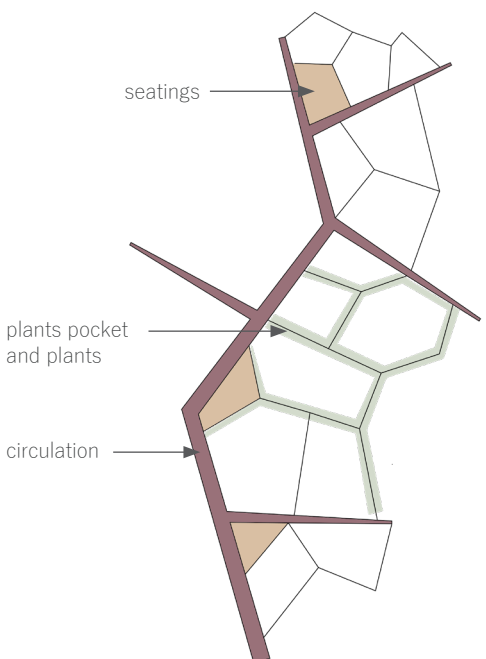


Fig.16 (Inhabitan, 2013). Reticulate vein



## Structure

The leaf plays a structural role through its mid rib pattern and size. The mid rib is thicker in size and depth at its lower parts and reduces as it reaches the tip of the leaf. The same ideology was used for the canopy structure by having different size and depth at different parts.

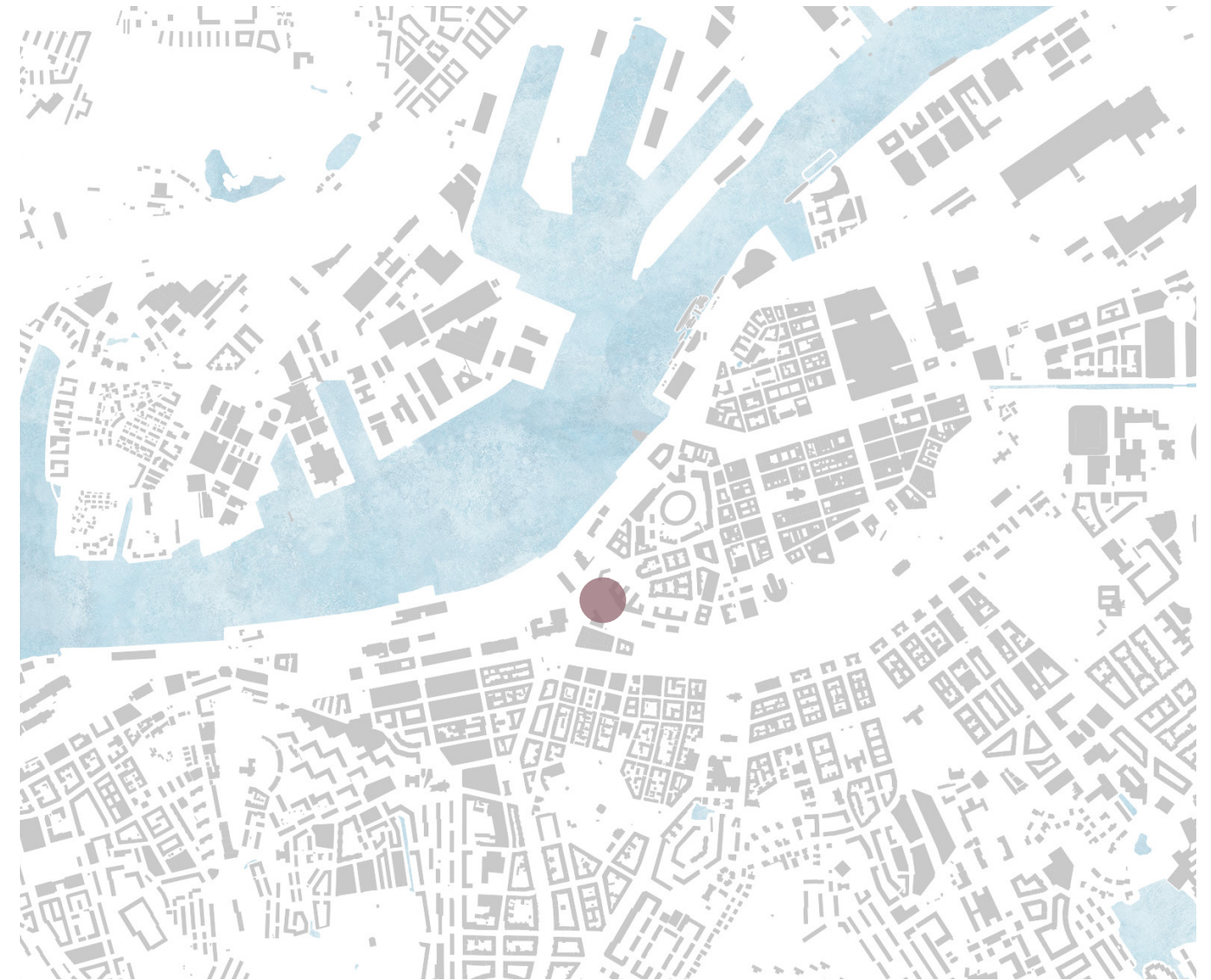


## Circulation

The mid rib also serves as the first point of nutrient circulation and then to the veins. The organic arrangement of the veins enhances the circulation of nutrients. The canopy adopted a circulation flow for both movement of people and plant nutrients.

## Site

The site is located at Eperantplatsen Gothenburg, a populated urban area with various human activities seen everywhere, urban activities such as commercial and industrial activities. The site is also a few distance from the river.



Eperantplatsen, Gothenburg

design proposal

5





site analysis

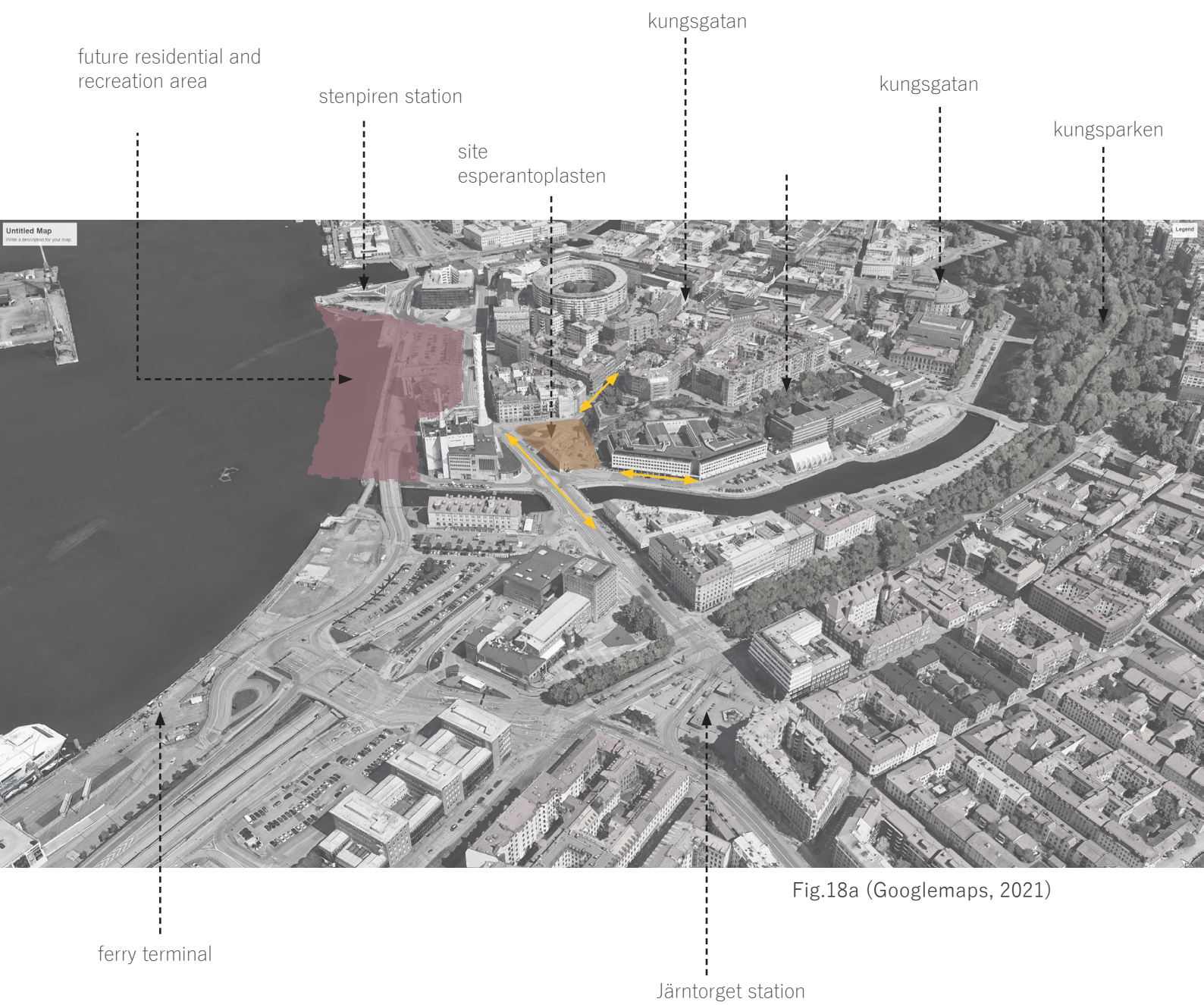
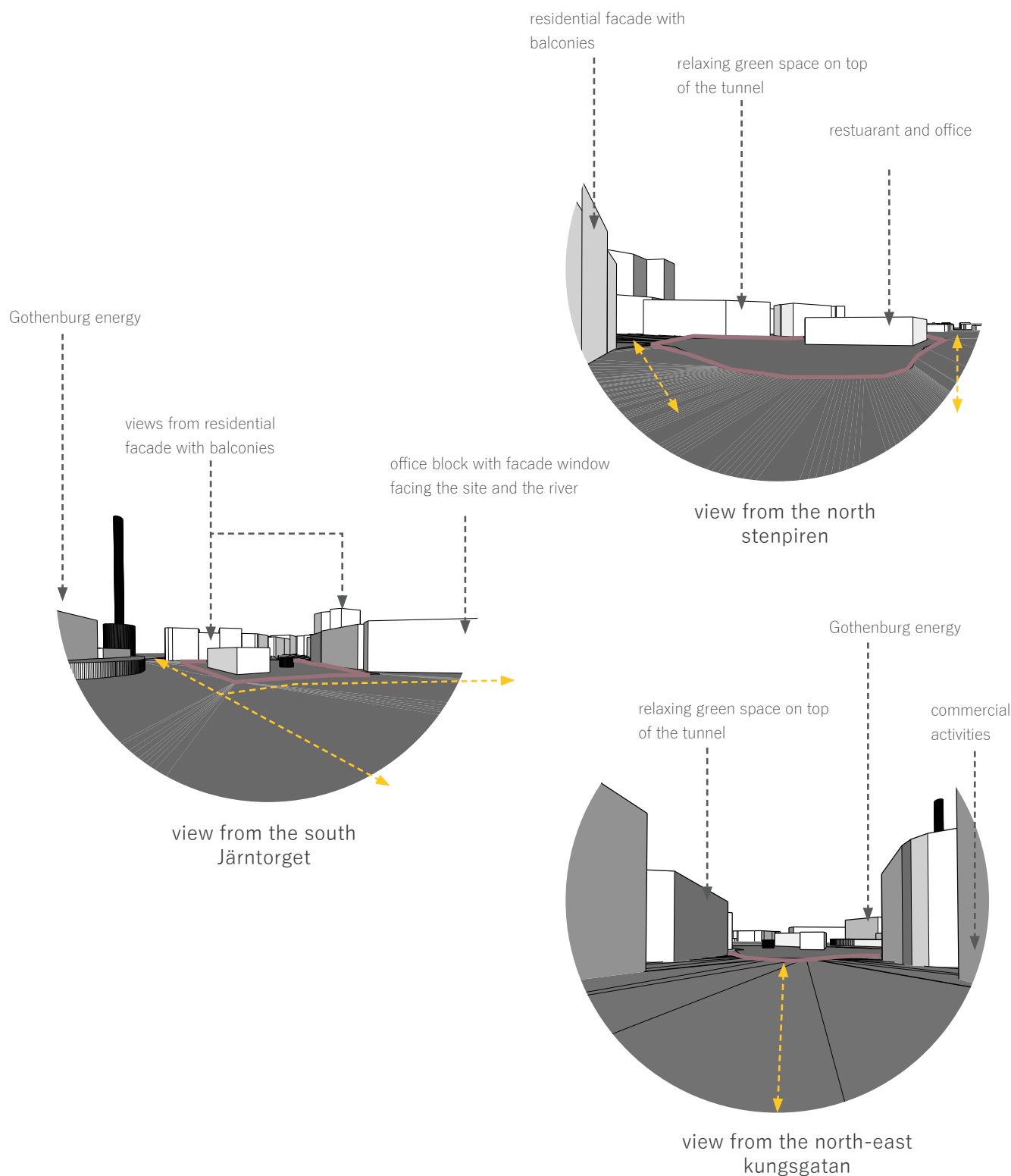


Fig.18a (Googlemaps, 2021)



# site analysis

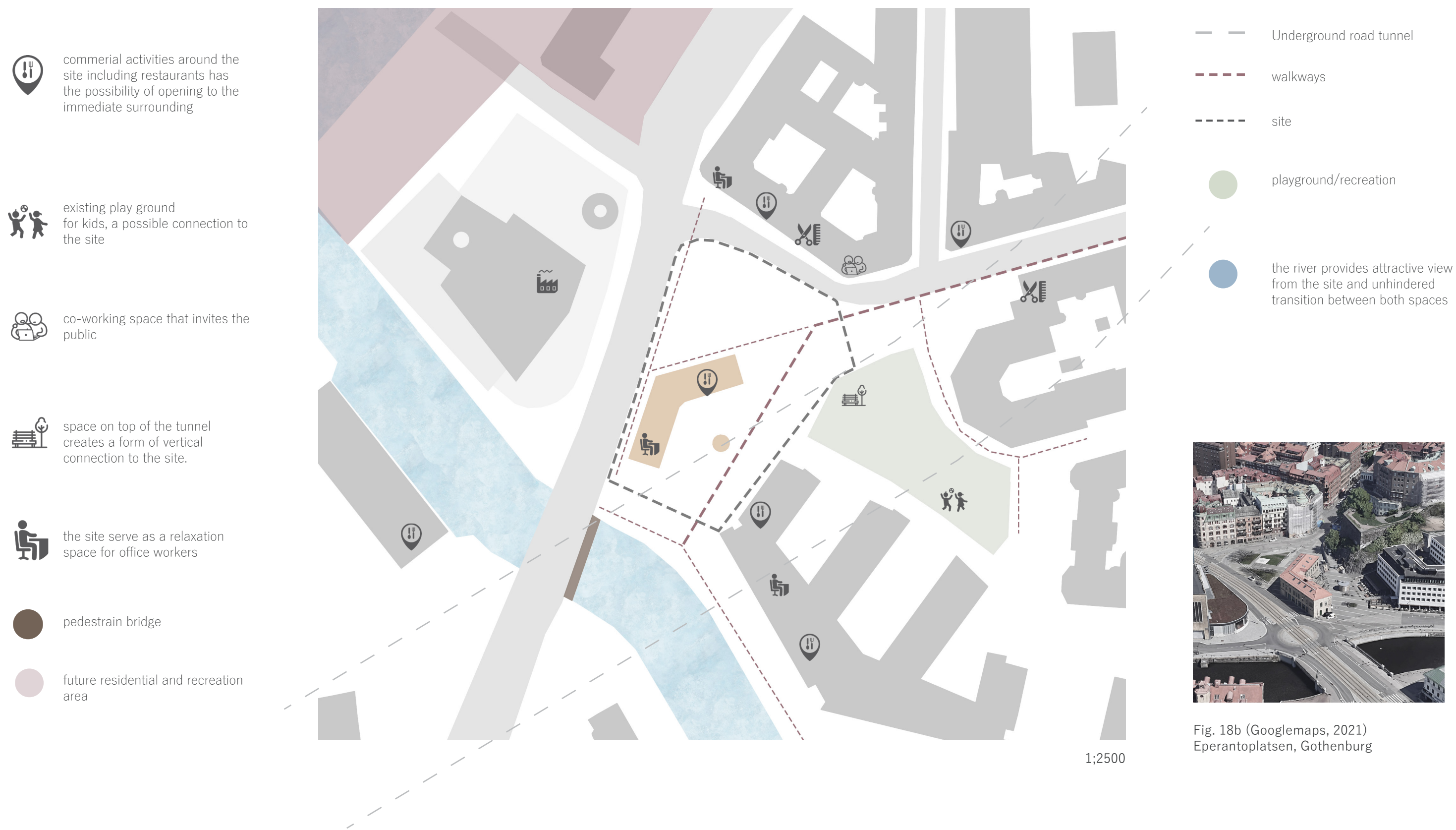
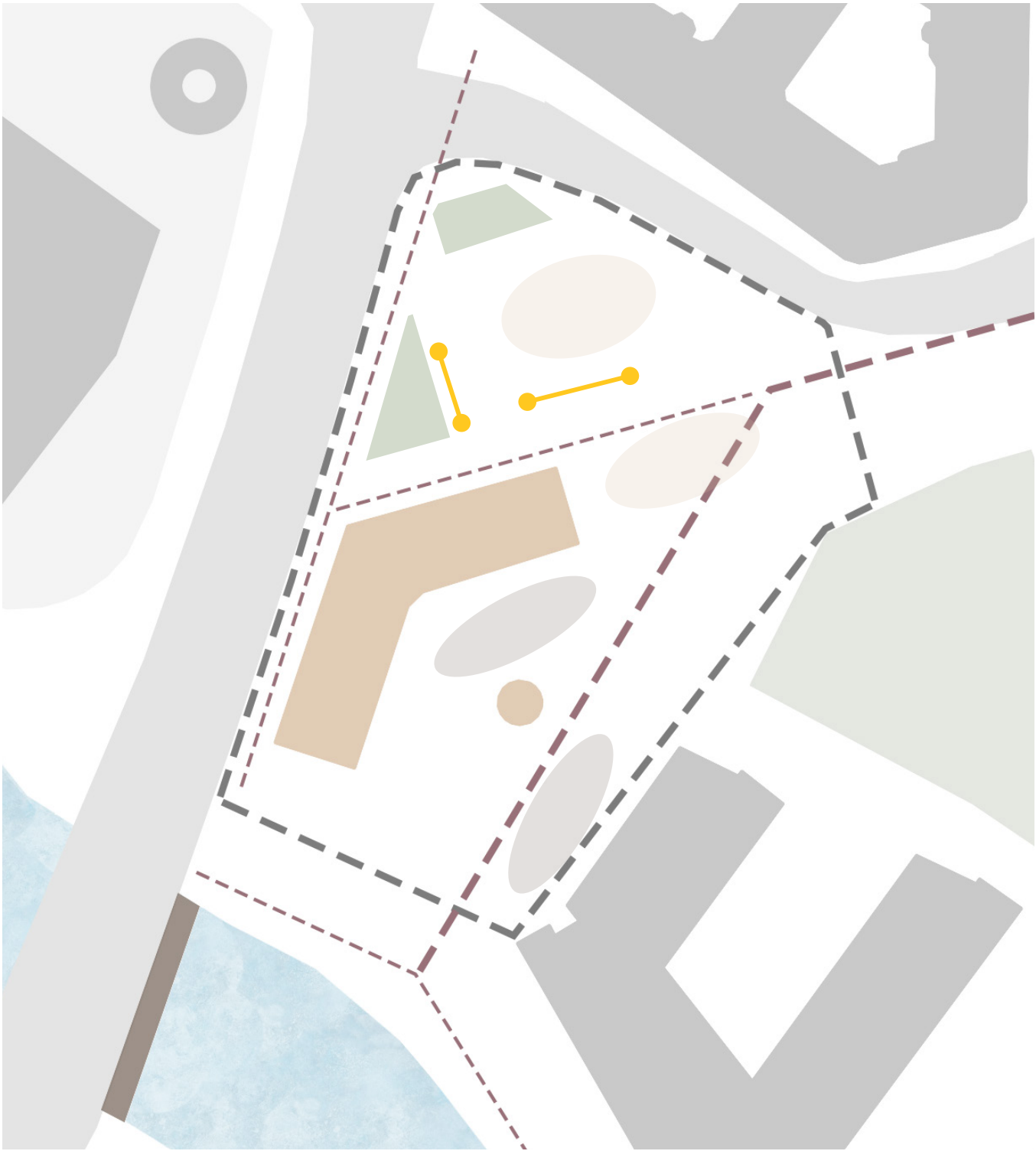


Fig. 18b (Googlemaps, 2021)  
Eperantoplatsten, Gothenburg



site analysis

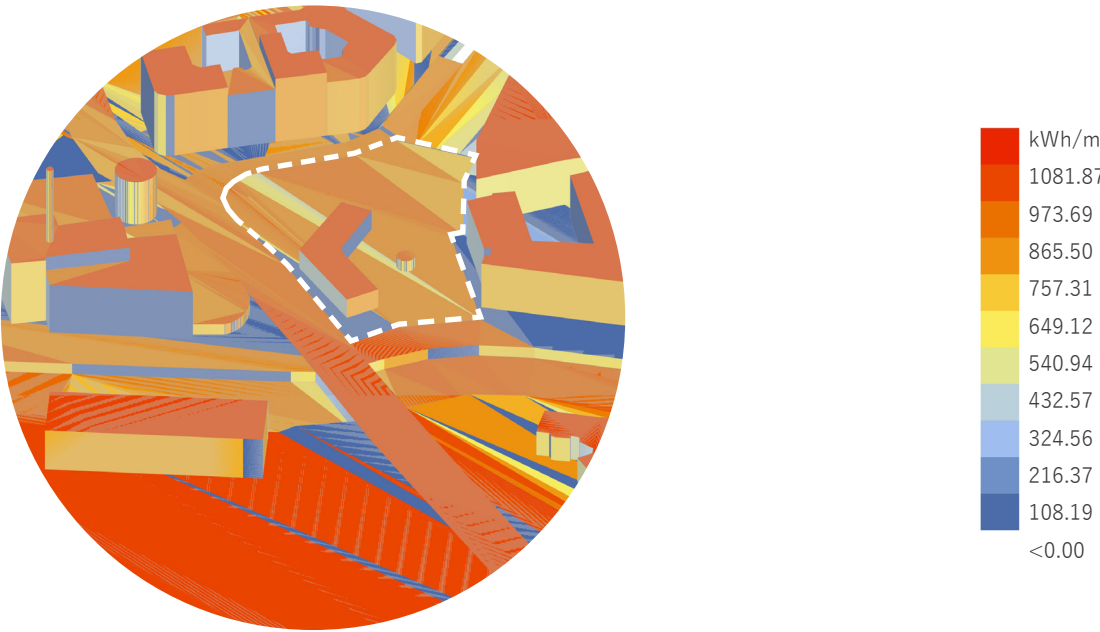


1;1500

- seating space
- green and relaxation space
- open space
- level of path usage
- active zone, outdoor restaurant
- pedestrian bridge

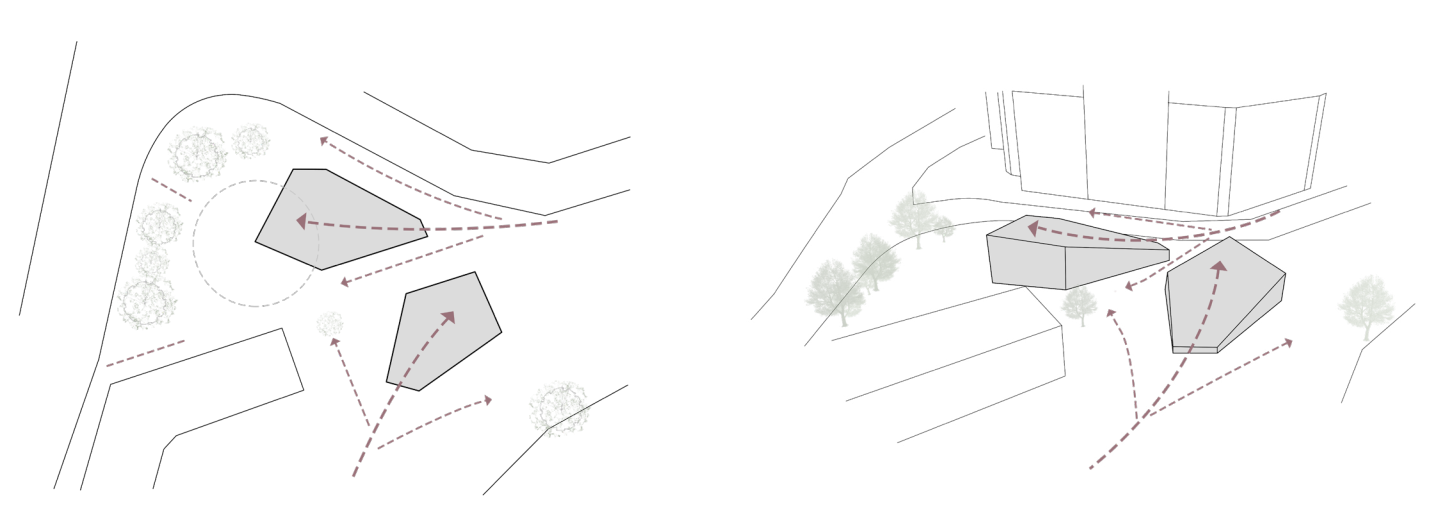
Radiation analysis

The radiation analysis of the site is to aid in the positioning of the structure. It was also implemented in the canopy structure design by testing different variation in the structure shape arrangement to allow enough sun to reach the activities on the ground.



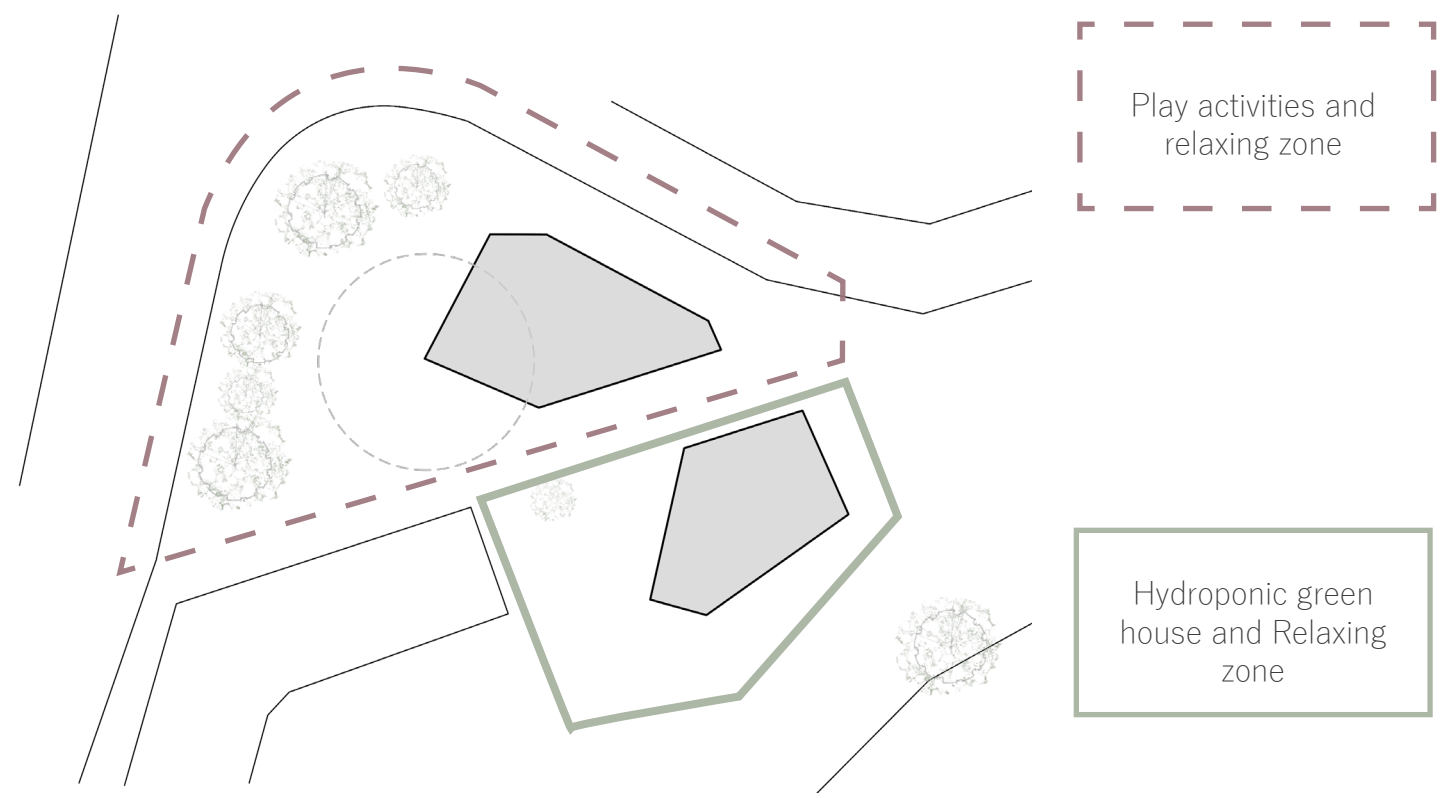
radiation analysis  
Göteborg Landvetter SWE  
1 Jan 1:00 - 31 dec 24:00

Concept development



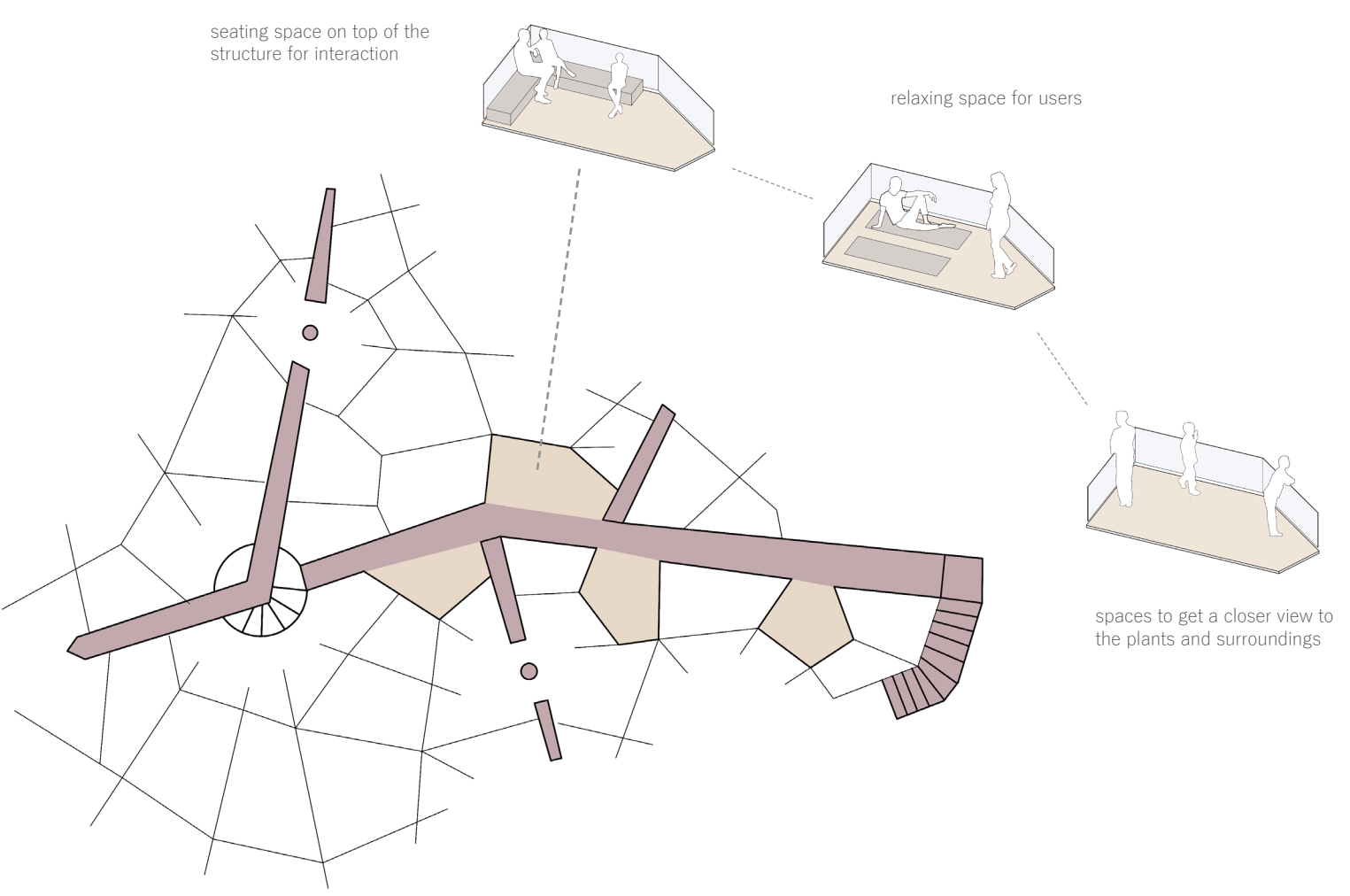
Positioning of structure between and around walking paths enhances its usability

The inclination of the structure to the ground enables users to access the top spaces



Play activities and relaxing zone

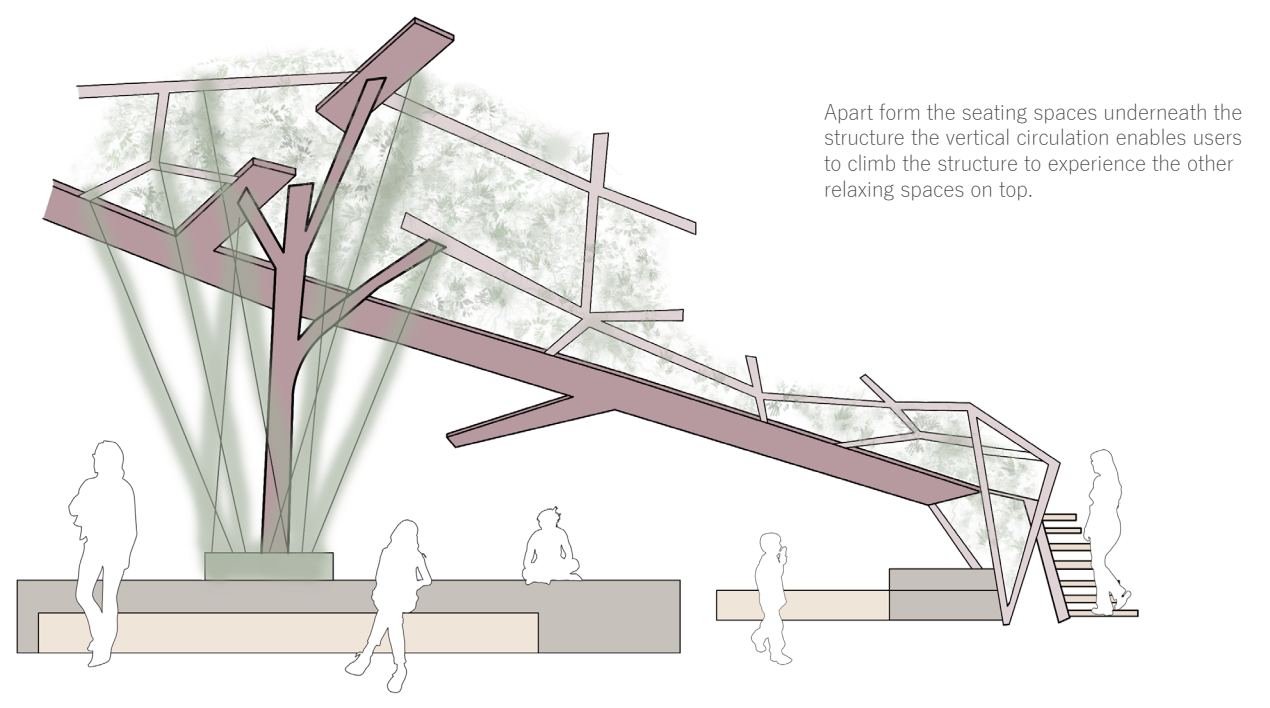
Hydroponic green house and Relaxing zone



seating space on top of the structure for interaction

relaxing space for users

spaces to get a closer view to the plants and surroundings



Apart from the seating spaces underneath the structure the vertical circulation enables users to climb the structure to experience the other relaxing spaces on top.



Site plan



pedestrian walking paths





Collage section

Among commercial activities in the area, there is also the presence of industrial activities such as the Göteborg energy which serves a landmark to the public space.

Hydroponic green house with view from above and around the structure. Additional relaxation spaces are also made available on top of the structure.



The urban context of the location makes it a vibrant urban space with a lot of activities simultaneously taking place. Surrounding outdoor sitting space in front of commercial blocks around the public square makes it a focal point for urbanites in the area and passbyers to effectively use the public space.



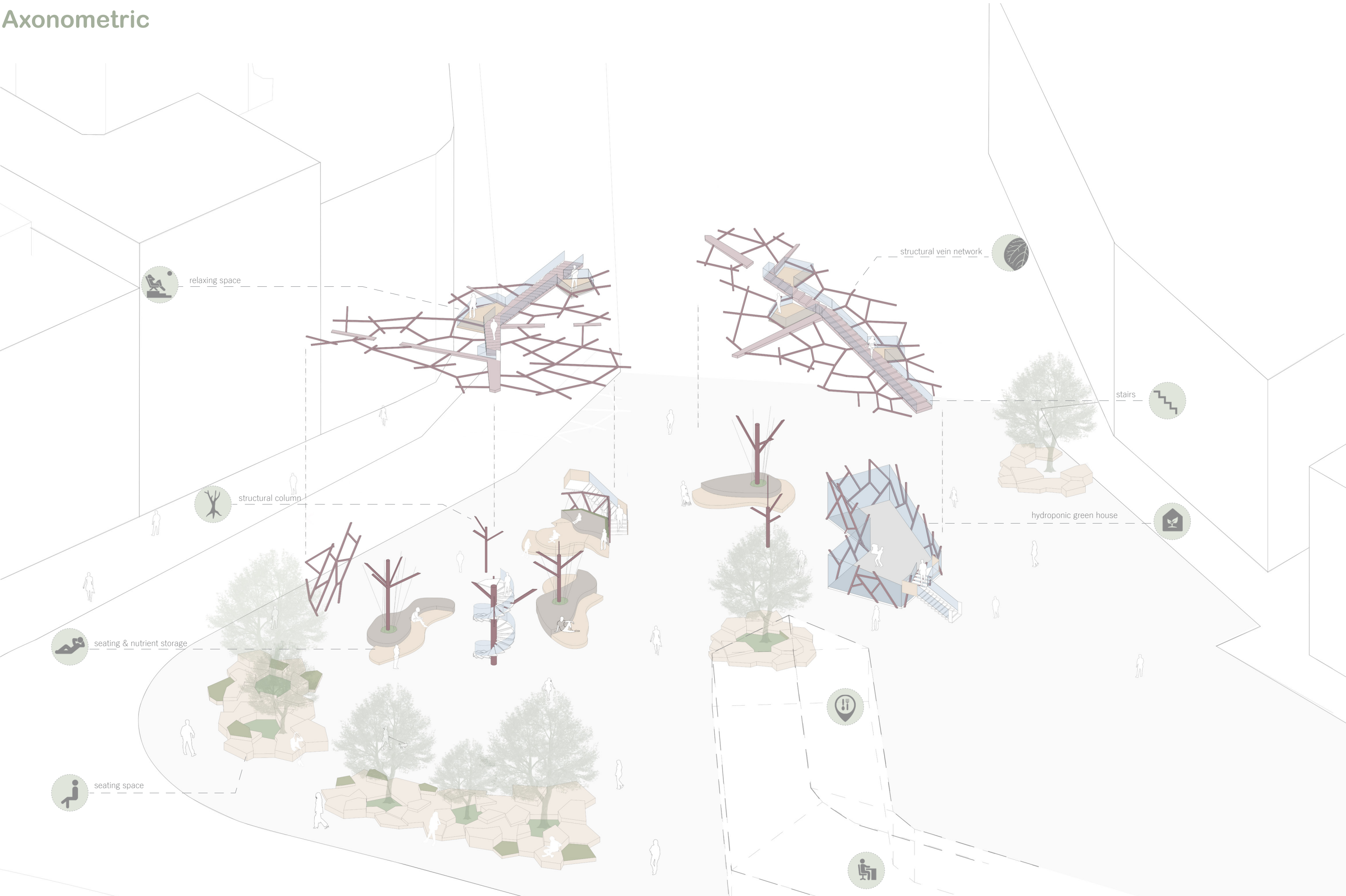
Living canopy structure with greenery integration both on a vertical and horizontal level. Diverse seats to enable users to enjoy the space.

Surrounding residential block with views toward the public space makes it attractive to use the space frequently.

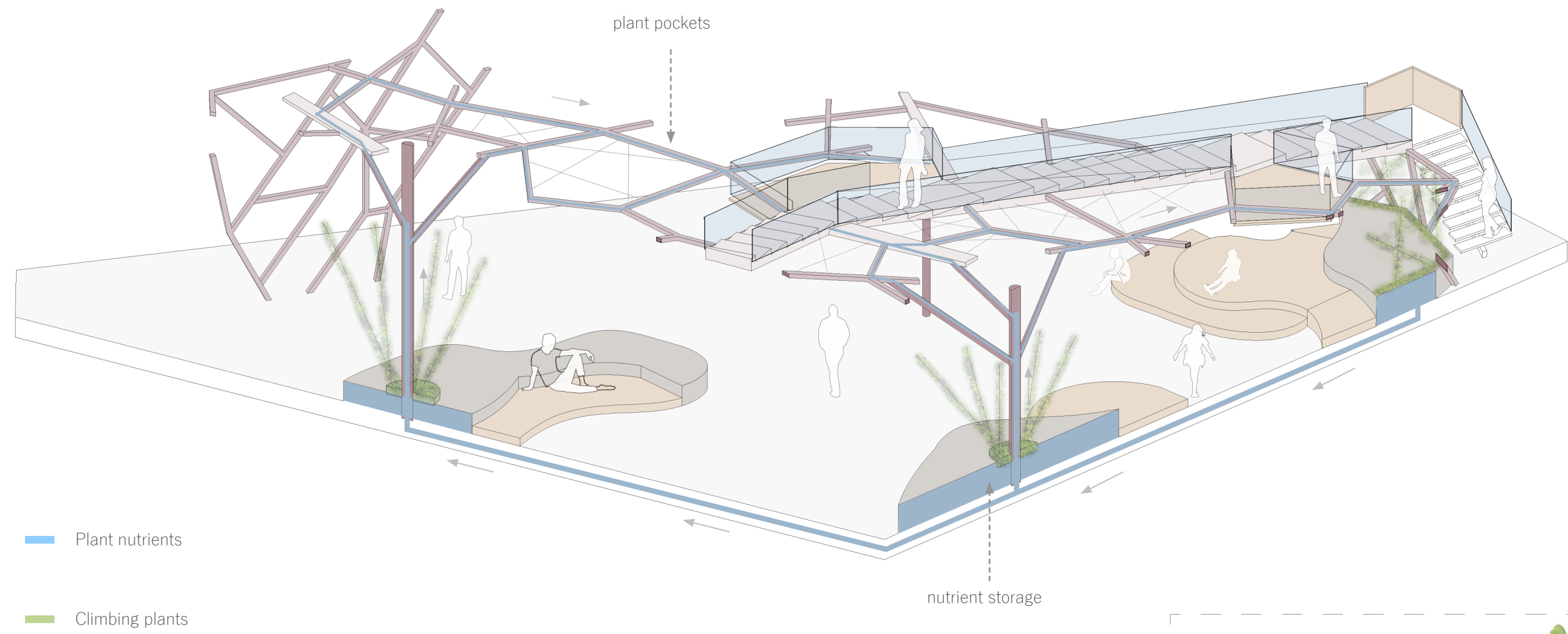




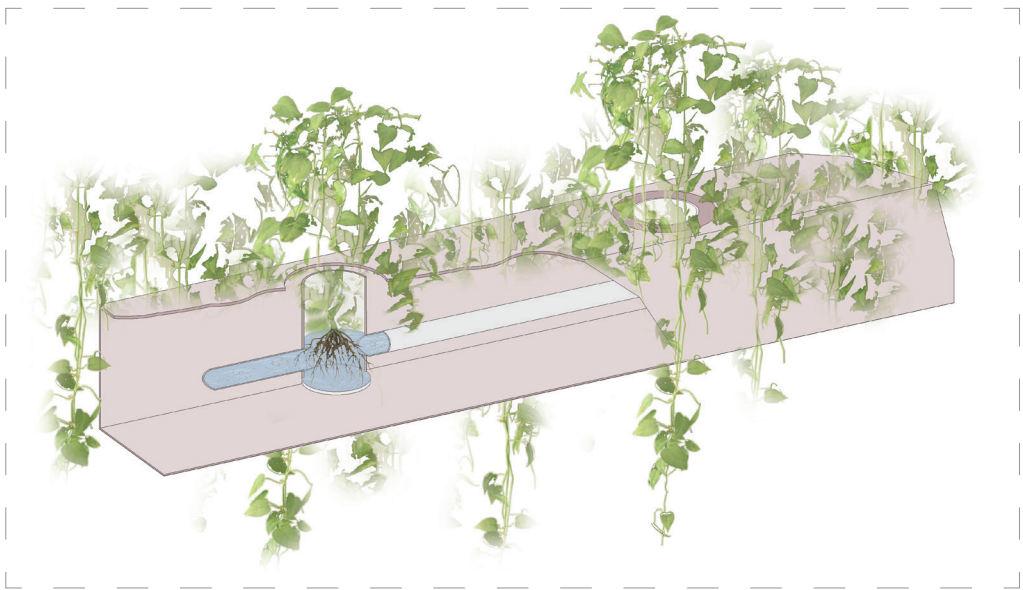
Axonometric



# Hydroponic system



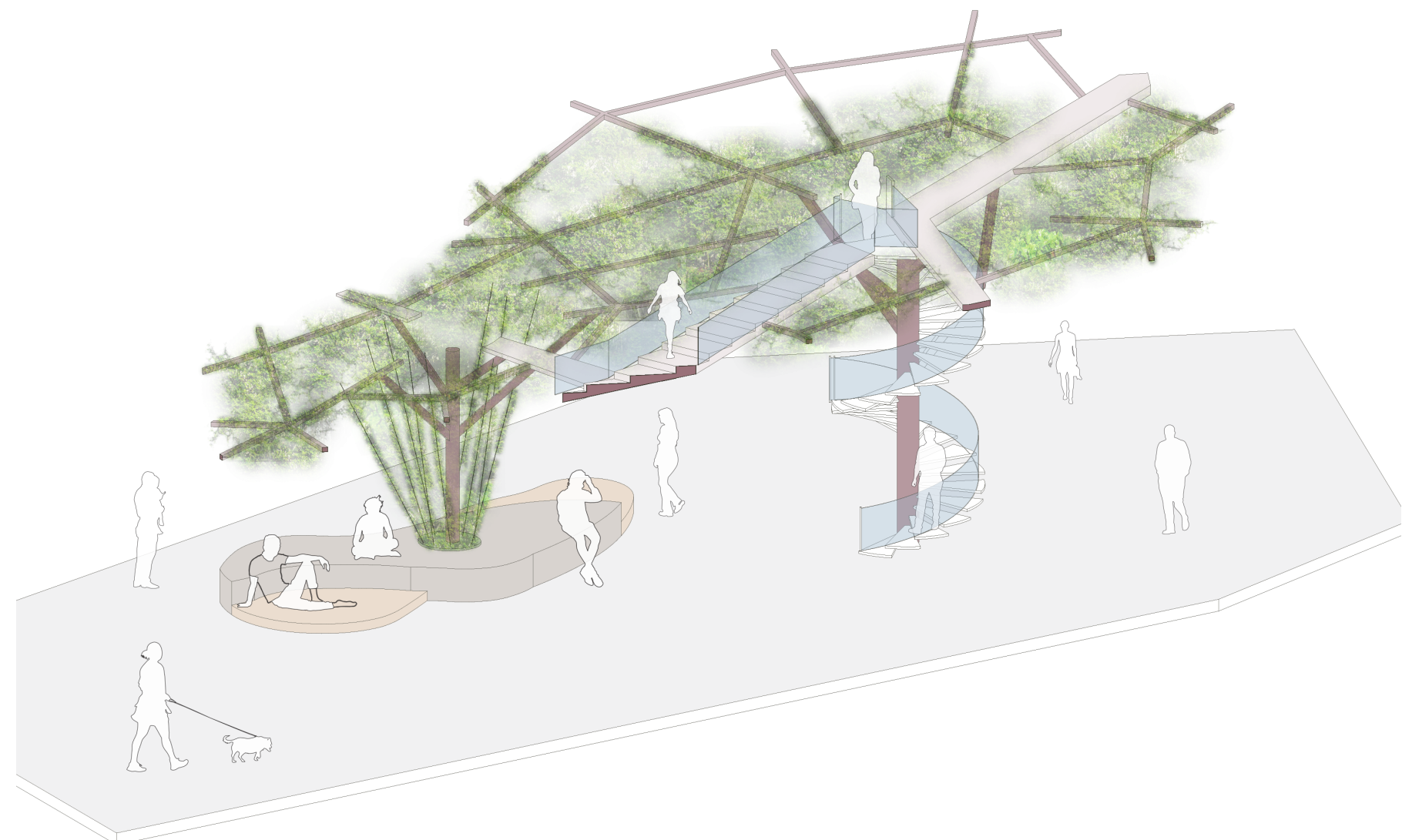
The living canopy structure uses a hydroponic system for its plant cultivation. Seating furniture underneath the structure houses plant nutrients and irrigation water. Nutrients are circulated from the ground level with the aid of pumps through the vertical columns then to the interconnect network above which also houses plant pockets. Plant pockets are located in some area of the structure for effective access to nutrients continuously.



plant pocket with hydroponic system



# A walk through

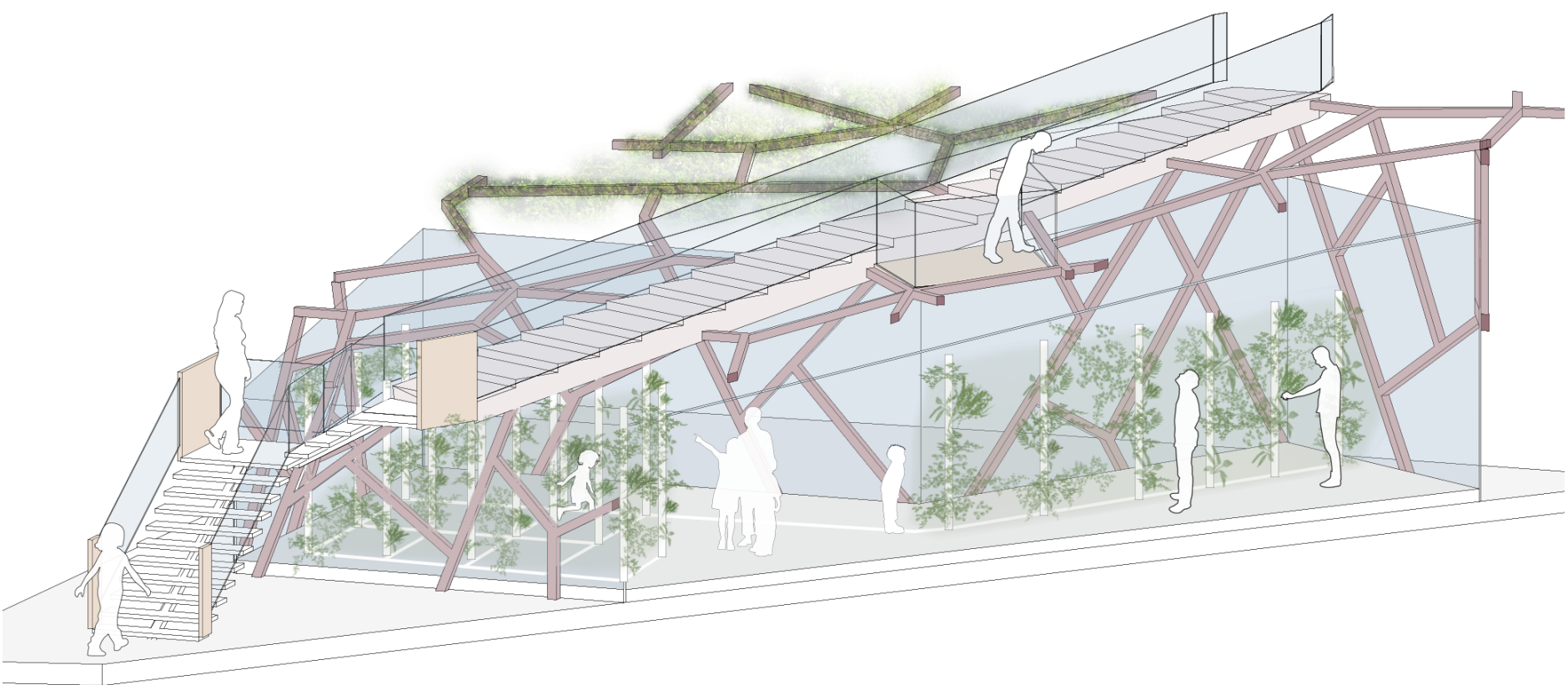


## Green space

The structure provides shelter and green space for its users, the seating form gives more flexibility in the way the space is used. The vertical circulation enables users to get closer to the green space on top of the canopy structure.

## Hydroponic greenhouse

The hydroponic greenhouse is integrated as part of the canopy structure, this is to enable the users to experience the hi-tech cultivation method through observation and to be aware of how effective these systems of plant cultivation can work in small spaces in dense urban areas.













Perspective









## Reflections

Integrating greening in dense urban areas in cities has been the talk and trend of many countries for some years now considering the benefits these space come with. Currently most green spaces can be found in the suburbs around cities because of the availability of land as compared to the dense urban areas in cities. The traditional method of cultivation of greening which is usually done by using soil may not fulfill the potential of dense urban space and this method would not achieve enough green space for urban dwellers to enjoy.

The thesis explored non-traditional way of cultivating and reintroducing greening in dense urban areas in an architectural design perspective. The research emphasized on the use of canopy structure as a means to explore and discuss how such structures can adopt hi-tech cultivating methods such as hydroponic cultivation system to support plant growth and integration. To connect the urban users to the proposed green canopy structure the thesis tried to incorporate relaxation spaces on top, below and around the canopy structure.

Exploring venation and tree analogy concept aided in creating a natural and organic form with a lot of flexibility in terms of plant movements to help growing plants densify in various direction.

The living canopy hydroponic cultivating system is to create awareness for the users and the passbyers of the public space. It also meant to serve as a small exhibition space to educate the public about the use of hi-tech plant cultivation systems in public urban space.

The hydroponic system adoption was to try and show its advantages in dense urban areas as an efficient means to reintroduce greening in small urban public space as compared to the traditional way. This approach can be adopted in similar dense urban public spaces. According to the research, the flexibility of the hi-tech cultivation method makes it possible to apply it to different existing structures on site.



It has been a great experience throughout the thesis journey in the quest of exploring an innovative way of introducing greening into urban public space. My interest in green space and nature can be seen in many of my studio design works.

As an architect I believe that more can be done in introducing green spaces in dense urban areas, in terms of public spatial usage and green densification in small urban spaces. I intend on continuing my exploration in my future design projects as green spaces are perceived as the lungs of the built environment.



# References

Allik, M. (2014). Exploring Urban Habitats- The Case of Frihamnen. Gothenburg: Chalmers University of Techonology.

Ekkela, E. D., & Vriesb, S. d. (2017). Nearby green space and human health: Evaluating accessibility. Elsevier, 214-217.

Geilfus, C.-M. (2019). Controlled Enivornment Horticulture. Germany: Springer Nature.

Greulach, V. A. (1955). Plant Movements. In V. A. Greulach, Plant Movements (pp. Vol. 192, 100-107). Minneapolis: Scientific American, a division of Nature America, Inc.

Institute of Landscape Development, R. a. (2012). Urban Densification and Recreational Quality of Public Urban. MDPI Sustainability, 703-704.

Kemperman, A., & Timmermans, H. (2014). Green spaces in the direct living environment and social contacts of the aging population. Elsevier, 45-46.

Malisia W, Allison K (2013) Onward & upward: filling the hunger gaps with vertical farming. Hort 408 Literature Review. Clemson University, p 50. Available from [http://www.clemson.edu/cafls/vincent/articles/lit\\_review.pdf](http://www.clemson.edu/cafls/vincent/articles/lit_review.pdf)

Nandwani, D. (2018). Urban Horticulture. Nashville: Springer International Publishing AG, part of Springer Nature.

Public Health England. (2020). Improving Access to Green Space. London: PHE Publication.

Statistics Sweden, SCB. (2015). Green Space and Green Areas in Urban Areas 2015. Stockholm: Department for Regions and Environment.

Trewavas, A. (2009). Plant, Cell and Environment. Edinburgh: Blackwell Publishing Ltd.

United Nation, (2018) Report from the UN's Department of Economic and Social Affairs. Retrieved from <https://www.un.org/development/desa/en/news/population/2018-revision-of-worldurbanization-prospects.html>

Zhou, X. (2011). Social Benefits of Urban Green Space. Emerald Group Publishing Limited, 174-176.

# Figures

Arboristnow (2016). Urban Forestry. [Online Image]. Retrieved from <https://www.arboristnow.com/news/always-hang-birdhouses-in-tree-friendly-ways>

Archdaily (2012). Black Tree, Public Solar Charger . [Online Image]. Retrieved from [https://www.archdaily.com/297306/black-tree-public-solar-charger-milos-milivojevic?ad\\_medium=gallery](https://www.archdaily.com/297306/black-tree-public-solar-charger-milos-milivojevic?ad_medium=gallery)

Archdaily (2016). Elytra Filament Pavilion Explores Biomimicry . [Online Image]. Retrieved from <https://www.archdaily.com/787943/elytra-filament-pavilion-explores-biomimicry-in-london>

Archdaily (2014). Green Wall Living Canopy . [Online Image]. Retrieved from [hhttps://www.archdaily.com/541903/move-over-green-walls-living-canopy-comes-to-west-vancouver/53ff391ec07a802fab000058-move-over-green-walls-living-canopy-comes-to-west-vancouver-image](https://www.archdaily.com/541903/move-over-green-walls-living-canopy-comes-to-west-vancouver/53ff391ec07a802fab000058-move-over-green-walls-living-canopy-comes-to-west-vancouver-image)

Butong (2016). Bjorns-Vertical-Garden. [Online Image]. Retrieved from <https://butong.eu/project/bjorns-vertical-garden/>

ClipArtETC (2021). Climbing Plants. [Online Image]. Retrieved from [https://etc.usf.edu/clipart/87700/87700/87700\\_climbing-plants.htm](https://etc.usf.edu/clipart/87700/87700/87700_climbing-plants.htm)

Ebertsgreenhouse (2021). Hedera helix English Ivy. [Online Image]. Retrieved from <https://www.ebertsgreenhouse.com/Plant-Name/Hedera-helix-English-Ivy>

Elizabethminchilli (2016). Eating My Way Through Italy. [Online Image]. Retrieved from <https://www.elizabethminchilli.com/2016/05/where-to-eat-in-monti-rome-2016/>

Googlemaps (2021). Google maps Gothenburg . [Online Image]. Retrieved from <https://www.google.com/maps/place/Gothenburg/@57.702619,11.9553657,74m/data>

Inhabitan (2013). Self-Healing Solar Cells Mimic Plant Leaves. [Online Image]. Retrieved from <https://inhabitat.com/self-healing-solar-cells-mimic-plant-leaves-to-repair-themselves/>

LiveWall (2018). Appleton-International-Airport. [Online Image]. Retrieved from <https://livewall.com/portfolio-items/appleton-international-airport/>

RSPB (2020). Giving Nature a Home . [Online Image]. Retrieved from <https://www.rspb.org.uk/birds-and-wildlife/wildlife-guides/bird-a-z/black-redstart/>

Specialtyproduce (2017). Leafy Vegetables. [Online Image]. Retrieved from [https://specialtyproduce.com/produce/Kale\\_7631.php](https://specialtyproduce.com/produce/Kale_7631.php)

The Conversation (2012). Biodiversity Sensitive Urban Design Approach. [Online Image]. Retrieved from <https://theconversation.com/heres-how-to-design-cities-where-people-and-nature-can-both-flourish-102849>

UrbanNext (2002). MFO Park: The North Zurich Parkscape . [Online Image]. Retrieved from <https://urbannext.net/mfo-park/>

UrbanNext (2005). Orchideorama . [Online Image]. Retrieved from <https://urbannext.net/orchideorama/>

Quora (2018). Venation . [Online Image]. Retrieved from <https://www.quora.com/What-is-venation-of-a-leaf>