DENSIFY & GREENIFY:
Sustainable Urban Infill in Thessaloniki, Greece

Amalia Athanasia Dimou

Chalmers School of Architecture
Department of Architecture & Civil Engineering
2024

Examiner: Liane Thuvander
Supervisor: Walter Unterrainer

"Nature holds the key to our aesthetic, intellectual, cognitive and even spiritual satisfaction"

- E. O. Wilson

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MPDSD
MSc. Architecture and planning beyond sustainability

Abstract

This thesis aims to explore two conflicting sustainable urban development strategies, urban densification and the creation of urban green spaces. The driving forces of both strategies often have them competing for the scarcely found available spaces within the urban context, and one is often neglected in favour of the other.

Looking for ways to bridge the gap between the two, I am utilizing biophilic and biomimetic design approaches to compromise between the two, with a goal of achieving the best possible results for both strategies through one design.

The conflict between urban densification and urban green spaces can be relevant in any context. For the thesis's purpose, a site was selected for the creation of a pilot project, which would showcase ways of combining densification and green spaces.

The plot is located in Thessaloniki, Greece, my hometown, a city already densely built. It is an urban gap, currently operating as a parking lot.

The plot is utilized for the creation of an infill building, which would take advantage of an underused space within the urban fabric.

The final design bridges the gap between urban densification and urban green spaces, by using biophilic and biomimetic strategies into one final infill building and brings new qualities into the area.

Through the design of this pilot project and the successful integration of densification and green spaces in one building, it is obvious that these conflicting strategies can be combined with high effectivity and add new qualities to urban spaces, without compromising on either end.

Keywords

Biomimicry, Biophilia, Context-aware design, Densification of cities, Greenification

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About me

"Completing a master's thesis is no easy task, but I couldn't be more grateful for the experience and happier with the result. Several people contributed and supported me throughout this process.

First and foremost, I would like to express my sincere gratitude to my supervisor, Walter Unterrainer, and my examiner, Liane Thuvande. Thank you for your guidance and feedback throughout this journey.

A big thank you to all the people from the MPDSD - Building Design and Transformation for Sustainability profile. We embarked on this journey together through our prep courses and made it all the way to the end.

An even bigger thank you goes to my friends, whom I met during the welcome day at Chalmers University of Technology almost two years ago. Now, as we close this chapter together, your friendship and support have been invaluable.

Finally, the biggest thank you is reserved for my family, for their unwavering love, patience, and support. To my parents, Eleftheria and Kosta, who have always encouraged me to follow my dreams, and to my sister, Martha, who, despite our occasional fights, is always there for me.

Thank you all for making this journey with me

Amalia"

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Thesis Framework

Starting point

The initial concept of my master's thesis was inspired by the idea of reconnecting people with nature, regenerating urban green spaces, and reviving places that are currently abandoned or misused.

With the increase in human population, human habitat is expanding into the already greatly threatened natural environment. For that reason, different strategies for sustainable urban development have been developed, often contradicting one another.

Problem statement

As urban populations expand and human activity takes over already threatened natural environments, the need for sustainable urban development becomes increasingly urgent. However, the pursuit of this goal is complicated by conflicting strategies. While cities are essential hubs for human well-being and economic activity, their rapid growth exacerbates issues of waste generation and environmental degradation, necessitating a shift towards more sustainable models of urban living.

In this context, the city of Thessaloniki, Greece, serves as a pertinent case study, given its growing population density and limited green spaces.

"I investigate two contradicting strategies, urban densification and the increase of urban green spaces, and I aim to bridge the gap between the two with the use of biophilic and biomimetic strategies."

Thesis questions

How can the conflicting strategies of urban densification and the creation of urban green spaces be effectively managed through the design of infill buildings in central Thessaloniki, Greece?

How can biophilic and biomimetic design be utilized to bridge the gap between densification and urban green spaces and enhance urban liveability with a densely populated area?

Aim

This research aims to explore the effective integration of urban densification and the creation of urban green spaces through the implementation of infill buildings in central Thessaloniki. By incorporating elements of biophilic and biomimetic design, the study seeks to enhance urban liveability within densely populated areas, addressing both the need for additional infrastructure and the imperative for environmental sustainability.

Motivation

The cities will continue to grow in numbers and in density. With an already limited number of green spaces in Greece and more new constructions and additions in buildings coming soon, this situation is an excellent opportunity to investigate how new constructions and green spaces can be effectively combined to solve two major issues at once. New spaces to host needed activities and green spaces that will help improve the microclimate of the area and make the heat more bearable. Working in my hometown, I am already familiar with the city, its needs, and its problems.

Cities contribute to the creation of wealth and human well-being. Despite their many disadvantages and problems, cities are not a concept that can be eradicated, they will continue to provide housing, give job opportunities, and offer services crucial to our survival.

The consumeristic character of human society has turned cities into places of waste. The excessive consumption of materials, and other resources, creates more waste than the natural environment can process, before reaching its maximum capacity. The effectiveness of cities and their role in the survival of the human species is a complex notion and it depends on their ability to change and adapt into a more sustainable model (Simon, 2016).

An indicator of the increasing importance of urban issues is their recognition by the international agenda. Several of Sustainable Development goals adopted by the United Nations General Assembly in 2015 refer to sustainable cities, the protection of the environment and the affinity between humans and nature (United Nations). The Sustainable Development Goals can be achieved by implementing different strategies towards a more sustainable urban future.

Method

My process evolves around research for design and research on design. I review literature and architectural references to develop my theories and understand how other designers implemented them.

Later the process turns to research through design. After building the theory and the background, I test possible designs and evaluate them.

Literature reviews:
The literature review is used to gather information by reading and analysing existing research. I use this method to gain a broad understanding of the topic, and to identify important findings from existing research to later implement them in my master thesis.

Inspirational cases:
Examination of specific projects. I gather information about the design, construction, and performance of buildings.

Biomimetic & Biophilic references:
Examples from nature, that I studied and tried to imitate in the design.

Biotope area factor:
A tool used to evaluate the contribution of my proposal to the biotope of the area.

Different site locations:
I investigate different possible plots. Their strengths and weaknesses before deciding on a final location.

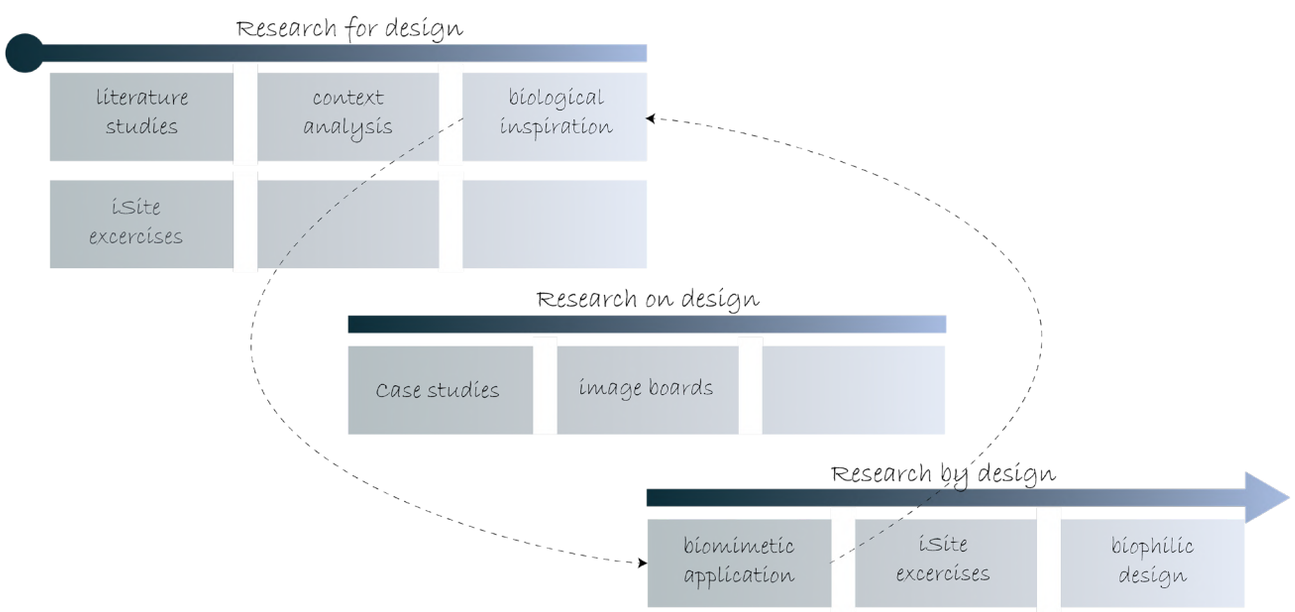
ISite exercises:
Reconnecting people with nature is one of the goals I want to address in my master's Thesis. To build that connection with nature is to be in nature. ISite is a series of exercises that will help me develop the skills I need to better implement biomimicry in my designs.

Site visit:
Observing and collecting data in the field.

Modelling:
Virtual and analogue models of the buildings. These models are made to evaluate the performance of different design options and predict the building's qualities and issues.

Proposal:
A final design proposal is developed.

SDG impact assessment tool:
SDG impact assessment tool can help get a better understanding of a project, of its strengths and weaknesses. I use the tool to evaluate the effect of my proposal according to the 17 SDGs. I have two rounds of evaluations, one at the beginning and one at the end of the design process.



Pic.1: Methods

Scope & Delimitations

It is about:

- -Densify the city
- -Infill building
- -Transformation of an area
- -Transformation of a building block
- -Biophilia-Reconnect people with nature
- -Bring nature into the city
- -Biomimicry to solve problems (e.g., sunlight, shading, overheating, etc.)
- -Sustainable cities and communities
- -Life on land

It will touch:

- -Microclimate of an area
- -Effective spaces
- -Materiality

It is not about:

- -Cost-effective construction
- -Transformation of an existing building

Theory

Glossary

Biomimicry:
The conscious emulation of life's genius. Learning from and then emulating biological forms, processes, and ecosystems to create more sustainable designs (The Biomimicry Institute, n.d.).

Biomorphic:
Biomorphic describes anything resembling or suggesting the forms of living organisms (The Biomimicry Institute, n.d.).

Biophilic / Biophilia:
Biophilia is a term popularized by E.O. Wilson to describe the extent to which humans need connection with nature and other forms of life. Biophilic design emphasizes using natural materials, forms, living things, air, sun, and water in a design (The Biomimicry Institute, n.d.).

Chimera:
In Greek mythology, the Chimera was a creature composed of body parts from many other creatures. In biomimicry, we talk of a Chimera approach as a combination of different biomimetic designs into one application (The Biomimicry Institute, n.d.).

Densification:
is a process by which the existing built environment is intentionally redeveloped or transformed to achieve a higher density in terms of population, land use or both (Verheij, Ay, Gerber, & Nahrath, 2023).

Urban green spaces:
is defined as any vegetated land adjoining an urban area and includes bushland, nature reserves, national parks, outdoor sports fields, school playgrounds and rural or semi-rural areas immediately adjoining an urban area." (Chong et al., 2013)

Urban development

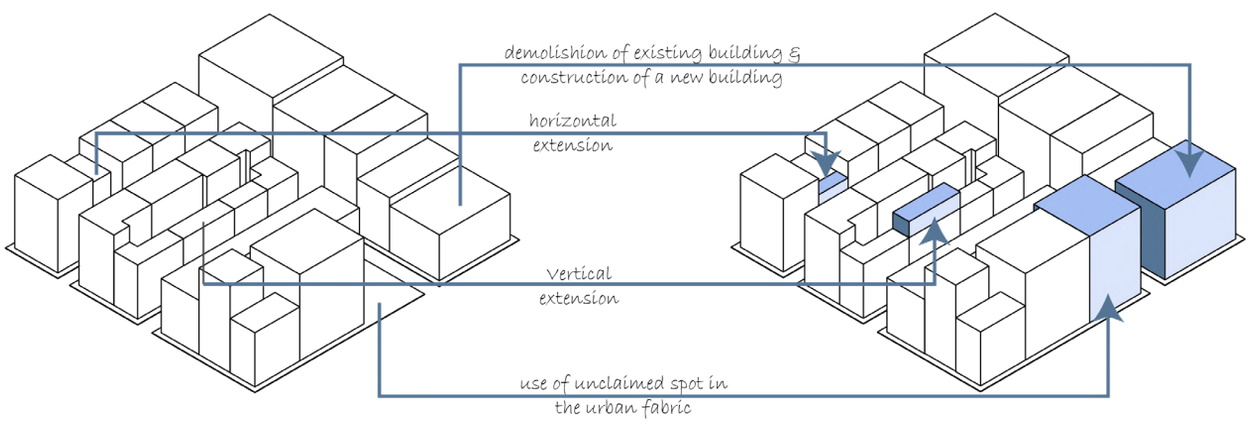
Cities are expanding by taking over natural land, in an unsustainable manner. The results include loss of agricultural land, destruction of ecosystems and biodiversity, fewer open spaces, increase in private car use, traffic problems, and pollution. Since the idea of sustainability was introduced, different strategies for sustainable urban development have been produced (Pelczynski & Tomkowicz, 2019).

Densification

Densifying the city is considered one of the major sustainable development strategies suggested on an urban scale. It is a way to achieve more efficient management of natural resources through the increase in the use of available spaces included in the urban fabric.

Urban densification can be achieved through the transformation and reuse of existing buildings, the extension of existing buildings, or new construction either by demolishing existing buildings or by using unclaimed spots within the urban fabric (Pelczynski & Tomkowicz, 2019). Yet, the process of urban densification is not happening in a uniformed matter resulting in different patterns within the city (Schorcht, Mathias & Krüger, 2023).

The strategy of urban densification has as a result the increase in value of properties already existing within the city limits, the activation of new funding resources, and the economic stimulation of the densified area. Additionally, it can decrease traffic problems, enrich urban diversity, and increase social resilience. But it also comes with a risk of decreasing the quality of life, an increase of the ecological footprint of the area, and, potentially, social disputes (Pelczynski & Tomkowicz, 2019).



Pic.2: Densification diagram

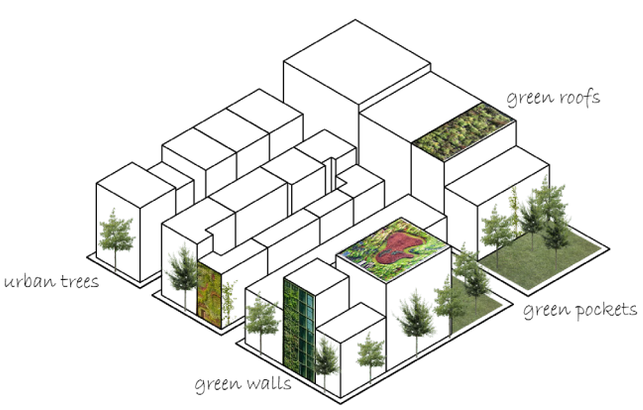
Greenification

Another fundamental element towards a more sustainable urban form is the preservation and creation of urban vegetation or green space. Urban green spaces can provide the urban fabric with the services and benefits of an ecosystem, enhancing urban liveability and resilience (Tan & Jim, 2017).

The idea to enhance urban sustainability through urban greening can be traced back to the 1980s, with a variety of meanings and associations attached to it. The creation of urban green spaces is strongly connected to climate change, and that connection is responsible for the popularity urban greening has gained in recent years (Simon, 2016).

Urban green spaces are an integral part of the design and function of any city, but their value should not be determined just by the presence of green features in the urban fabric. Often, poor design decisions and implementation techniques have as a result human mismanagement and a bigger ecological and urban footprint, than the benefits provided by it.

Urban vegetation can affect the quality of life in the cities. The presence of green elements in the city can help regulate the temperature and avoid its increase in extremely uncomfortable levels. The results can be found on different scales of green implementations (Tan & Jim, 2017).



Pic.3: Urban green spaces

Densification vs. Urban Green Spaces

The relationship between urban densification and urban green spaces presents a paradox. While the development of dense, yet liveable, urban environments relies on providing sufficient public and green areas, the densification of cities usually has the opposite results. Densification usually results in the reduction of available public green spaces and the overuse or congestion of existing ones. Consequently, securing enough urban green spaces becomes a critical aspect in realizing urban densification that genuinely contributes to the creation of more sustainable cities (Verheij, Ay, Gerber, & Nahrath, 2023).

While the end goal for both strategies is the same, the sustainable development of the cities and urban spaces, urban densification, and urban green spaces are two strategies that usually contradict each other.

Urban densification aims to take advantage of every possibility to increase the density of buildings, uses, and population, while the increase of urban green spaces aims, in some ways, to decrease density and to introduce more natural elements within the urban fabric.

> *The principal ideas of both strategies often have them competing for the scarcely found available land within the urban fabric (Tan & Jim, 2017).*

Urban densification often results in the loss of green spaces, which leads to conflicting sustainability strategies (Schorcht, Mathias & Krüger, 2023).

> *Yet, for the successful densification of the cities, the integration of urban green spaces is non-negotiable.*

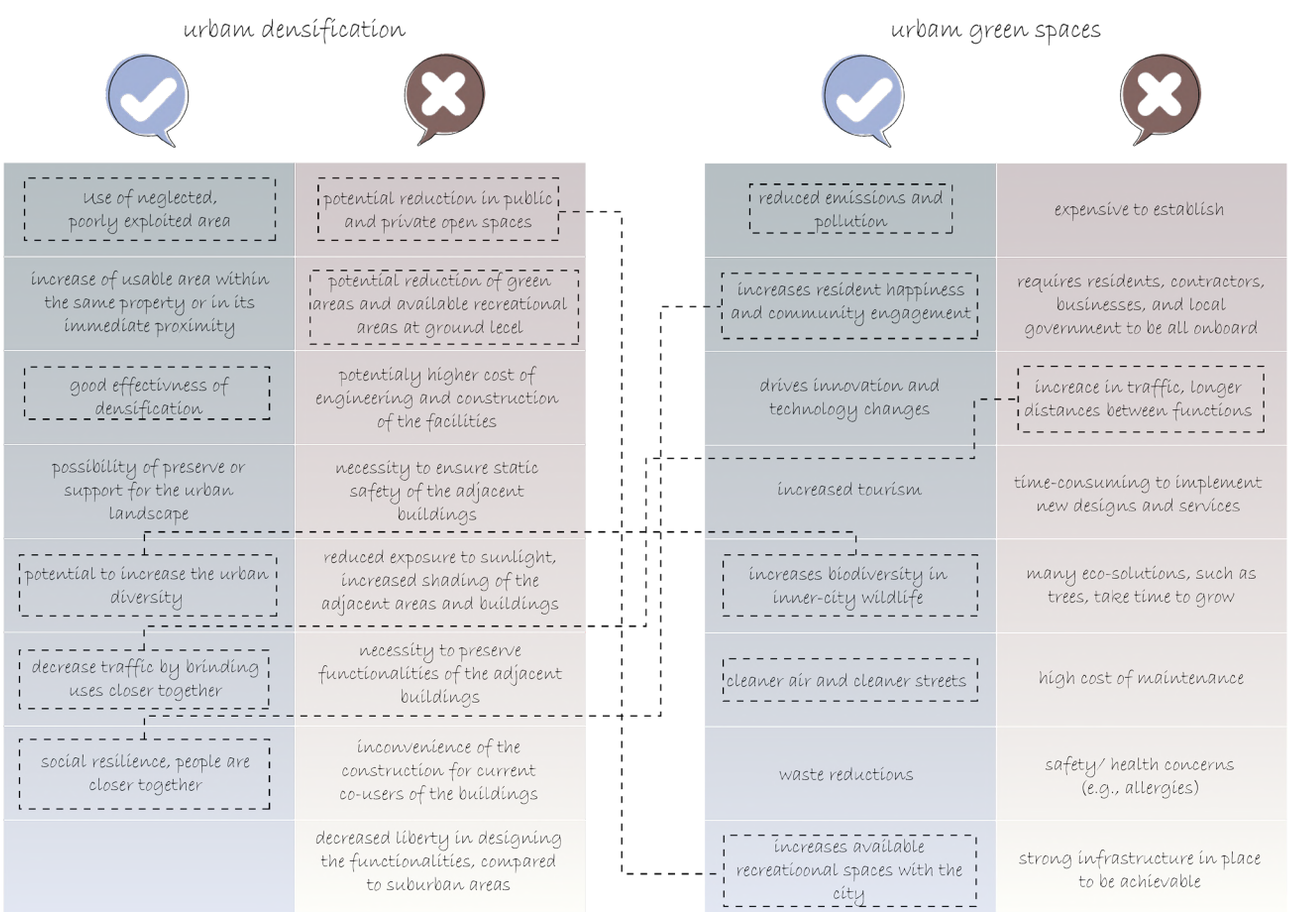
We tend to focus on implementing one over the other strategy when we should explore in which ways we can successfully combine the two towards the creation of the most sustainable urban environments possible.

Combining the theory of densification with that of urban green spaces, when the way of realizing one immediately contradicts the other is going to be a challenge. For this reason, I had to research theories that would help achieve urban densification without compromising the presence of nature in the cities.

The goal is to find ways to reconcile the built

environment with nature. Complex ecosystems are already present in the cities. In many ways, the human-built environment and nature already coexist. It is all about highlighting and building upon what is already there.

Green, sustainable, biophilic, biomimetic building design is considered a specialty field. When that idea fades away, and the kind of building design is considered normal, then we will have achieved a fundamental change in our design process.



Pic.4: Pros and cons and overalp/conflcts of Urban Densification & Urban Greening

Biotope Area Factor

Biotope Area Factor (BAF) is used to calculate the absorbent qualities of a surface. The indicator is based on the relationship between the ecologically effective surface area compared to the total surface area of a plot. BAF is utilized in urban planning so under-used spaces can be incorporated in the greening policies. It can be a useful tool when trying to bridge the gap between urban densification and green policies.

BAF is developed in relation to each city's context. Since Thessaloniki does not have its own version of BAF or a similar tool available, I am going to use the BAF modelled for the city of Berlin to make my calculations. The calculations are not going to be 100% accurate and related to my particular context, but they would still provide an indication of the success of my design decisions.

To calculate the BAF all potential green areas (courtyards, roofs, walls, etc.) are included. The minimum BAF for each structure or implementation can change depending on the type of function and the type of development.

In my case, I have a new structure with mixed use, residential and commercial, with both functions using open spaces. Based on that, I will assume that the BAF goal of my design is 0.6 (Berlin.de Das offizielle Hauptstadtportal, 2020).

Biophilia

The concept of biophilia is based on evidence that people are happier, healthier and more productive when they are in contact with nature. The use of plants, natural materials, and visual escapes to the natural environment can be used in the design to create buildings that perform better and improve well-being (Pawlyn, 2016a).

The term "biophilia" was used for the first time in 1964 by Erich Fromm, to describe a psychological orientation, an attraction towards that it is alive. In his book titled "Biophilia" E. O. Wilson deals with the relationships that people have with nature and defines biophilia as "the need to be in touch with other forms of life' (Wilson, 1984). Contact with nature can be beneficial for everyone, regardless of gender, age, nationality, etc. Constant contact with nature strengthens the values of respecting and caring for the environment (Dias, 2015). At the same time, the benefits from the design of biophilic cities are notable and concern the part of ecology, the economy, and mental health (Beatley, 2016).

Biophilic design can be explained as the application of biophilia to the design of human environment, and, in this case, as a form of long-term sustainability that aims to restore and enhance people's positive relationship with nature in the built environment and promotes contact between people and nature in modern buildings and landscapes. It refers to environmental features, natural shapes and forms, natural patterns and processes, light and space, place-based relationships and evolved human – nature relationships (Kellert, 2008).

Specific strategies, divided into three main categories, can contribute to the practice of biophilic design. All these categories are related to the way humans experience nature. The "direct experience of nature" involves contact with the natural environment, the "indirect experience of nature" refers to different forms of representation of nature, and the "experience of space and place" refers to the context of the build environment.

The "direct experience of nature" is based on contact with the natural environment, and it includes naturalistic elements such as light, air, water, flora and fauna, landscapes, weather, views towards nature and outdoor spaces. The "indirect experience of nature" consists of images and representations of nature and includes characteristics of the natural world changed from the original state. It is achieved through the representation of the natural world with images, pictures and paintings, and the use of natural materials in different forms and shapes. Finally, the "experience of space and place" is focused on the context and the way people experience it. Transitional spaces, connecting indoor and outdoor spaces, ecological and cultural connections to the area and the ability to effectively navigate through space, are some of the characteristics included.

In my design, I aim to acknowledge attributes from all three categories. I aim to find ways to maximize natural light, introduce green spaces and elements and achieve a good airflow. I plan to make use of natural materials, textures and colours. At the same time, I will utilize biomimicry to implement the attributes from the first category. For the third category, my focus will be on the transitional spaces and the connection between indoor and outdoor (Kellert, 2018).

Pic.5: Gardens by the Bay, Singapore (Waddington, 2016)

Biomimicry

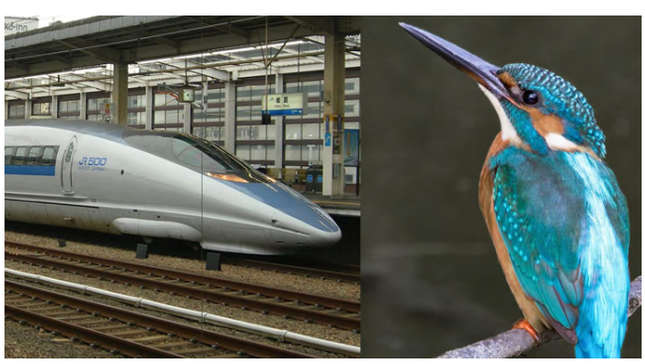
The concept of biomimicry (< bios/βίος = life + imitation/μίμησης) refers to a philosophy, that observes the functions, forms, and processes of the natural environment and biology to produce solutions, which serve human needs (Benyus, 1997).

Historically the concept of biomimicry appeared with the term biomimetics, in 1950 (Cohen & Reich, 2016). A few years later, in 1962, the term biomimicry appeared in scientific literature (Benyus, 1997). In architecture, biomimicry is already used in building design. Through the study of ecosystems, many architects have started to create urban models of cities, which draw inspiration from ecosystems (Davis, 2014).

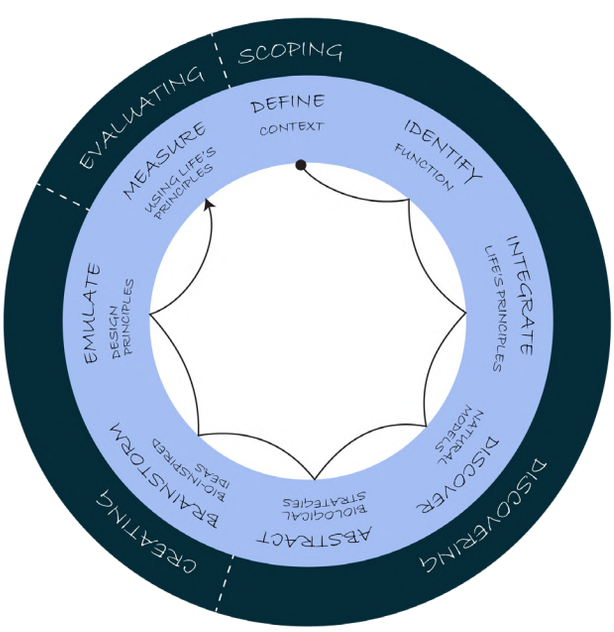
Biomimicry is an analogue process. It helps transfer knowledge from biology (which acts as a source) to technology and design (which is the target) (Mak & Shu, 2004). Biomimetic design often involves complex proportions, especially when the design concept is based on a combination of ratios from different fields (Vattam, Helms & Goe, 2008). It is based on the study of nature and the application of physical functions in design. Nachtigall, however, urges biomimetic designers to be cautious and not be led to overly direct interpretations (Nachtigall, 2010). A typical example is Leonardo da Vinci's works, who developed a mechanism that attempted to imitate the movement of birds' wings; however, the work was focused more on imitating their form (biomorphism) and not so much on how they operate and move (biomimicry) (Pohl & Nachtigall, 2015).

There are different approaches that one can follow in design. Including biomimicry into the process increases the level of complexity. It is possible to start the biomimetic design process from different directions. The first one is to identify a design problem and then research a solution in biology. The second process focuses on finding inspiration in biology and then identifying possible applications for a corresponding problem in technology (Cohen & Reich, 2016).

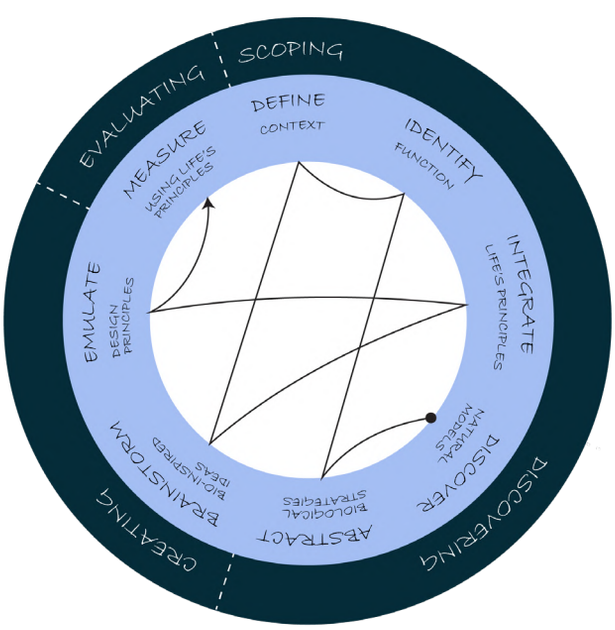
In my case, I will focus on the first process. I will identify possible problems and then research the natural world for biological strategies that can help me solve these problems (problem to biology).



Pic.6 a&b: Kingfisher inspired high-speed rail design (Rsa, 2009), (Laitche, 2015)



Pic.7: Problem to biology



Pic.8: Biology to technology

ISite exercises

Reconnecting with nature is an essential part of biomimicry and it can happen in different ways for different people. Being in nature is the easiest and most obvious way to achieve that. Being in nature is not just about being outdoors, following a program or being extremely active. Reconnecting with nature requires slowing down, to be able to focus on the natural environment.

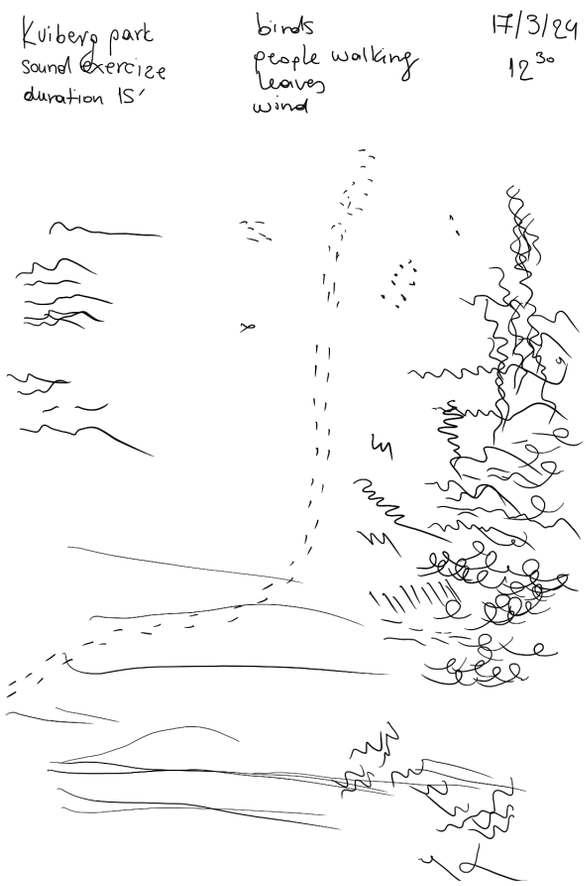
ISite exercises are designed to help the practitioner reconnect with nature. They require some planning, in terms of when and where the exercise should take place, but the outcome cannot be predicted, it is whatever comes up as the result of the exercise.

ISite exercises aim to help the practitioners develop skills needed to become good biomimics (Baumeister, 2014).

I am practicing these exercises with the aim to reconnect with nature, widen my field of inspiration and gain a better understanding of the natural world. I do not expect the exercises to have a direct impact on my design. I am following through with them to develop and sharpen my understanding of the natural world and as a result have a more critical approach on the natural references, that I am going to use to my design.

Although my design project is located in Thessaloniki, I do the iSite exercises in Gothenburg, where I study. The results of the iSite exercises are dynamic and they are changing depending on the location, the time, the season, the weather, etc. Doing the same exercise in the same place at a different time, even within the same day, can have very different results. ISite exercises are made to hone the observation and critical skills of the practitioner, and they do not affect the results of the design.

Pic.9: Observation excercise



Pic.10: Soundscape exercise

Inspirational cases

I have investigated different reference buildings and the ones presented here were selected because of special design decisions and features that relate to the problem of my project.

All the projects relate to the problem of natural lighting, while other issues mentioned are natural ventilation, green spaces, and the design of an infill building. All the projects relate to the issue of biophilia, while some of them have more direct references to biomimetic design.

1. Council House 2 (CH2), Design Inc, 2006
Melbourn, Australia

2. Solaris, TR Hamzah & Yeang, 2010
One-north, Singapore

3. The Biomimetic Office Building, Exploration Architecture, Zurich, Switzerland

4. Rue des Orteaux, Babled Nouvet Reynaud Architects, 2014, Paris France

Pic.11: Location of case studies

Council House 2 (CH2), DesignInc

Melbourne, Australia Year: 2006

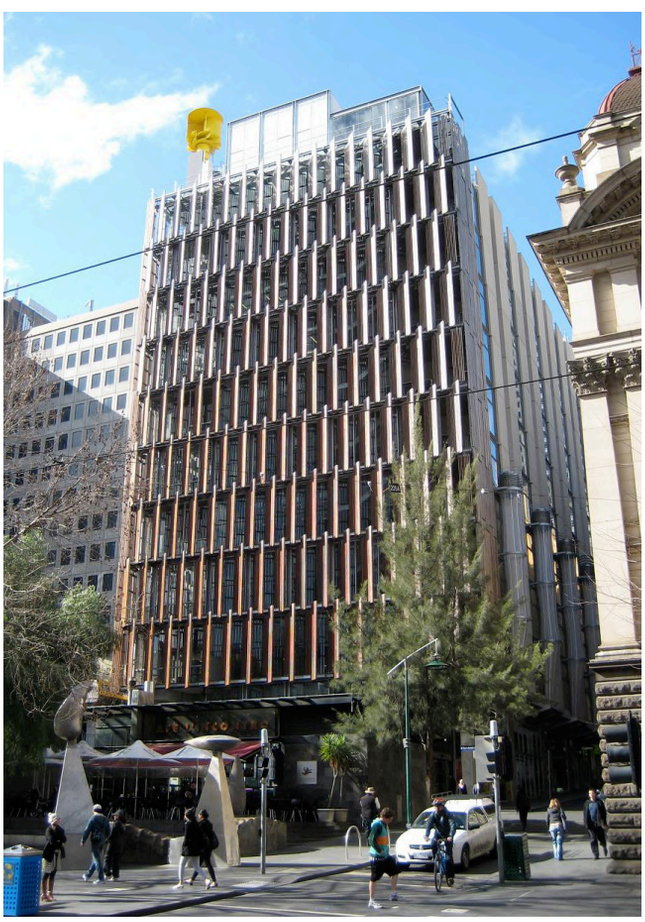
The Council House 2 (CH2) is an office building, designed with nature as a source of inspiration.

CH2 has a passive cooling system, which is a biomimetic application of termite mounts, taking advantage of the air temperature difference between daytime and nighttime. A whole side of the building opens during nighttime allowing the night air to run through the building cooling it down. This technique vents the warm air acquired during the day out of all the spaces of the building. The warm air is driven out through openings in the ceiling and hollow floors to a vertical air shaft and from there out from roof vents.

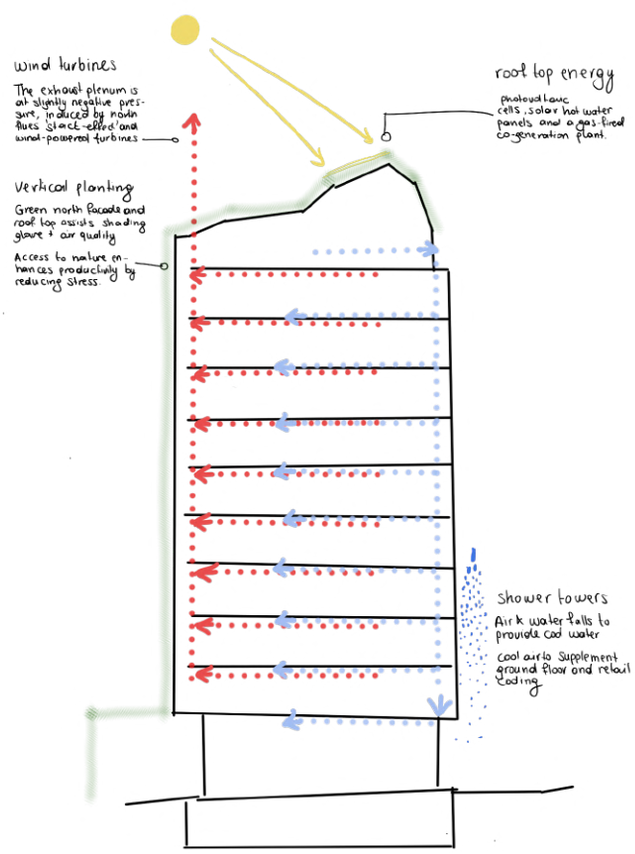
Additionally, the building is using water to further condition the air inside. "Shower towers" are installed on the outside of the structure, the water runs down them creating cool air through evaporation (Pearce, n.d.).

The CH2 utilizes the natural light by installing floor to ceiling windows, while the balcony slabs provide shading from the northern sun. An external "light shelf" on the northern windows, protects them from the direct sunlight and bounces natural light into the building. Vertical green walls on the balconies on the northern side protect the windows from the low-angle sun and filter the glare. Moveable shutters on the western façade remain open through the day to allow natural light into the building, and close when the sun is in the west in the afternoon. The windows are divided into two sections, with blinds that work independently to protect from direct sunlight, but still letting in natural light (City of Melbourne, 2019).

In relation to my project, CH2 is a good example of how to maximize the intake of natural light in a building through smaller design features and details. The collaboration of small-scale installations significantly improves the indoor quality by enhancing the natural light. At the same time, CH2 gives inspiration on how to utilize the difference in air temperature between day and night to achieve passive cooling of a building and its spaces.



Pic.12: CH2 Western facade (Hyde, 2008)



Pic.13: CH2 cooling system diagram

Solaris, TR Hamzah & Yeang

One-north, Singapore Year: 2010

Solaris consists of two tower blocks connected through a naturally ventilated atrium. The project introduces a total vegetated area that surpasses the building's footprint. Different ecological design features are incorporated in the building.

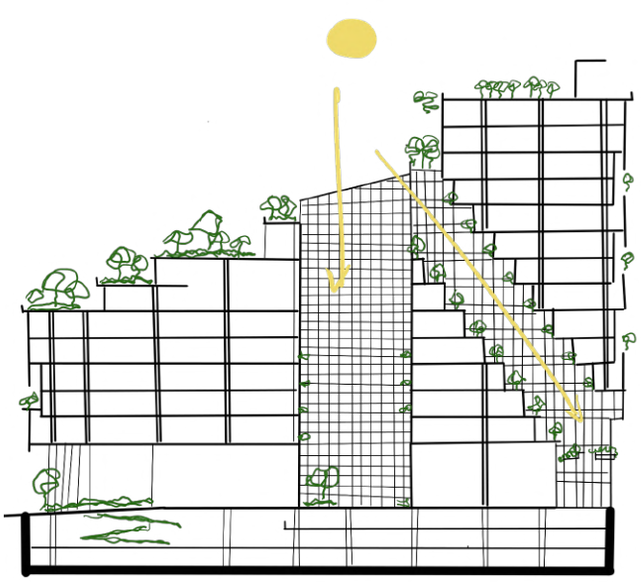
A landscape ramp connects the building with the neighbouring park. The pathway continues from the base to the roof-top lined with planters. The ramp, along with the roof gardens and sky terraces, act as a thermal buffer, while giving opportunities for the building's users to interact with nature.

A diagonal cut through the tallest of the two towers allows daylight to reach deep into the building. The automatic lighting system turns off when there is enough light in the space. Planters installed within the solar shaft add extra qualities to the space.

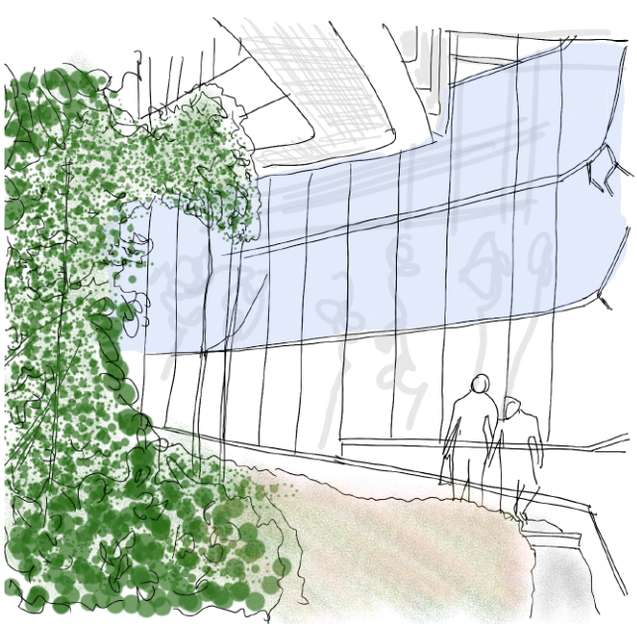
A rainwater harvesting and recycling system is installed. It has the capacity to irrigate the buildings landscape for about 5 days.

Finally, the climate-responsive facade was based on the analysis of the local sun-path. The shape and depth of the sunshades, which also work as light-shelves reduce heat transfer in the building (TR Hamzah & Yeang, n.d.).

Through the cooperation of natural elements and technological advances Solaris stands for a pristine example of sustainable building design. The green spaces incorporated in the design are utilized both from an environmental and a biophilic perspective and are a valuable inspiration for my design. Additionally, f large scale design decisions, like the cut through the building, are considered for their effectiveness and the qualities they bring to the building.



Pic.14: Section of the building



Pic.15: Sketch of the exterior view

The Biomimetic Office Building,
Exploration Architecture

Zurich, Switzerland Year: -

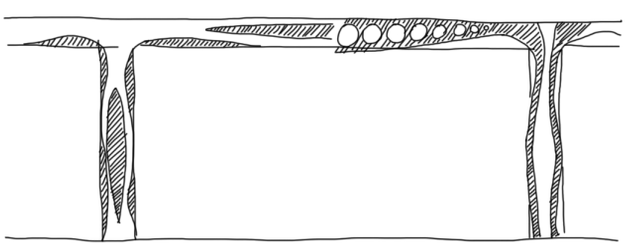
Exploration Architecture aspired to achieve the ultimate environmental planning for the development of an office building. For this reason, the building was designed to adapt and exploit the climatic conditions and the resources that are available in the area, for the improvement of its environmental performance. At the same time, nature-inspired features are integrated into the environmental and sustainable design (atelierten, 2021)

One of the main problems was the optimal lighting of the entire building. Finding that the light enters the building at approximately 6 meters, they proceeded to create two independent buildings with a total width of 12 m., which had a sufficient distance between them, so that the light can enter unobstructed in the interval between the two sections. While the logic appeared particularly effective on the higher floors, the problem of effective lighting at lower levels remained (Belgian Building Awards, 2020).

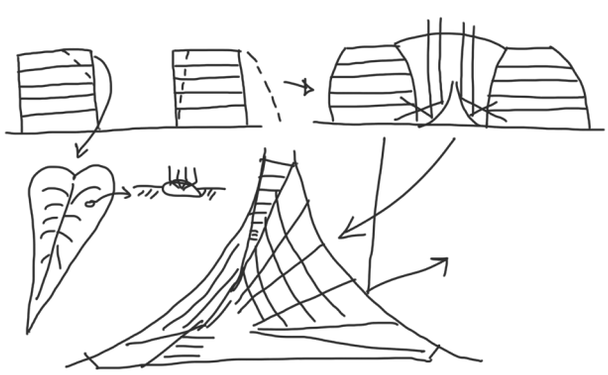
The spookfish, which uses a kind of mirror to focus the light on the pupil of his eye, inspired the creation of large-scale reflectors, which would be placed in the gap between the two buildings and will reflect light to the lower levels of the building.

For the creation of the skeleton, biomimicry was exploited to reduce the material required for the construction. The cuttlefish bones and bird skulls were examined for efficient placement of materials for rigid forms. Through the analysis of the standard building skeleton and the forces present there, they found that there is a large amount material which does not contribute to the building's stability, and it can be removed. The skeleton then was designed according to the force lines to utilize less material than typical constructions. (Architecture Foundation, 2013).

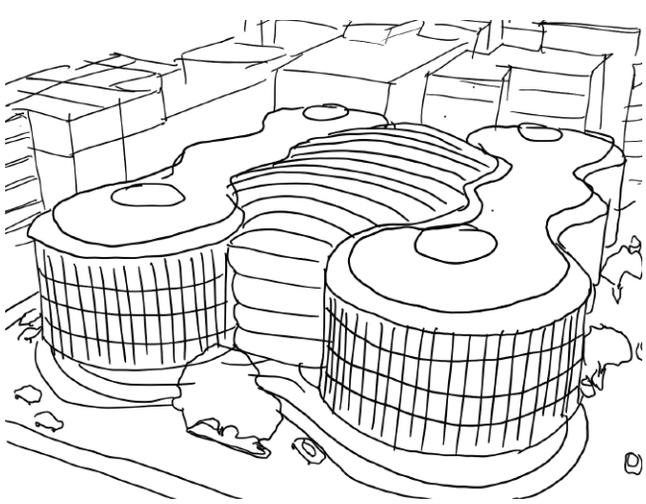
The design of the Biomimetic Office Building inspires me to research for unconventional solutions to conventional design problems. Looking into nature and biology for design solutions can produce new building design strategies.



Pic.16: Structure strategy



Pic.17: Light reflection sketch



Pic.18: Building sketch

Rue des Orteaux,
Babled Nouvet Reynaud Architects

Paris, France Year: 2014

Rue des Orteaux is a social housing complex with a design influenced by the characteristics of its local context. It is an infill project on an L-shaped plot designed to close the street corner (Duro & BABLED NOUVET REYNAUD ARCHITECTES, n.d.).

The project was designed to achieve sustainability through an architectural approach, while avoiding the use of machine-made solutions. Environmental solutions are given through design and construction (DARRIEUS, 2015).

The project consists of three buildings of decreasing volume ("Logements Expérimentaux Rue Orteaux Babled-Nouvet-Reynaud," 2021). The main components of the project were decided based on the character of its location (Duro & BABLED NOUVET REYNAUD ARCHITECTES, n.d.).

The shape of the individual buildings is also affected by the plot. At the same time, their depth and orientation are designed to maximize natural sunlight. A double bioclimatic skin, responsive to the climatic conditions, completes the design. During winter, the skin improves thermal regulation, while during summer the skin is set open and allows natural ventilation in the apartments (Duro & BABLED NOUVET REYNAUD ARCHITECTES, n.d.).

The main building has entirely glazed facades exposed to the sun. The double skin made of glass and wood ensures efficient passive heating while providing good acoustic insulation. The two sliding glass walls form small spaces 0.30 to 1.20 m thick. In places, a black concrete sensor wall replaces the 2nd glass skin: it heats the air circulating in contact with it which then enters the housing by mechanical draft ("Logements Expérimentaux Rue Orteaux Babled-Nouvet-Reynaud," 2021).

The floor plan is organized to give the apartments a south and south-east orientation to optimize the natural light (Duro & BABLED NOUVET REYNAUD ARCHITECTES, n.d.).

In relation to my project, it is important to observe how the form of the building can affect the intake of natural light. Although, this is an infill project, thus limited by the pre-existing conditions in the area, the designers were able to adjust the form to maximize natural lighting.

Pic.19: View of the apartments (Guillaume, 2013)

Pic.20: Exterior view (Guillaume, 2013)

Learnings

Urban densification and the increase of urban green spaces are two strategies that contradict each other, yet urban green spaces are integral to the successful densification of cities. Implementing biophilic and biomimetic elements within the design can contribute to the successful merge of the two.

Other tools that can be utilized towards that goal include the calculation of the Biotope Area Factor of the design, a tool that started to gain popularity recently and the practice of the "iSite" exercises, which can help designers rebuild their connection to nature.

Through the study of different examples, it is easy to see that in architecture there is not a "one size fits all" approach. Rather, the design solutions of each example depend on the context of the area and the perspective of the designer.

Site studies

History & City

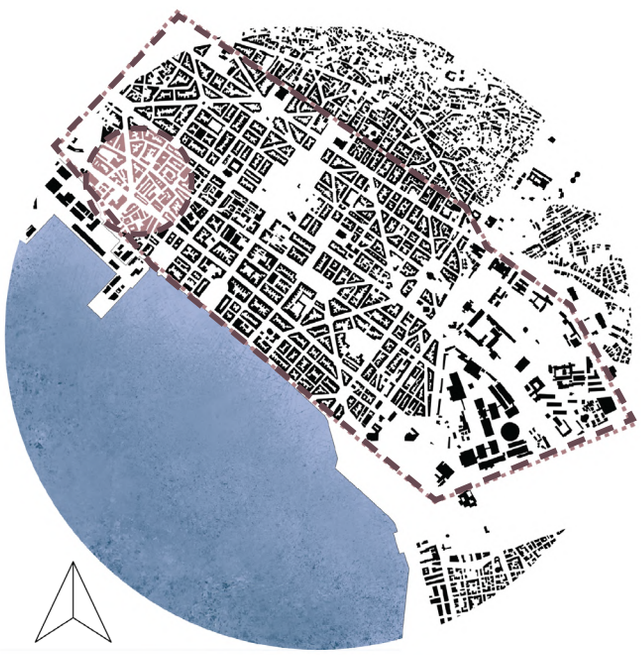
The city of Thessaloniki as an urban centre was founded in 316 B.C. Because of the advantageous location of the Gulf of Thessaloniki, the area was inhabited as early as the Neolithic period. Due to its geographical location, the city attracted a grand population and has been continuously inhabited ever since.

The port of Thessaloniki, and as a result, the city has been an important cultural and economic centre throughout the centuries. Its importance is prominent throughout the Roman and Byzantine Empires, the Ottoman Occupation, and even now in the contemporary area.

Thessaloniki is the second-largest city in Greece, the most important cultural, economic, and administrative centre in Northern Greece, and has approximately 1.1 million residents in its metropolitan area. It is in a key location, with one of the biggest ports in the Mediterranean Sea and a few hours' drive from 4 major capitals).

The city is located in an active earthquake zone. The historic centre of Thessaloniki is an area of approximately 3 km2, that covers the biggest part of the current city. On the Northwest, the border is Dimokratia's square, Agiou Dimitriou street is the border on Northeast, the campus of Aristotle University of Thessaloniki is the border on the Southeast and the coastal Avenue Nikis is the border on the Southwest. When talking about Thessaloniki, one may refer to the Municipality of Thessaloniki, the Urban Complex of Thessaloniki, or the Prefecture of Thessaloniki. For comparison, when talking about the city's density, I will present data for the Municipality and the Urban Complex of Thessaloniki (City of Thessaloniki, 2021).

Pic.21: Location of Thessaloniki in Greece



Pic.22: Border of the historic city centre

Weather

The climate of Greece is Mediterranean, it has mild and rainy winters, relatively warm and dry summers, and great sunshine almost all year round.

The year can be divided mainly into two seasons: The cold and rainy winter season that lasts from mid-October to the end of March and the warm and rainless season that lasts from April to October.

During the first period, the coldest months are January and February, where the mean minimum temperature varies from 0-5 °C. Winter bad weather is often interrupted during January and the first fortnight of February by sunny days, known as "Halcyonids days".

During the warm and rainless season, the weather is stable, and it does not rain except for rare breaks with rapid rains or storms of short duration. The hottest period is the last ten days of July and the first of August when the average maximum temperature ranges from 29 °C to 35 °C.

Spring has a short duration. Autumn is long and warm and often extends in Southern Greece until the middle of December (Hellenic National Meteorological Service, n.d.).

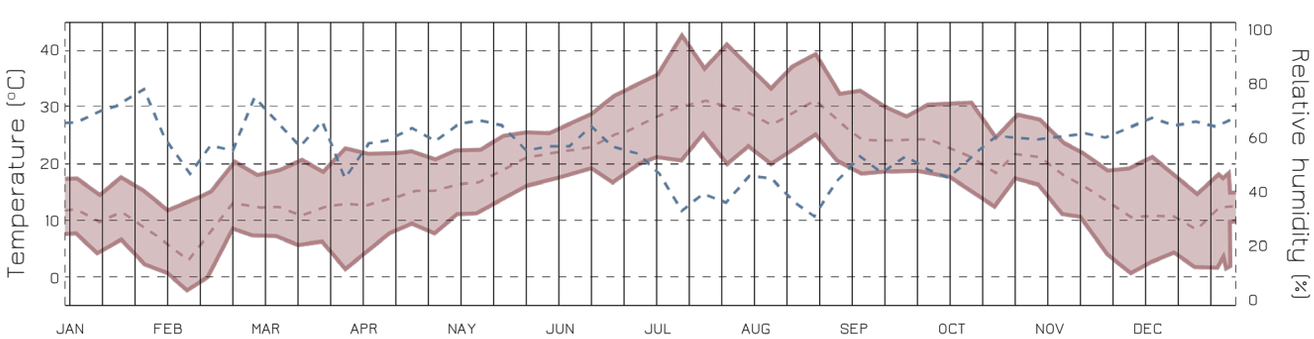
Natural environment

The city of Thessaloniki is built near the sea and surrounded by the Seih Sou peri-urban forest. Seih Sou is the largest green area around the city, helping improve its air quality, and one of the most popular spots for recreational activities in nature.

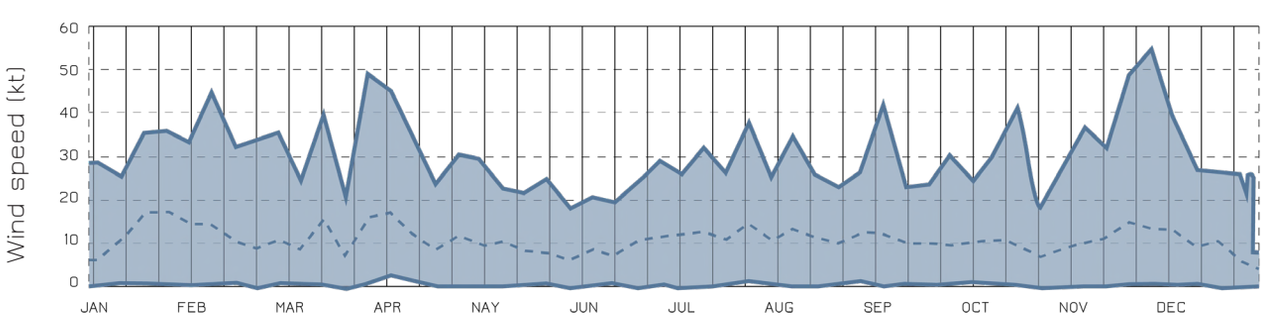
The peri-urban forest of Thessaloniki is home to 277 species of higher plants. Seih-Sou belongs to the Para-Mediterranean Vegetation Zone. Based on its high ecological value, the peri-urban forest has been designated as a landscape of special natural beauty, in accordance with the provisions of Law 1469/50 (Hercheletzis, 2022).

Thessaloniki has an extremely low percentage of green area per citizen, around 2,8 m2, which is unevenly distributed. The lack of greenery in the city has caused the urban heat island effect. Practically, the temperature in the city is about 4 °C higher compared to surrounding areas. Prominent people in the city have stressed the need for more green spaces ((n.a.), 2023).

The trees that are already in the city include sophora, American maple, sycamore, sycamore, sycamore, lingostra, and others (Tsigganas, 2020).



Pic.23: Minimum, Mean, Maximum monthly temperature during 2023



Pic.24: Wind speed during 2023

Current situation

Thessaloniki is a densely developed city. With an area of 85,5 km^2 and a population of 747.870 residents according to the population census of 2021, the density reaches about 8.747 residents per km^2. At the same time, the Municipality of Thessaloniki with an area of 19,29 km^2 and with 319.045 residents, reaches a density of 16.539 residents per km^2.

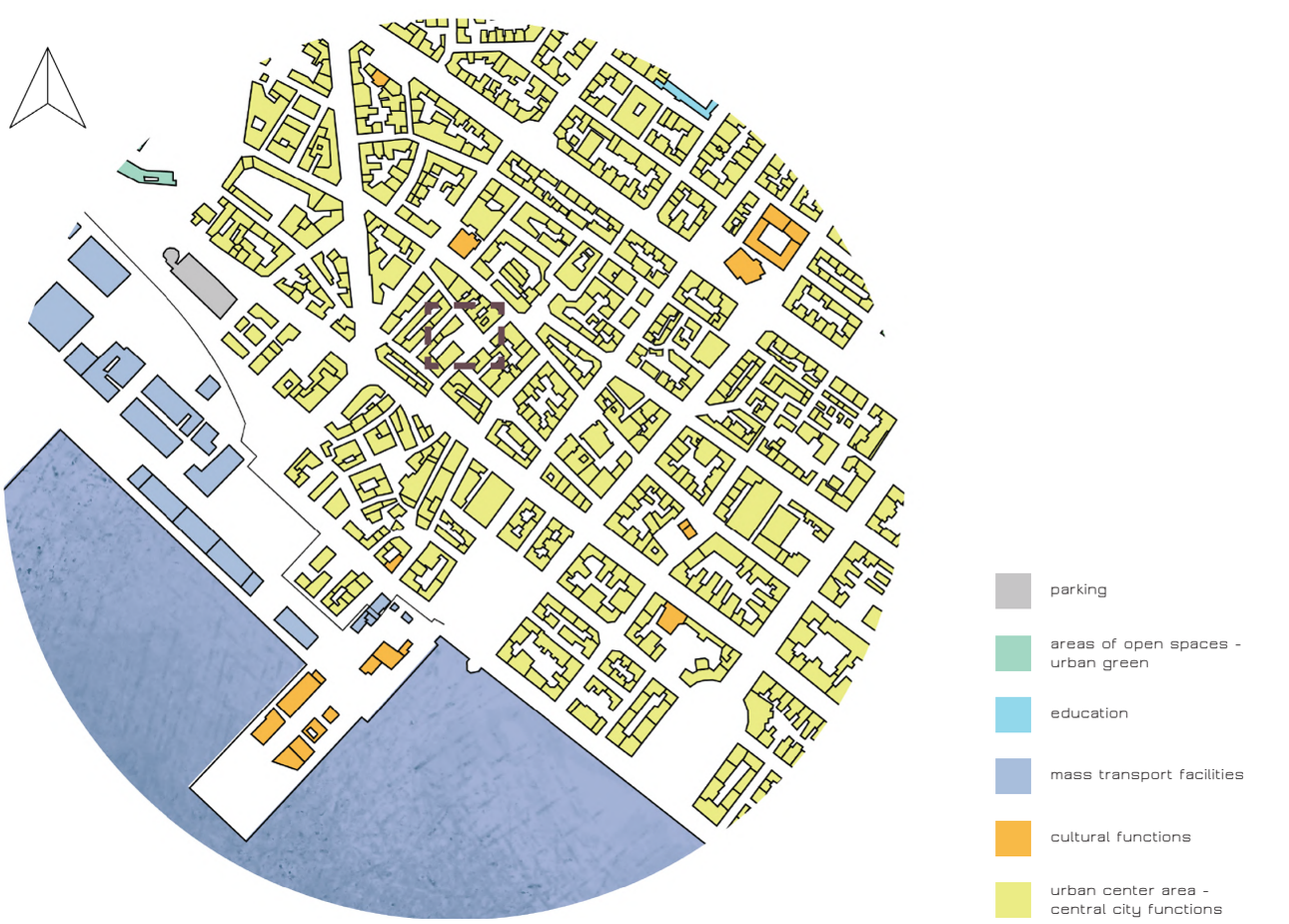
The high density is due to the urban planning of the city, which consists of narrow streets, and the building regulations, which had as a result the construction of tall buildings in the city centre. About 65% of the buildings have 3 or more floors and about 18% of them have more than 6 floors (Hellenic Statistical Authority, 2023). As a result, there is limited access to sunlight to certain areas of the city.

This situation results in the limited presence of urban green spaces, which is estimated to be 2,8 m^2 per resident, which sets Thessaloniki low on the ranking compared to the minimum limit of 8-10 m^2 of greenery per inhabitant set by the World Health Organization (Iliadis, 2022). Coupled with the changing climate and the rise of the temperature, the lack of green spaces often results in overheating, especially during the summer months.

Pic.25: Green spaces in and around the city

Pic.26: Greenery in a focused area

Pic.27: Road classification



Pic.28: Land use

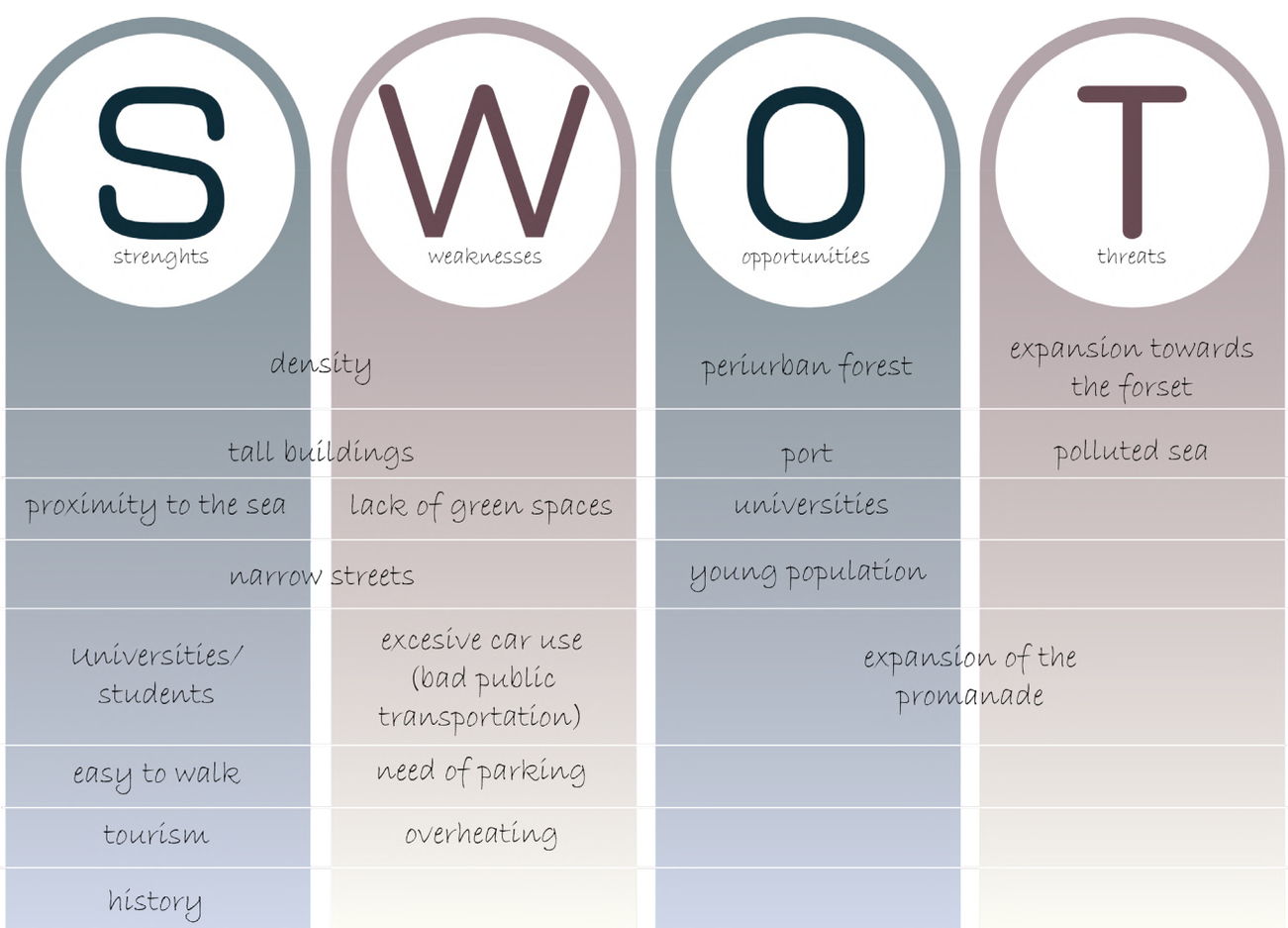
City SWOT

Thessaloniki, like all cities, has its own strengths and weaknesses. Its rich history and the proximity to the sea make it a popular destination among tourists, while the universities make it a popular destination for prospective students and decrease the average age of the city population.

The density of the city makes it easily walkable, an important aspect considering the bad condition of the public transportation system, which promoted the use of private cars and the lack of parking spaces.

The density of the city, along with the tall buildings, the narrow streets and the lack of green spaces make for an uncomfortable living environment, especially during the summer months. But this situation makes Thessaloniki a good case study for my thesis question.

Taking into consideration, the data I have collected and presented so far, along with my personal experience of the city, since it is my hometown and the city I was studying before, I have a well-rounded understanding of the context.



Pic.29: SWOT diagram of Thessaloniki

Building regulations

I have identified three possible sites within the city centre. All three sites are gaps in building blocks, and they are currently operating as parking lots. The sites are on the western side of the city centre.

The area has a "Central City Function" which include the following uses:
-Residences
-Guest houses, hotels, other tourist facilities
-Commercial shops
-Offices, banks, insurances, non-profit organizations
-Administration (neighbourhood-level administration buildings)
-Restaurants
-Refreshments
-Leisure entertainment centres
-Public gathering places
-Cultural buildings and facilities
-Education buildings
-Religious places
-Social welfare buildings
-Low disturbance professional workshops
-Buildings parking lots
-Gas stations
-Sports facilities
-Trade show facilities
-Public transport facilities.

The construction terms for all three plots are according to the New Building Regulations of 2012 (NOK 2012) and the revisions that followed.

Coverage of the plot is the surface defined on a horizontal plane by the projections of all the contours of the buildings of the plot. For all the sites the coverage rate is 60%.

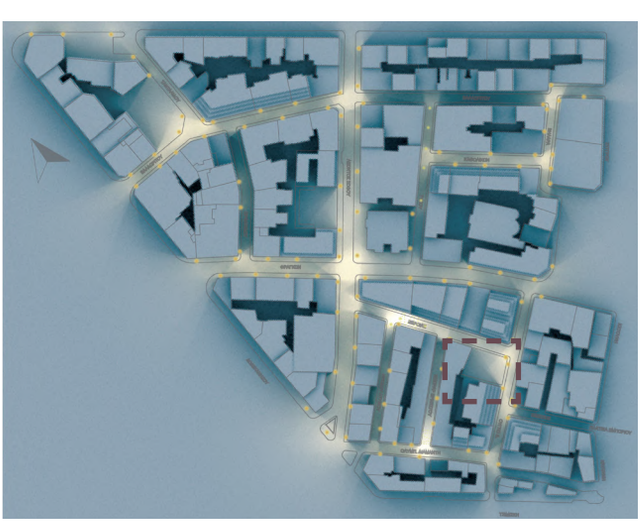
Uncovered space is the space of the plot which is not structured.

Floor area ratio is the number, which, multiplied by the surface of the plot, gives the total permitted building surface. One of the plots located close to the port has a ratio of 2,6, while the other two plots have a ratio of 4.8 (N. 4067/2012).

The floor area ratio determines also the permitted height of the building. In the case of the first plot, the maximum allowed height is 26 m, while for the other two sites, the maximum allowed height is 32 m. Different roof typologies can allow for extra height.

Main use areas of the buildings are those intended to serve the basic use of the building. These spaces have a minimum height of 2,65 m.

Pic.31: Sounds scape, 29/12/2023 12:00



Pic.30: Lightscape in the area

Pic.32: Sounds scape, 09/02/2024 23:30

The Regulation of Energy Performance of Buildings forms the framework of principles that determines the terms and conditions of improvement of the energy efficiency of buildings. Its purpose is the reduction of the consumption of conventional energy for heating, cooling, air conditioning, lighting, and hot water while ensuring comfort conditions and indoor environment quality of the buildings.

A new building design should make the most of the local climatic conditions, configure the environment for the improvement of the microclimate, have appropriate design and placement of openings, ensure proper location of functions, make use of at least one of the passive solar systems, include techniques for natural ventilation and ensure visual comfort (ΔΕΠΕΑ/ οικ.178581).

Pic.33: Active - Non active spaces-Ground floor

Pic.34: Active - Non active spaces-Top floors

Neighborhood

I will work within the historic area of "Ladadika", an integral part of the history and the development of Thessaloniki. The warehouses and shops selling oil (=ladi-λάδι,) and oil-related products are responsible for the name of the area.

The area was developed during the Ottoman occupation, close to the port and outside of the city walls. It became part of the city after 1870, when the sea walls were demolished. During the WWI, many of the warehouses and shops were turned into brothels and bars. In 1917, a fire destroyed a huge part of the city and changed completely the city scape. The French urban planner Ernest Hébrard had included the area in his original designs for the reconstruction of the city, suggestion which was later reviewed in 1921. Until the 70s' Ladadika district was one of the most infamous neighbourhoods of the city. During the 80s', the area attracted the interest of the Ministry of Culture, it was declared protected, and more than 70 buildings were considered preserved.

Today "Ladadika" district attracts visitors and locals, as it offers all means of entertainment (Kritikou, 2022).

Pic.35: Ladadika district

Possible plots

I have identified three possible plots, with similar characteristics as possible sites for my Master Thesis. The three plots are close to one another and close to the historic area of Ladadika and the port. The area is popular among citizens and tourists for its cafés, restaurants, bars, and nightclubs. Other uses in the area include commercial shops, hotels, and offices. Excluding the Ladadika part of the area, the rest of it consists of high-rise buildings, with some protected buildings scattered around them. Although the possible plots are from 160 to 300 m. away from each other, the character of the immediate area of each plot changes noticeably.

Plot 1

The first plot is located within the old "European neighbourhood". It is approximately 642,4 m2 and it has two facing sides open. It used to operate as a parking space within the city, but it is currently under construction. Although it is in a historic area, only some historic buildings are still present. Most of the buildings were developed around 1930. As a result, most of the buildings are 7-8 stories high, concrete constructions. The street is relatively narrow, and it has urban trees from both sides.

Pic.36: Points of interest

Plot 2

The second plot is located close to the first, but it belongs to the historic area of "Ano Ladadika". It is a corner plot of 525 m2. It is currently operating as a parking lot. V. Hugo Street is a clear border between two areas. On one side we have taller, concrete buildings 6-7 stories high and on the other side there is an area of mostly protected buildings 3-4 stories high. The streets on both sides of the plot are paved, and there is limited greenery in the immediate area.

Plot 3

The third plot is located right outside of the "Ladadika district", but it is in close proximity to the port. It has an area of 1187,7m2 and it is open from two facing sides. It is currently operating as a parking lot for the hotel and the other commercial activities in the area. It faces Politechniou Street, one of the biggest and busiest roads in the city. The buildings in the area are newer and mainly between 7-8 stories high.

Plot Selection

Different criteria led me to the final plot selection.

The 3rd plot was eliminated first due to its large size. Considering the time limitations of the master thesis period, working on a smaller site is fitting better in the time frame.

It was hard to decide between them, since they share so many similar characteristics. During the project plan phase I had initially selected the 1st plot, due to the challenge it would present to design on a plot with two facing sides open.

After my site visits, I revised my decision. The 1st plot is already under construction, limiting my knowledge on what is happening in the centre of the building block, where one of the sides is facing. Additionally, the 2nd plot had the advantage of being right opposite a plot I had worked on in my previous studies. This means I already had a good understanding of the area, and some analysis material was already produced, and it just needed to be revised.

plot open on 2 facing sides	plot open on 2 consecutives sides	plot open on 2 facing sides
Area: 642.4 m^2	Area: 525 m^2	Area: 1187.7 m^2
formerly parking, currently under constraction	parking	parking
buildings 7-8 stories high, exception: State Conservatory of Thessaloniki	buildings different heights, one side 6-7 stories high, other side 3-4 stories high	buildigns 7-8 stories high
uses in the area: hotels, office building, student housing, housing, commercial uses, recreational uses	uses in the area: housing, commercial uses, recreational uses, hotels	uses in the area: hotels, recreation uses, commercial uses housing, parking
points of interest: Olympian gallery/ stoa, State Conservatory of Thessaloniki	points of interest: Ano Ladadika, Emniet Han, Kirtsi gallery/stoa, Bensousan Han, Emporiou Sqr., Hrimatistirioou Sqr.	points of interest: port of Thessaloniki

Pic.37: Plot comparison

Site

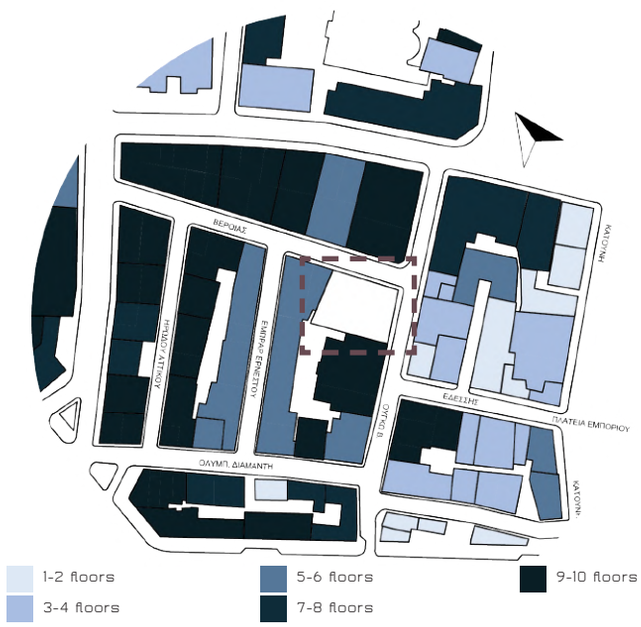
My plot is in the Northern part of "Ladadika" district, known as "Ano Ladadika". It is close to one of the most popular recreation and entertainment areas in the city. The plot is situated right on the border between the preserved historic part of "Ano Ladadika" and the tall blocks constructed later in the area. Despite its proximity to a lively area, the immediate surroundings of the plot still have a sense of abandonment. The popularity of the general area is gradually changing the urban scene, with recreational and entertainment activities spilling in the area around the plot.

There is a distinction between the preserved area and the contemporary constructions. The buildings on the plot's eastern side are shorter, typically between 1 to 4 floors. Some of them are preserved. A selected few were constructed before the fire of 1917 and are typical examples of the architecture of the later years of the Ottoman Empire. On the plot's western side, the buildings are taller, typically between 5-8 floors, and were constructed after the 1950s. The floor organization is similar on both sides, with a higher ground floor, between 4-6 m., a mezzanine or attic space, with an approximate 2,5m height, and the floors above being between 3-4 meters height each.

The distinction is also obvious in the uses present. The eastern side is dominated by recreational, entertainment and cultural activities, with a lot of cafes, bars, and restaurants. On the western side, the functions are mostly related to trade.

Other uses present are small industries and office spaces, many of which are abandoned. In recent years, there has been a shift in the uses of the western side, with many places which were abandoned now slowly reopening with recreational or entertainment functions.

Concrete is the dominant material in the area, used in the construction of the taller buildings. The historic and preserved buildings are made of brick. The pedestrian sidewalks are made of cement tiles and the streets are either



Pic.38: Building heights

Pic.39: Uses-Ground floor

Pic.40: Uses-Top floors

asphalt or stone paved. Both V. Hugo Street and Veroias Street were paved with stone after the redevelopment of the area which was completed in 2016.

The plot I am working on is a privately owned and operated parking lot. It is in the corner of a building block, with buildings from 20 to 32 m. high. It has a total area of 525 m2. On the ground floor the uses of the block are focused on trade, with some more recent additions to recreational functions. The higher floors were mainly used as small industries or office spaces, which are currently out of order.

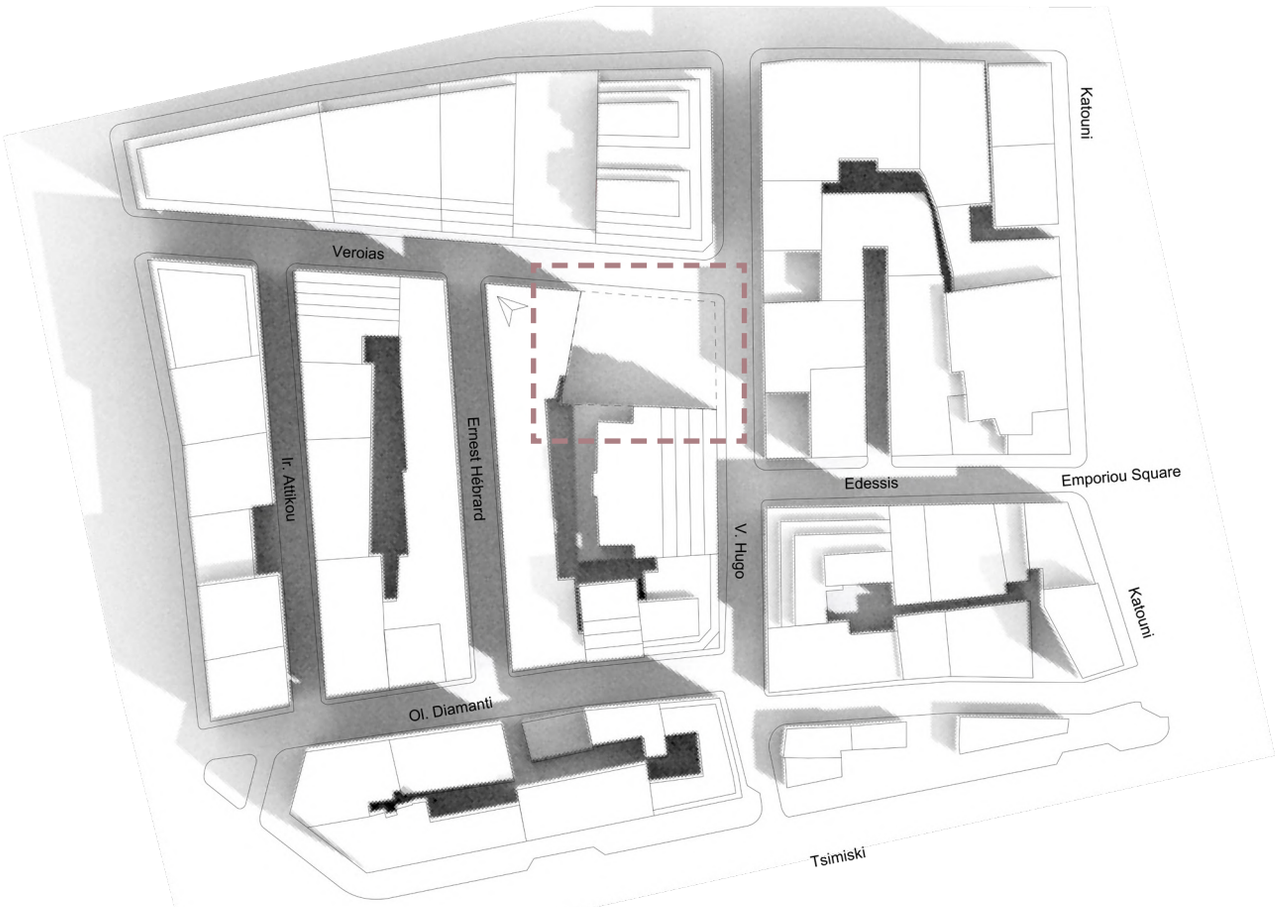
I could have chosen to work with an existing building within the block, emphasizing densification through transformation. However, taking into account the ongoing tendency of revitalizing abandoned ground-floor spaces, I expect this pattern to extent to higher levels as well. Instead, I choose to work with a new building, as an opportunity to reflect upon and change the building habits in Greece. The goal is to do a transformation project by adding qualities of value in a currently misused area within the city complex.

Although parking space in the city is limited, I am excluding it from my proposal. The streets are dominated by pedestrians, especially at night, and it is hard to accommodate both them and the cars in the area. If the parking were to be retained, it would have to move underground, since the ground floor will be utilized for the creation of green spaces, a task hard to complete given the narrow streets and the limited space for a proper entrance.

Pic.41: Greenery

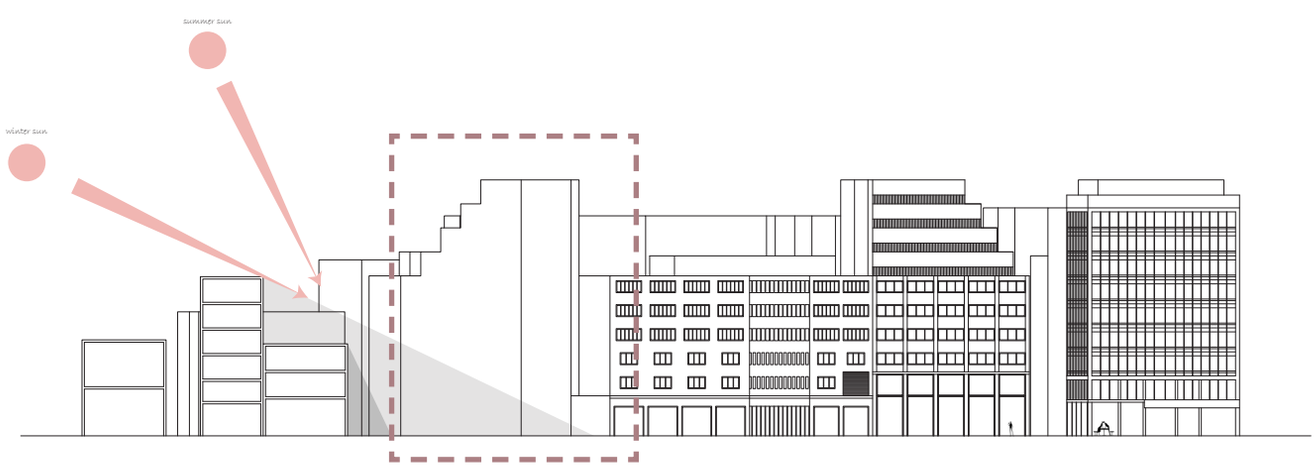
S strenghts	W weaknesses	O opportunities	T threats
density		city centre	excessive car use
tall buildings		port	lack of green spaces
historic area	lack of greenery	young population	
students	overheating	proximity to recreational area	
narrow streets		universities	
abandoned spaces		tourists	
tourists			

Pic.42: Uses-Ground floor



Pic.43: Top view of the plot

Pic.44: Elevation from V. Hugo str.



Pic.45: Sun position and shadows, Elevation Veroias str.

Pic.46: Photo from Veroias str.

Pic.47: Photo from V. Hugo str.

Pic.48: Bird-eye view

Pic.49: Photo from the corner of the street

Pic.50: Panoramic photo

Design strategies

Strategies

My design will revolve around five main design strategies. The main design strategies are related to different sustainable urban development strategies presented in the beginning.

For my design, I will be aware of the area's qualities, such as the height of the neighbouring buildings, their floor heights, the shading effect on the neighbouring buildings and the streets, the functions present in the area and the main users of the space.

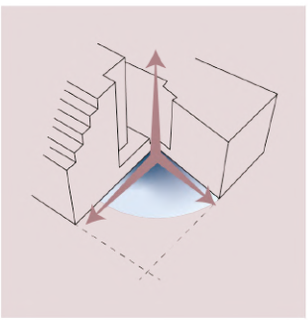
For the successful densification of the area, I will aim to maximize the use of the plot. Considering the building regulations, I will aim for maximum plot coverage, buildable area and allowed height.

To achieve densification without compromising the living conditions and qualities of space I will introduce green elements to my design, such as gardens, green walls, green roofs and potted plants.

The challenge will be to blend these strategies for a harmonious result. In this case, the maximum buildable area will mean the maximum buildable area that will also successfully incorporate green elements.

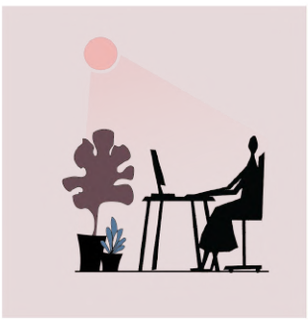
Incorporating biophilic design strategies, such as natural light, greenery and natural materials, will help me blend greenification into my design and mitigate some of the negative effects of densification.

Finally, through research on biological references I am to find solutions in standard building design problems such as natural lighting of spaces, effective shading and overheating.



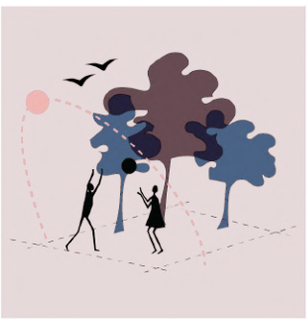
Densification

i aim to maximize the use of the plot through coverage, buildable area, and maximum allowed height.



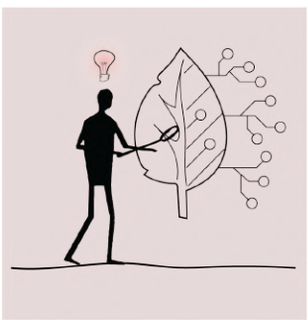
Biophilia

I am going to incorporate biophilic elements to my design by introducing natural light, green elements and natural materials.



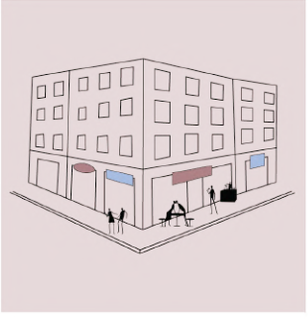
Greenification

i aim to increase the available green space peer resident closer to the WHO recommended. That will be achieved with the implimentation of gardens, green walls & roofs, potted plants, etc.



Biomimicry

I am going to seek biological inspirations to solve problems such as the natural light, shading and overheating in the building.



Context aware design

During my design process I will be aware of the properties of the neighboring buildings (height, floor height, shading), but also of the character of the area (functions, users, etc.).

Pic.51: Design strategies

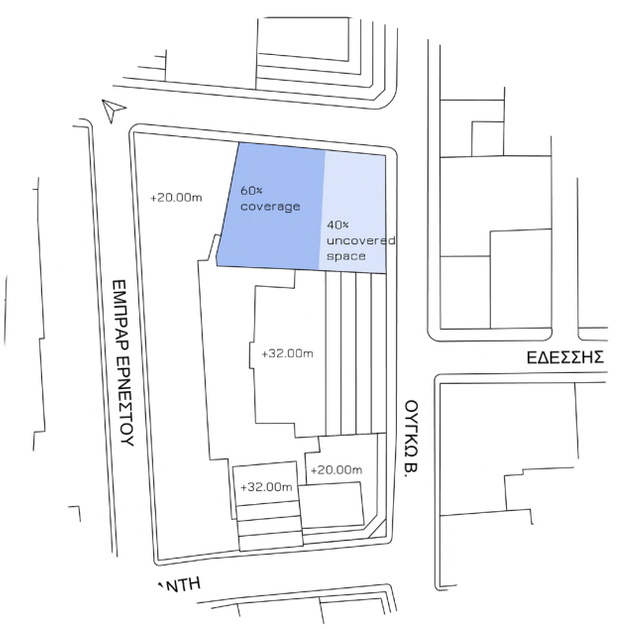
Densification

The plot has a total area of 525 m^2. The maximum coverage allowed on the plot is 60% of its total area, which results to 315 m2 of built area and 210 m^2 of uncovered space. The floor ratio of the area is 4,8. Multiplying the ratio with the plot's area we get a total surface area of 2.520 m^2 for our building, with a maximum height of 32m, which can be adjusted depending on if we have a flat, a tilted, or a green roof, in which cases we can get a few extra meters of height.

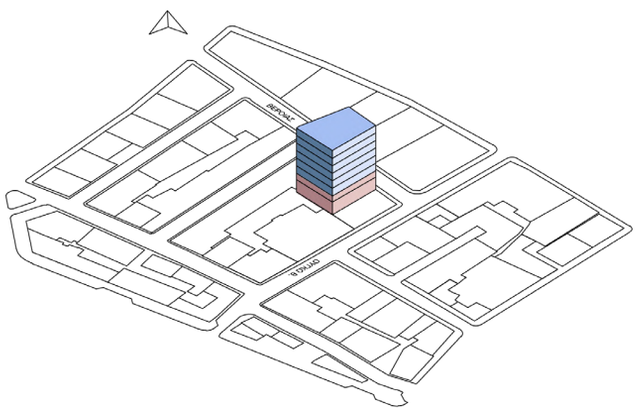
We could reach the maximum buildable square meters, by building a solid block of 8 floors, 315 m^2 each. Considering many of the surrounding buildings reach the maximum allowed height of 32 m, while others stay closer to 20 m, it would be optimal to bridge the difference.

Reaching both maximum height and maximum buildable square meters would require the gradual decrease of each floor's footprint.

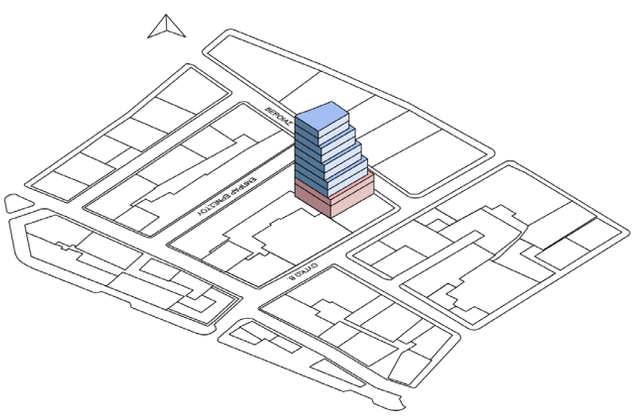
Some of the square meters will be given for 1 person residences, approximately 25 m^2 each, while the rest, about 630 m^2 would be dedicated for more public functions. In case, all the available square meters are utilized for the creation of 1-person apartments, we would have 75 residential units on the plot, resulting in about 75 residents. The number will change, when the final form of the buildings is decided and the different functions get fitted in the building.



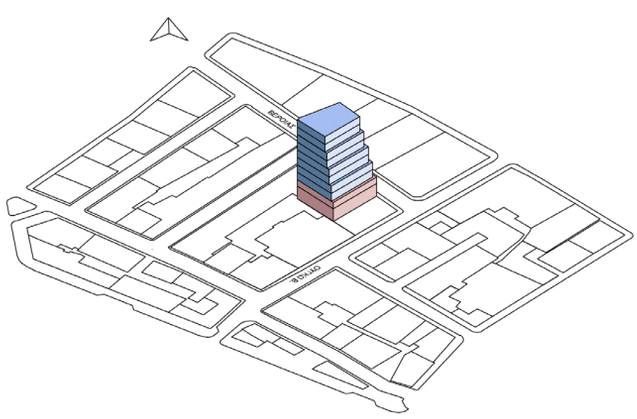
Pic.52: Plot coverage



Pic.53: 8 floors 315 m^2 each, total area: 2520 m^2, total height: 19.5 m



Pic.54: 10 floors - decreasing area (1.5 m from 2 sides), total area: 2.266,8 m^2, total height: 31.5 m



Pic.55: 10 floors - decreasing area (1 m from 2 sides), total area: 2.535,9 m^2, total height: 31.5 m

Greenification

Considering the current situation regarding the square meters of green space per resident different options were calculated:

1. Currently there is a 2,5-2,8 m^2 of green space per resident in the city. By utilizing the uncovered space of the plot to introduce greenery in the plot immediately we have 2,8 m^2 per resident

2. In case of doubling the available green space square meters per resident, reaching 5 m^2 per resident, we would need a total of 375 m^2, 210 m^2 from the uncovered space and 165 m2 added through other forms of green areas.

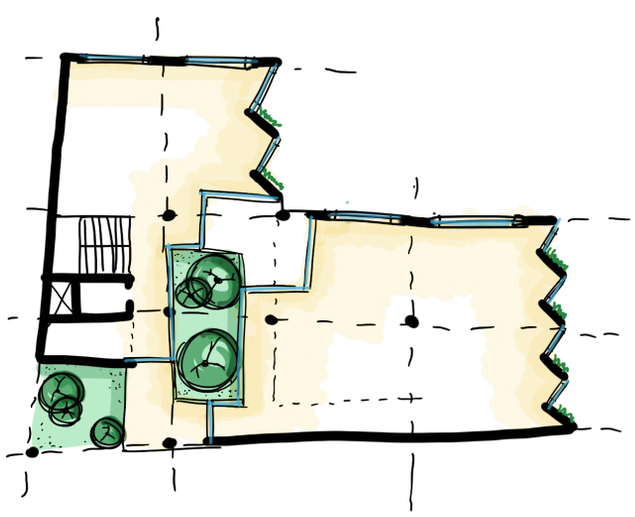
3. Reaching an average of square meters between the current situation and the WHO recommended number, we would need 7 m^2 per resident resulting in a total of 525 m^2, 210 m^2 from the uncovered space and 315 m^2 added through other forms of green areas.

4. According to WHO, the recommended green space per resident is 10 m^2. In that case, we would need a total of 750 m^2, 210 m^2 from the uncovered space and 540 m^2 added through other forms of green areas.

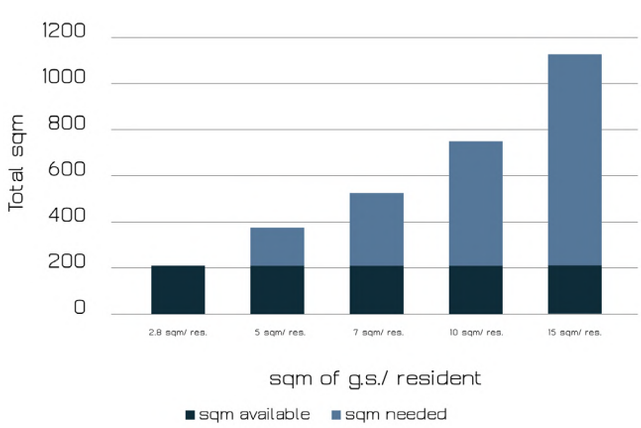
5. In case we want to go above the WHO recommended number, at about 15 m^2 of green space per resident, we would need a total of 1125 m^2, 210 m^2 from the uncovered space and 915 m^2 added through other forms of green areas.

Calculating the Biotope Area Factor is another indicator of the successful greenification of the area. Having as a goal a factor of 0.6, utilizing the 210 m^2 of uncovered space already results in a factor of 0,275. The uncovered space is divided into two different green zones. An area of approximately 103 m^2 with a greened surface permeable to water and air, water infiltration and plant growth with a factor of 0,4 per m^2, and a vegetated area connected to the soil below of approximately 107 m^2 and a factor of 1 per m^2.

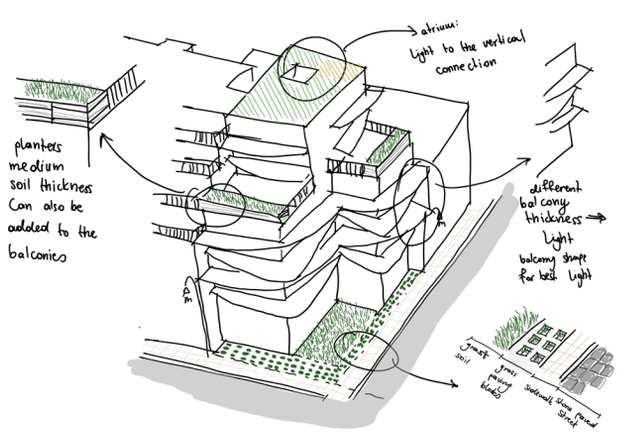
Adding other green elements, such as a green roof, green walls and planters will contribute to reaching the desired 0.6 Biotope Area Factor.



Pic.57: Showcasing green spaces on plan



Pic.56: Square meters of green space



Pic.58: Showcasing green spaces on 3D

Context aware design

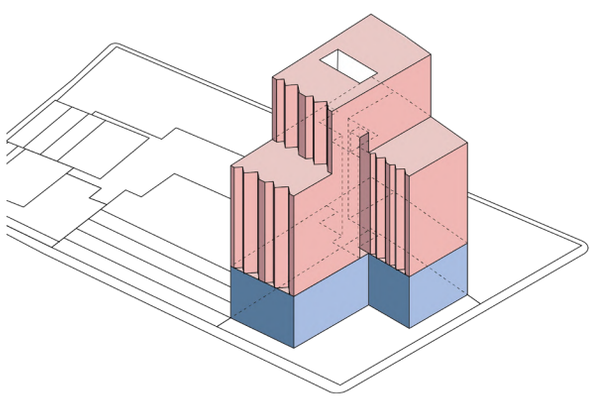
In terms of the actual building, I aim for a form that will be aware of the different heights in the area and it will not negatively affect the other buildings in terms of sunlight. I aim for a building that will respect and get inspiration from the architectural character, such as the heigh ground floors and the mezzanines, but it will also challenge curtain of the existing conditions of the area With the added benefit of the green areas, that have a substantial role in my design process, the new building could have a positive impact on the whole area. Other elements influencing the design are the area's climatological data, access to sunlight, and optimum building orientation.

At the same time, my personal experience of living in the city along with the context helped me formulate the final program.

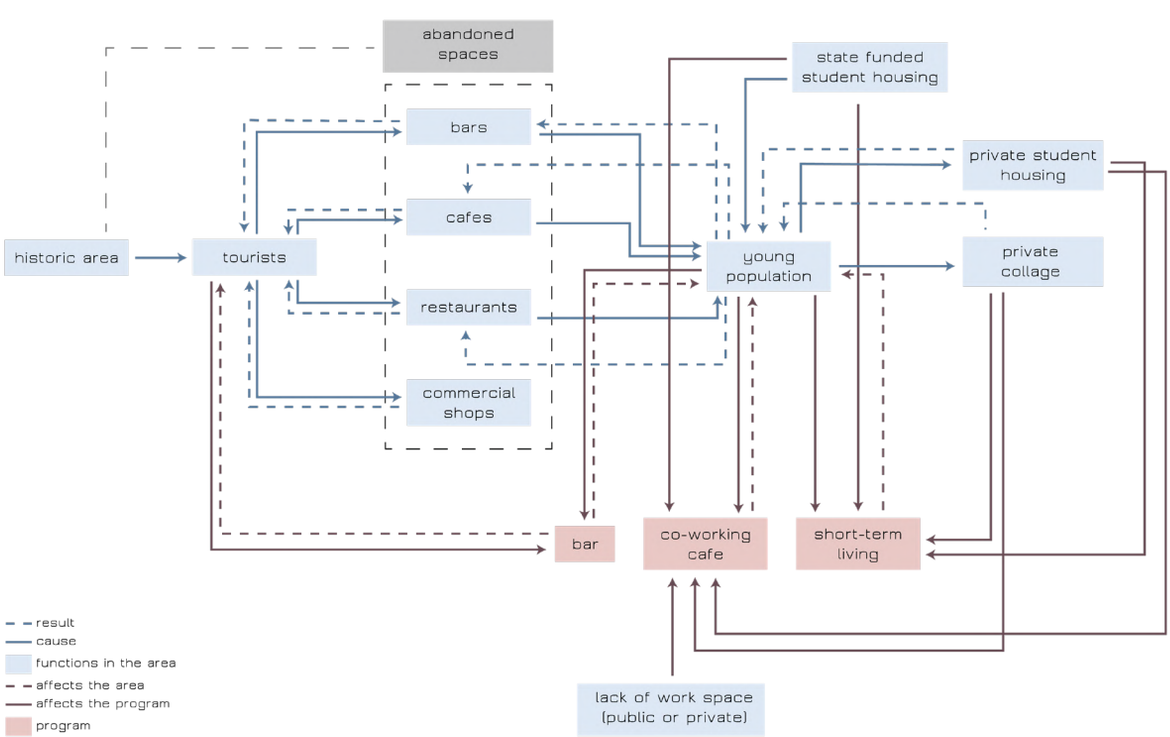
Thessaloniki is a student-oriented city. But there is only a small number of state-funded student housing available, which are given to students according to social and economic criteria. Most students find their residences privately. Since the city is becoming more popular for different people, including entrepreneurs and people working online the demand for housing is becoming higher.

The plot is near a state-funded student housing, a private student housing, and a private collage. These, along with the several cafes, bars and restaurants available in the surrounding streets make this place an ideal location for a short-term living residential building.

Following the pattern of the area, where the ground floor and the mezzanine or the first floor are dedicated to public uses, while the rest of the floors take more private functions. On these two floors a small cafe and co-working space will be created. This use will give a solution to lack of working spaces that university students experience in the city.



Pic.59: Private and public functions



Pic.60: Program

Biophilia

Directly related to the greenification strategy, I am to incorporate biophilic elements to my design. The introduction of more green spaces is also connected to the concept of biophilia. These green spaces aside from surfaces with vegetation, connected to the soil below, will take the form of green roofs unconnected to the soil with a specific substrate thickness, green walls and potted plants (Berlin.de Das offizielle Hauptstadtportal, 2020). The introduction of green spaces will help improve the air quality and the biodiversity of the whole neighbourhood.

Other biophilic elements that I aim to introduce in my design are to optimize access to natural light and achieve good ventilation conditions. The creation of transitional spaces will reinforce the connection between indoor and outdoor environment. With these elements, my goal is to contribute to the good health, emotional, mental and physical, of the users of the buildings, but also to the other residents and users of the area.

Based on that, and the strategies presented so far, I created collages for both the exterior and interior qualities of my building. These collages were created to visualize my ideas for the building and are not indicative of the final forms or qualities of the space.

Pic.61: Exterior vision

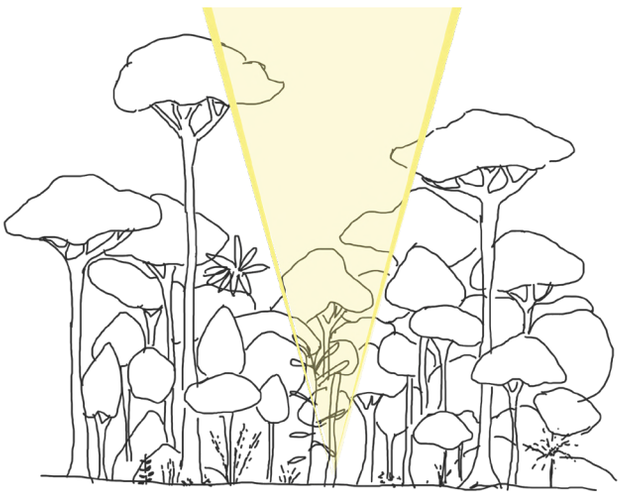
Pic.62: Interior vision

Biomimicry

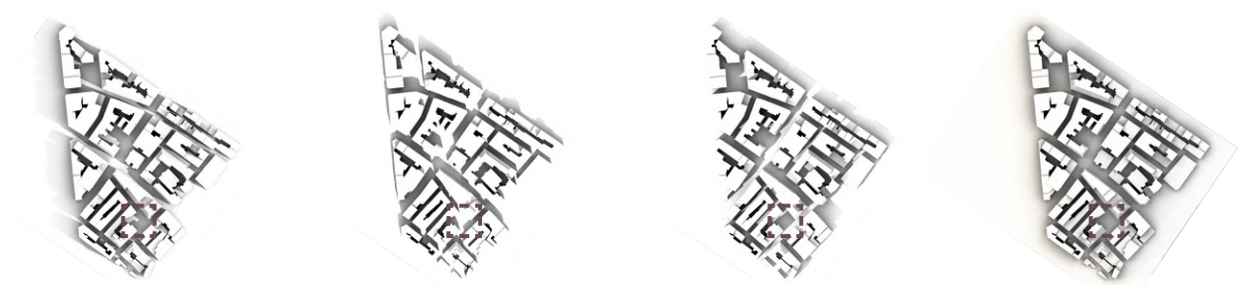
Plants of all kinds need sunlight to complete all the functions necessary for their survival. Growing in different climatic conditions, they come up with different strategies, to get better access to sunlight, avoid overheating, getting cold, etc.

For my biological references, I look for different plants and how they optimize their access to sunlight, how they avoid overheating, how they manage water and other strategies that could be integrated and would be useful to establish in an already densely build environment.

The sun studies will give me a guide for the area of the plot that get the most sunlight throughout the year.



Pic.63: Forest organization



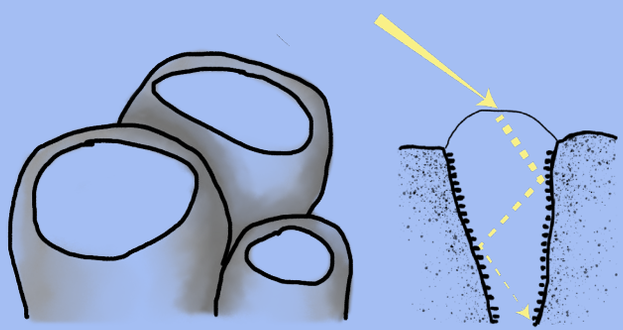
Pic.64: Shadow studies on specific dates and times

Window plant (Fenestraria aurantiaca)

The window plant had to adapt to a dry and hot climate, while finding a way to harvest sunlight.

The plant buries its body in the ground, to protect from the sun rays and the heat and uses its top, the lens, which is exposed, to guide the sunlight on the inside. The lens is curved to bend the light and guide it at the centre of the plant. Beneath the lens, there are clear cells, filled with water, that bend the light and scatter it in all directions.

Sunlight shafts simulate the strategy, of vertically transmitting light into the building. Taking inspiration from the window plant we can use water, or other materials, shapes, and forms, that can bend the light to direct sunlight into the areas that is most needed (Hoff, 2019).



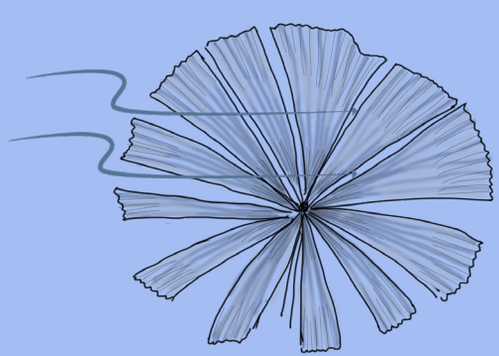
Pic.65: Window plant

Australian Fan Palm

Sunlight is integral for the survival of plants, but exposure to extreme heat can be harmful, which is why plants develop strategies that help them keep temperature below harmful levels.

The leaves of the Australian Fan Palm are thin, and separated into segments and tilted in a way that allows the wind to blow through them, reducing the temperature around the plant (AskNature Team, 2016).

Inspired by the Australian Fan Palm we could create openings in our buildings that would allow the wind to blow through the building carrying away the heat and reducing the temperature.

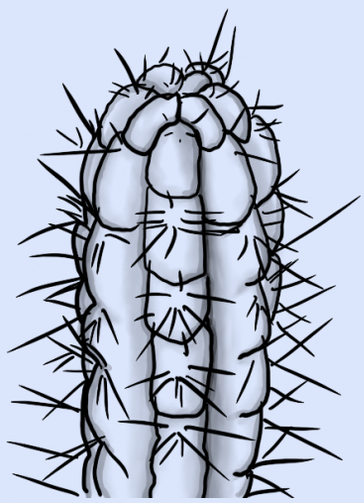


Pic.66: Australian Fan Palm

Cactus

Cacti had to adapt in extreme heat conditions, and they developed adaptations to keep cool and save water. The alternating ridges create a peaks-and-troughs pattern that protects cacti and prevents them from getting too hot and dry. The peaks shade the troughs and reduce the heat that gets to them. Due to the shading provided by the peaks the air in the troughs is cooler. The cooler air can absorb more heat from the plant. As the air warms up it rises upwards, where the wind carries it away. Furthermore, the ridges disturb the airflow around the plant allowing the wind to carry away more heat (Lippsett, 2017).

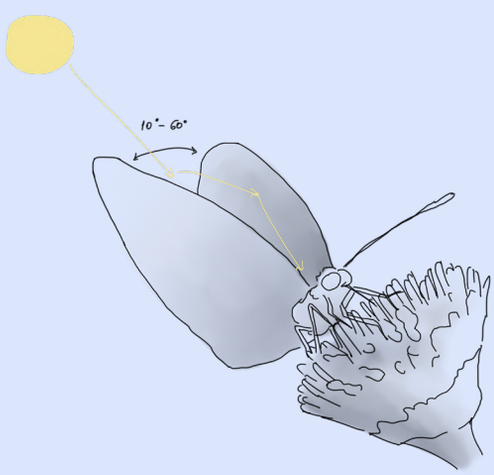
The peaks-and-troughs pattern of the cacti could inspire facade designs, which would take advantage of the self-shading ability of the design.



Pic.67: Cactus

White cabbage butterfly

The butterfly needs to be warm to fly. In the morning, it turns its body towards the sun and positions its wings at an angle between 10-60 °C. The sunlight to bounces from the wings to their bodies, increasing their temperature (Stier, 2023).



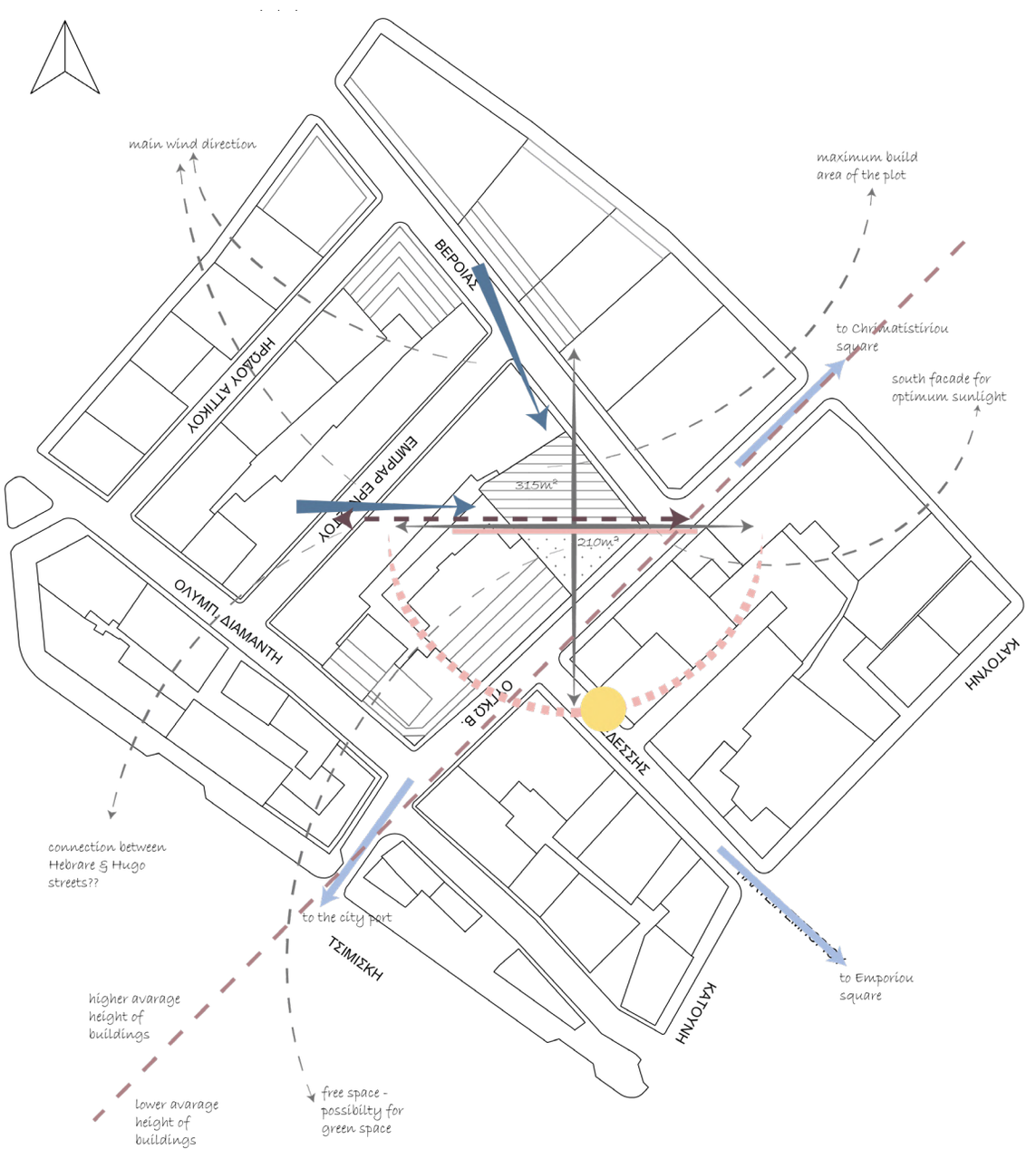
Pic.68: White cabbage butterfly

Sketching process

I started my design process by sketching my impressions of the site, along with information I consider important for the design, such as the maximum coverage, the sun path, main wind directions, connections to important points and the division between the building heights. Sun studies that I presented earlier, gave an idea of where the areas which get the most sunlight throughout the year are located.

My sketching process can be divided into 3 rounds. In the initial sketching I focus on investigating different forms and how they connect to neighbouring buildings, without restricting myself more in terms of context. The forms produced are mostly prismatic and unusual for the area. On the second round, I focus on forms that are much more guided and aware of the context. The forms produced are conventional and expected to be seen in the area.

Taking the learning from both sketching rounds, I begin with the final round of sketching which results in the final form of the building. That is the point where I start to sketch and investigate more focused points on the form, internal organization, facades, movements balconies and other important characteristics that will compose the final proposal.



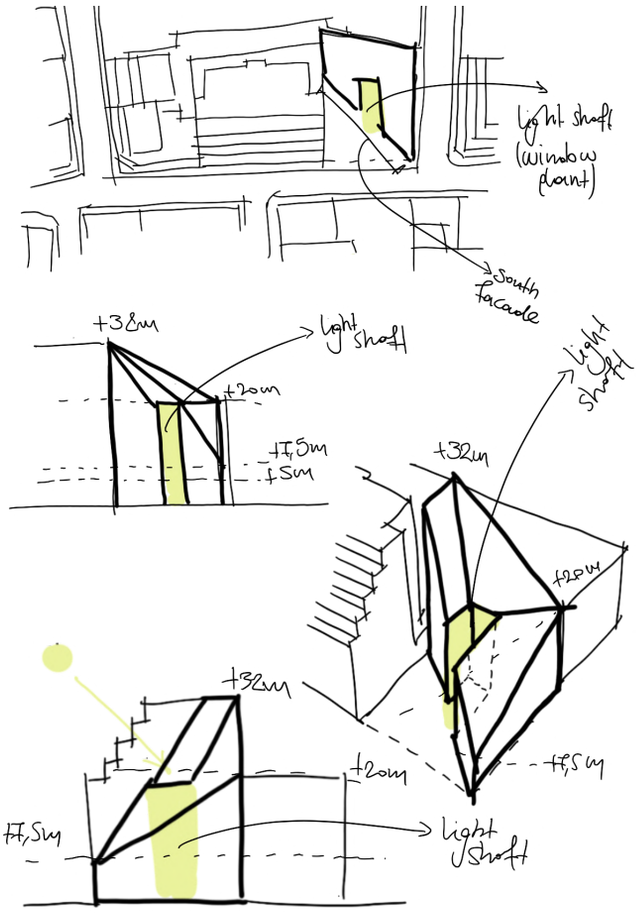
Pic.69: Area diagram

Initial sketches

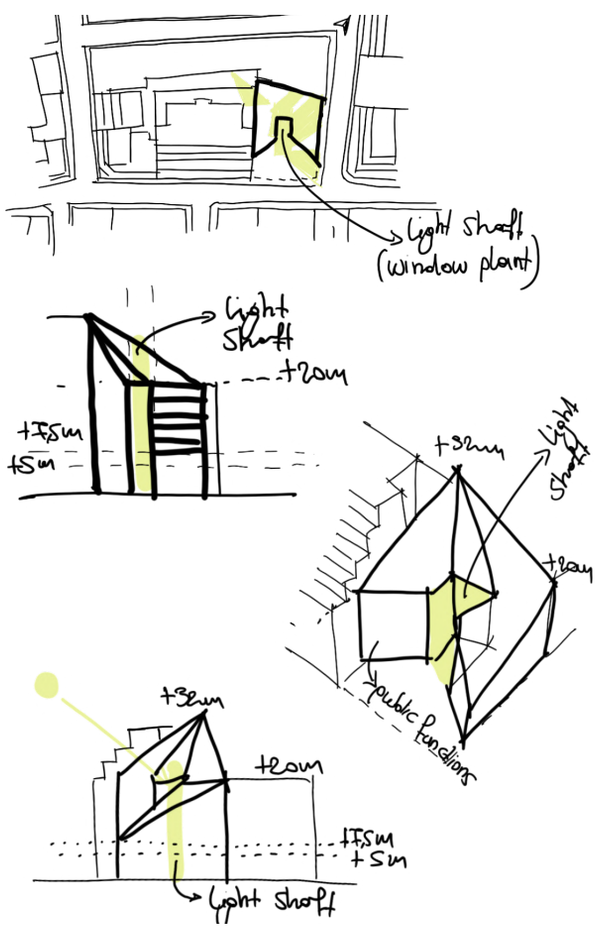
The initial sketches investigate different volumes and how these volumes connect with the adjoining buildings. In these sketches, I try to create south facing facades and lights shafts in the areas with the most sunlight throughout the year. The results are usually prismatic forms, with no further building or liveable qualities.

I sketched all the volumes on plan, facades and 3Ds, to have a clear understanding of how they are working from all different angles.

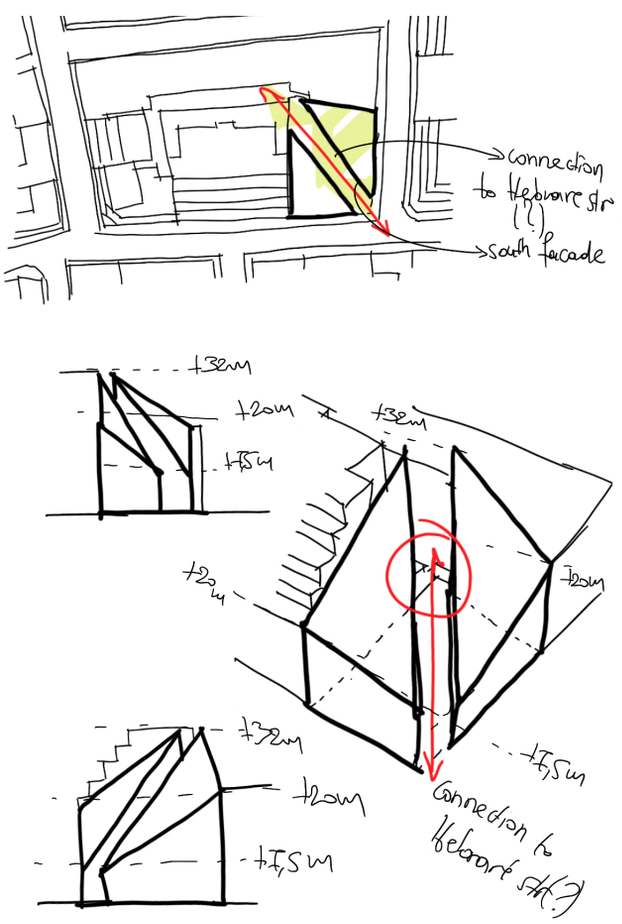
During the whole sketching phase I was always aware of the building regulations, of maximum allowed plot coverage, buildable area, and height.



Pic. 71: Option 2 - Hand sketch



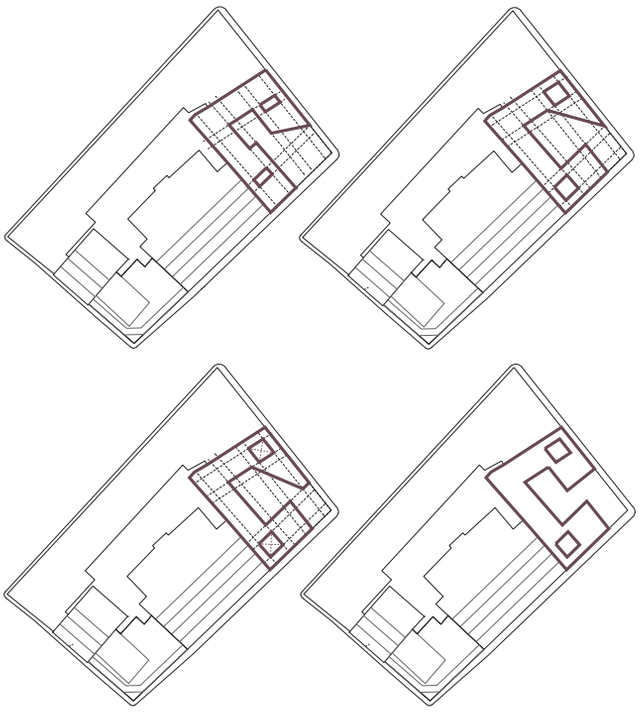
Pic. 70: Option 1 - Hand sketch



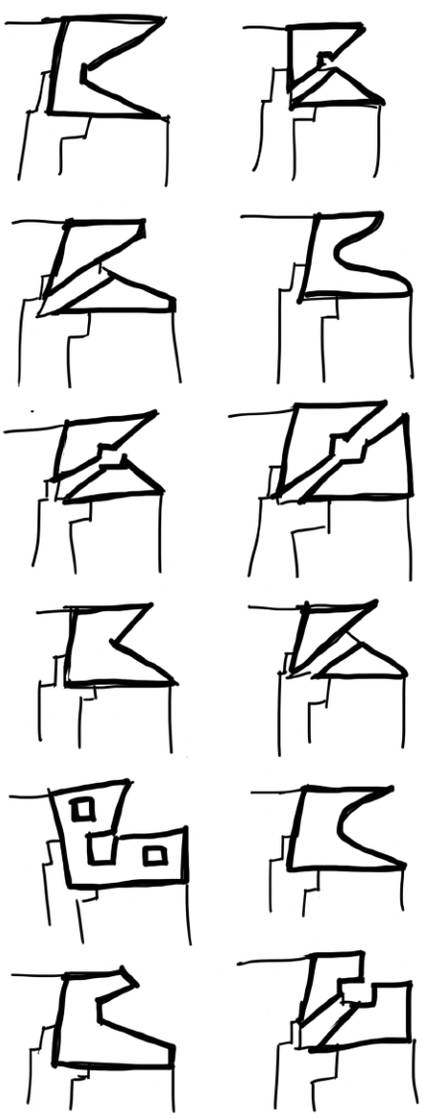
Pic. 72: Option 3 - Hand sketch

After evaluating the initial sketches, I tried to blend some of them together. Important things I considered while sketching included: south facades, horizontal connections on the higher floors and the shading of the area. This time in my sketching, I tried to consider vertical connections and movement, while trying to keep as much of the original volume as possible.

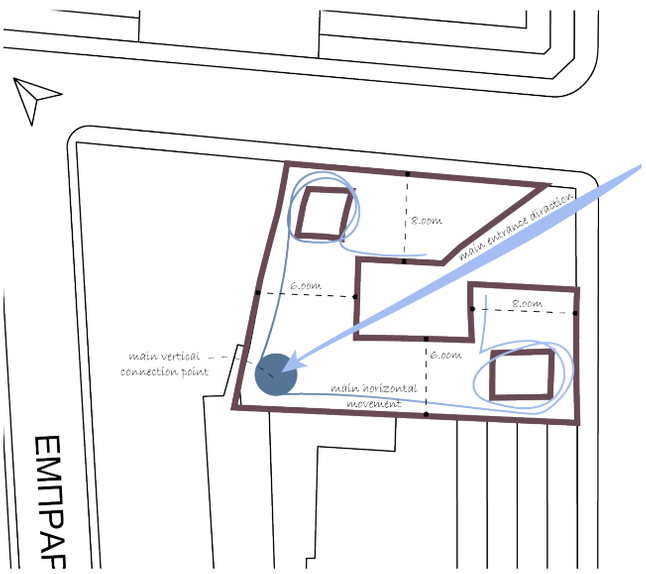
When I actively tried to place these elements into the volumes, I encountered problems such as long distances to access the vertical connections, corners that could not be utilized, unclear placement of corridors and a lot of square meters lost in dark spaces and multiple vertical connections.



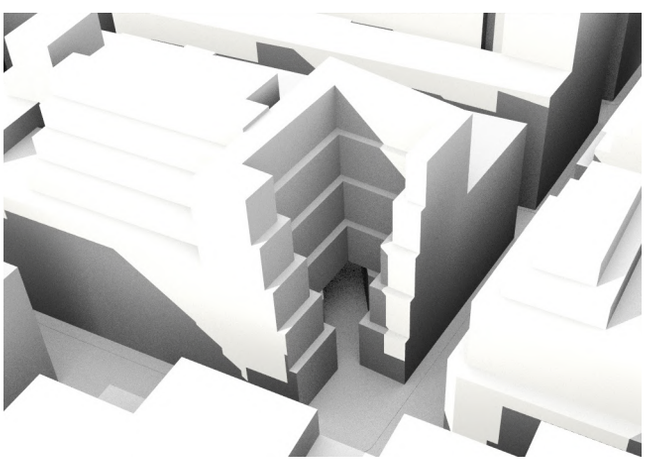
Pic.74: Selected CAD alterations



Pic.73: Combine elements from Options 1 & 3



Pic.75: Sketcing on movement

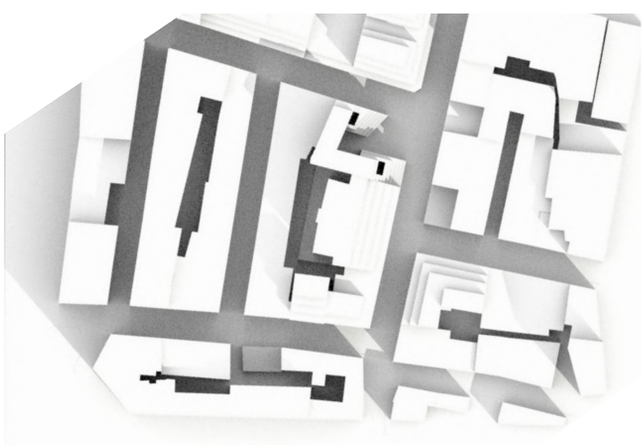


Pic.76: Perspective

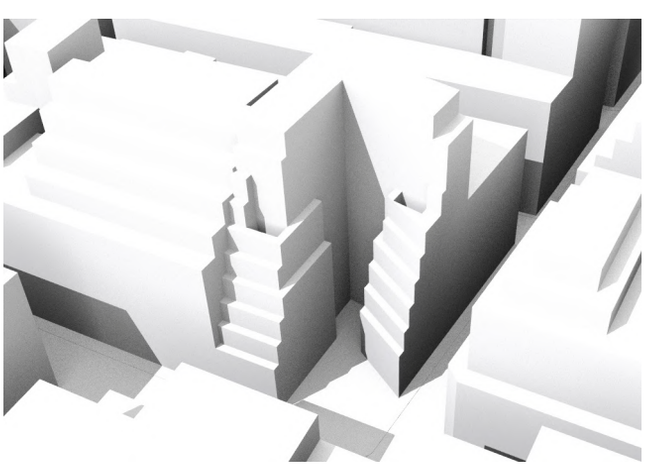
Moving forward I kept in mind important information and observations to consider during the next round of sketching.

While south facades, with the proper shading would be the optimum choice according to the climatic conditions, the orientation of the plot and the placement and height of the surrounding buildings, are not optimum for such a design decision.

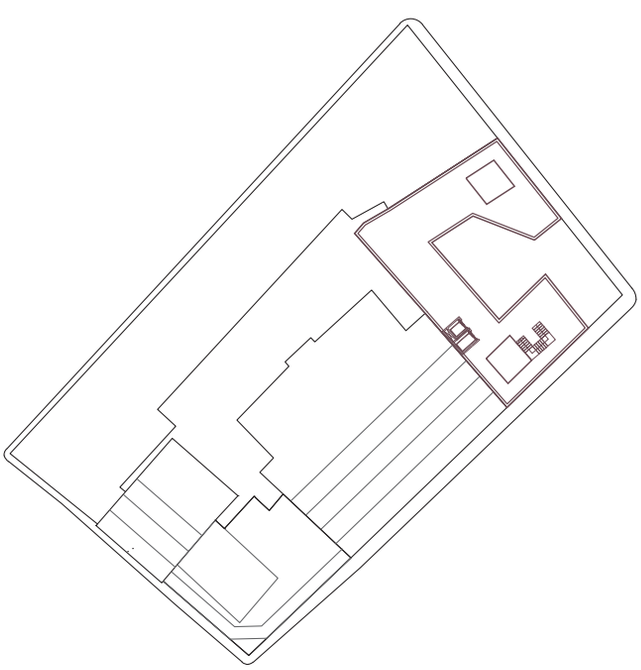
A long building placed on the edges of the plot would need at least two vertical connection places, which would result in the loss of valuable square meters. A thin building placed on this plot results in the creation of corners, which are hard to solve in the design and create dark areas.



Pic.77: Top view



Pic.78: Perspective



Pic.79: CAD alteration

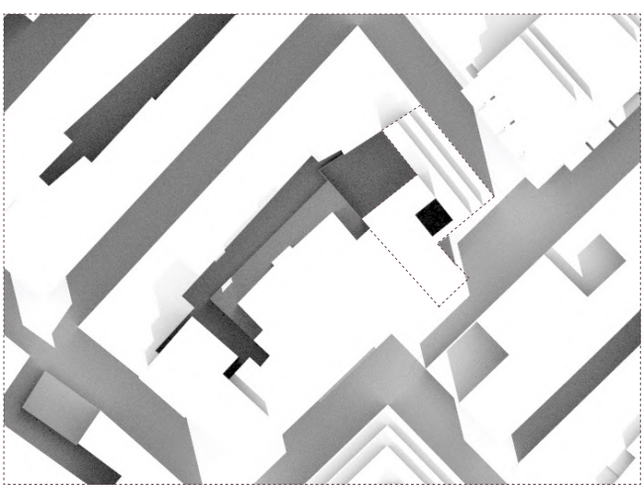
Context driven sketches

During my second round of sketching, I focused more on the context.

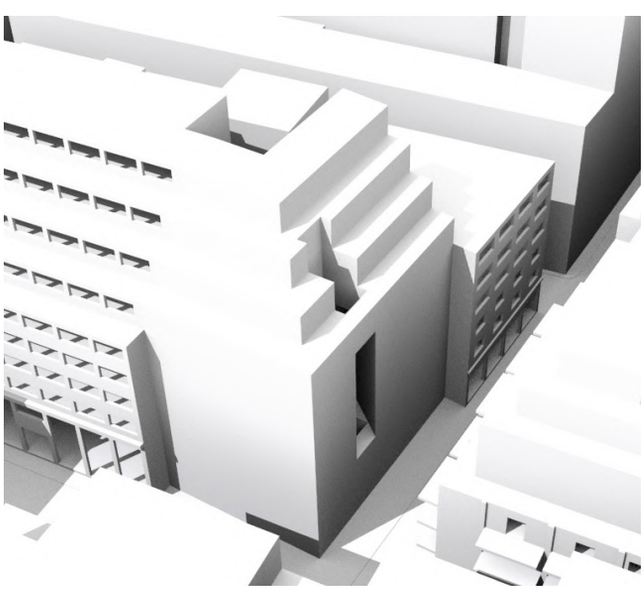
The form was designed to complete the gap in the building block, leaving a part of the uncovered space at the back of the plot and blocked from sunlight.

Movements and points of interest in the area indicated a crossover point for the entrance at the corner of the plot, with the vertical connection point close by. An atrium was introduced in the area to bring light to an otherwise, somewhat, dark area.

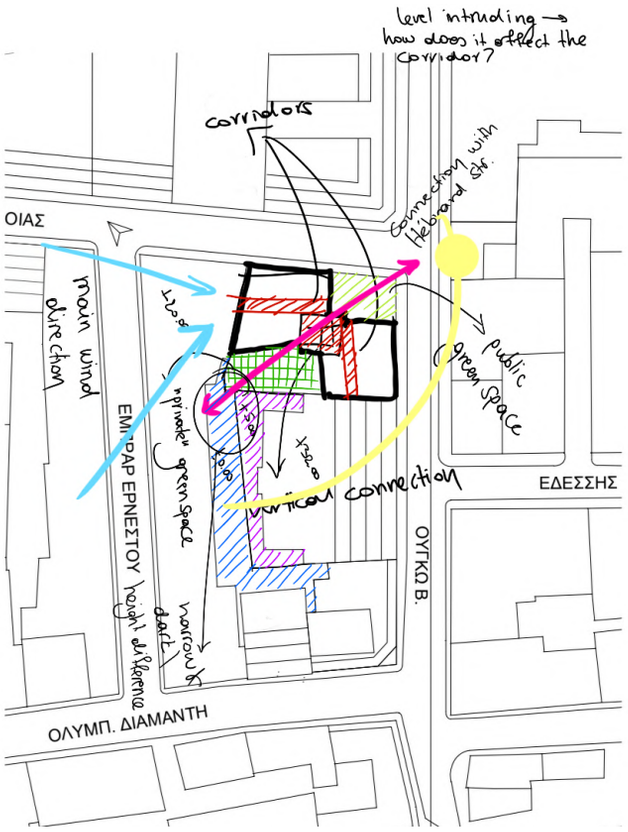
On the hight floors a cut was introduced for access to more natural light and for the natural ventilation of the building.



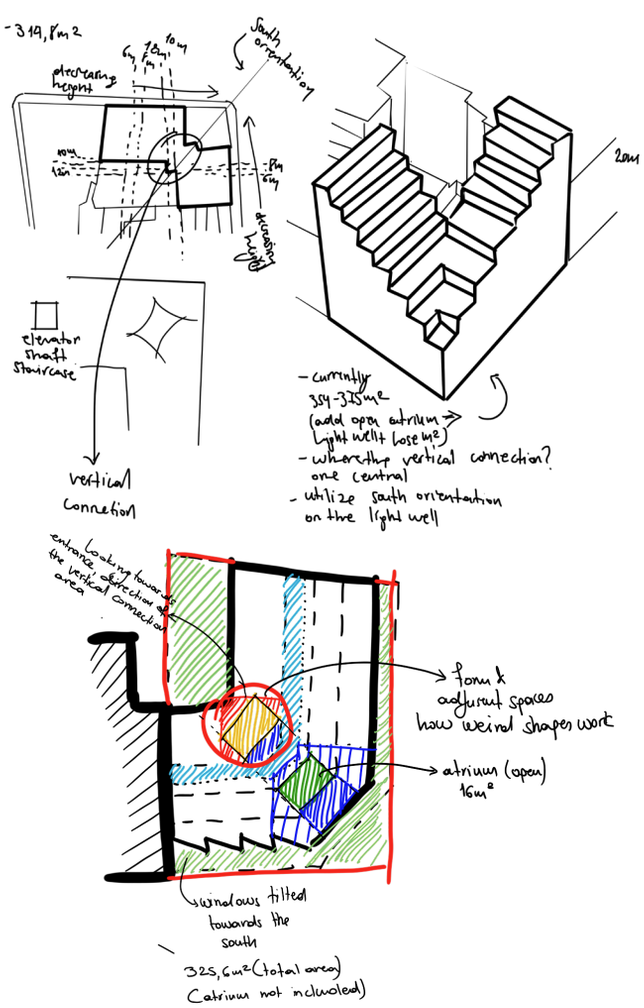
Pic.80: Placement of the atrium



Pic.81: Priliminary gap sketches



Pic.82: Context driven site sketch

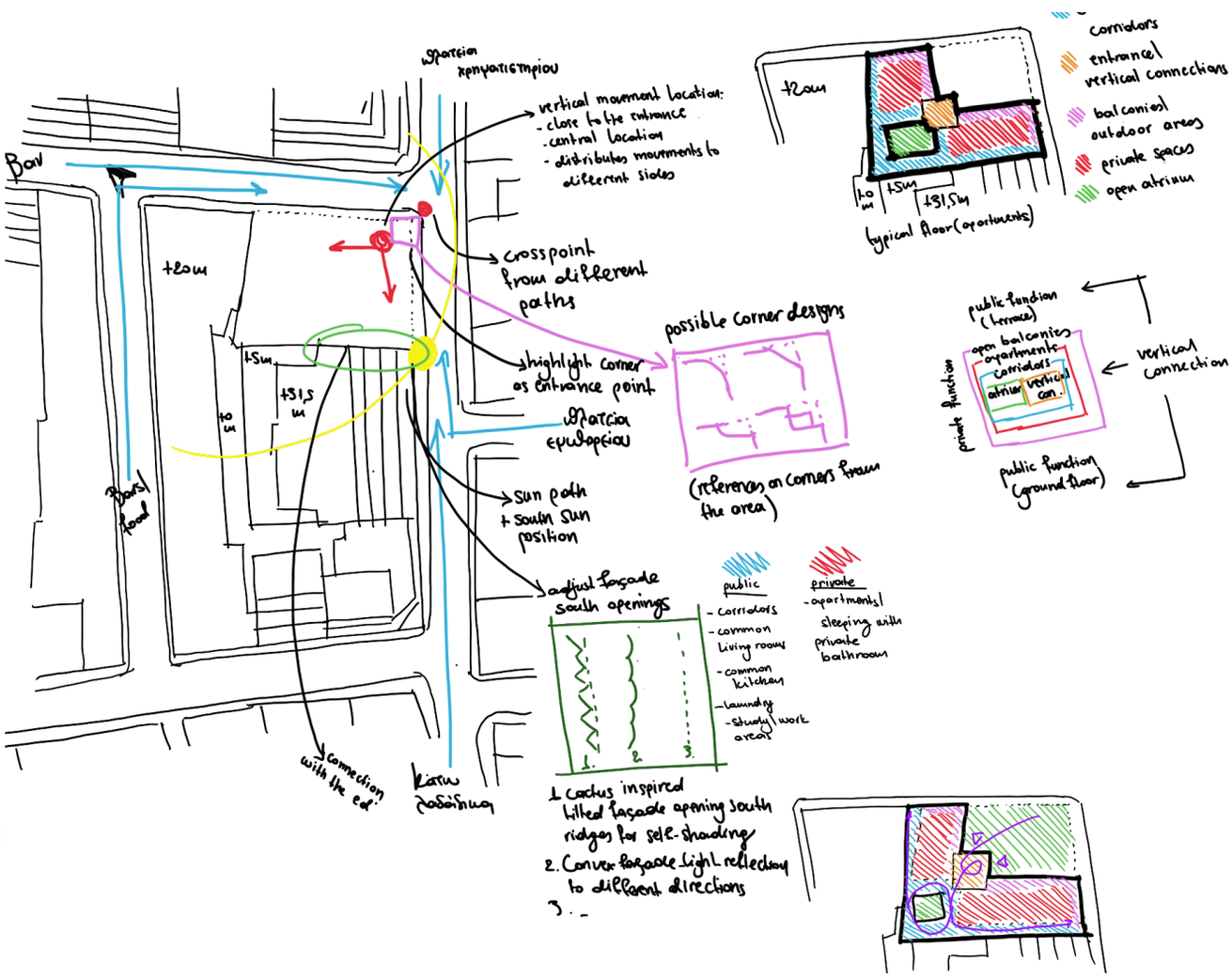


Pic.83: Context driven sketches

Final result

Combining my learnings from both sketching rounds, the goal was to create a building that is functional, successfully bridges the gap between densification and urban green spaces and is still aware of the surrounding context.

The final form, although far less prismatic compared to the ones created during the original sketches, completes all the goals. The final design successfully brings together urban densification and urban green spaces, through the implementation of biophilic and biomimetic design strategies. It achieves almost maximum densification, according to the building regulations, while increasing the available green space per resident, and achieving the required Biotope Area Factor.

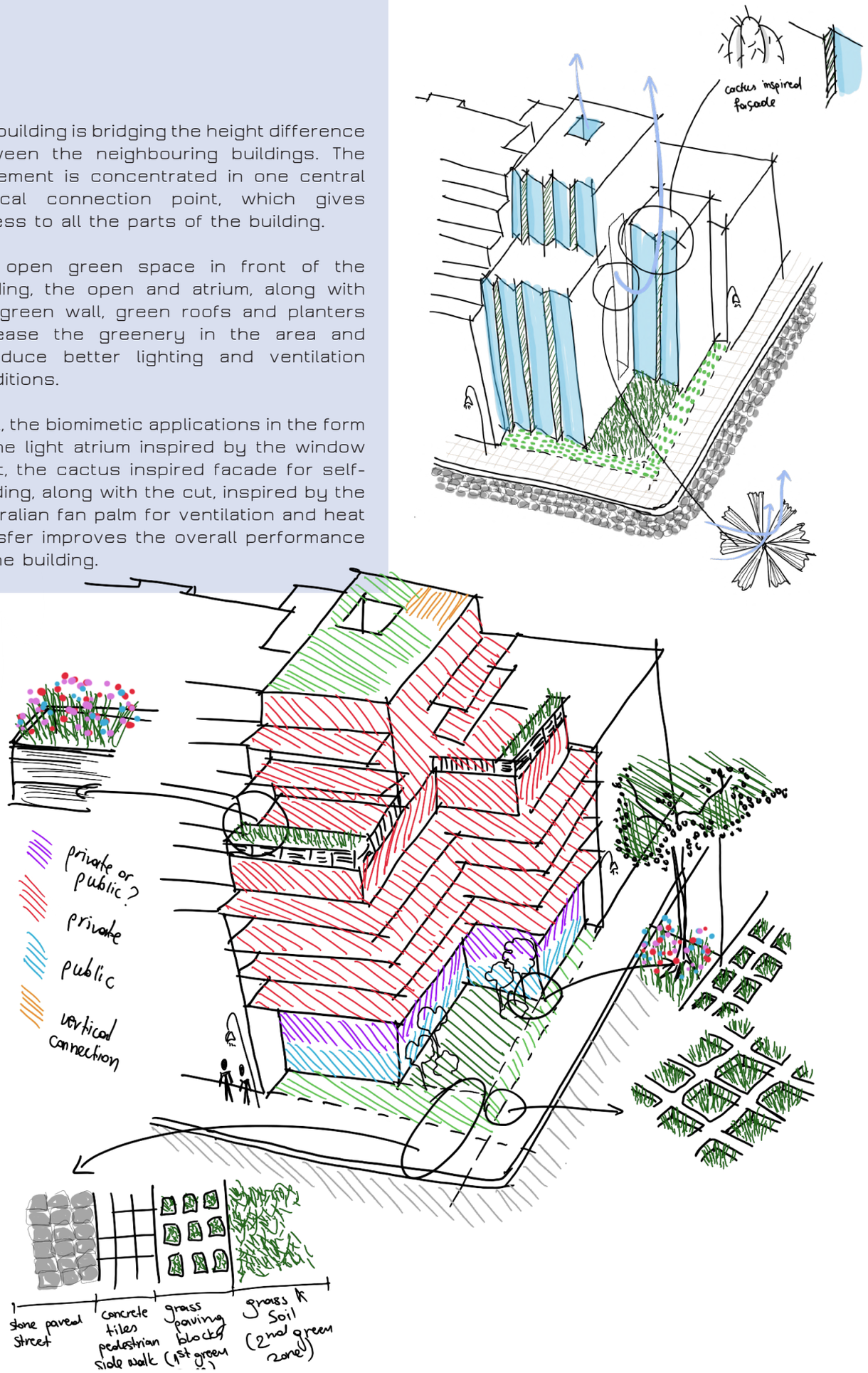


Pic.84: Area diagram

The building is bridging the height difference between the neighbouring buildings. The movement is concentrated in one central vertical connection point, which gives access to all the parts of the building.

The open green space in front of the building, the open and atrium, along with the green wall, green roofs and planters increase the greenery in the area and introduce better lighting and ventilation conditions.

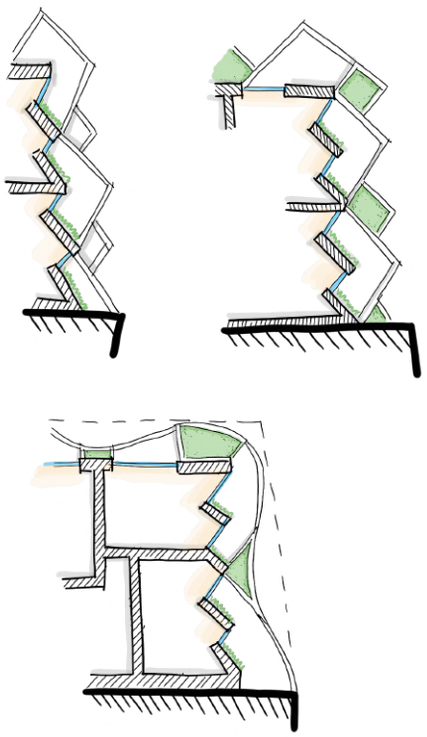
Final, the biomimetic applications in the form of the light atrium inspired by the window plant, the cactus inspired facade for self-shading, along with the cut, inspired by the Australian fan palm for ventilation and heat transfer improves the overall performance of the building.



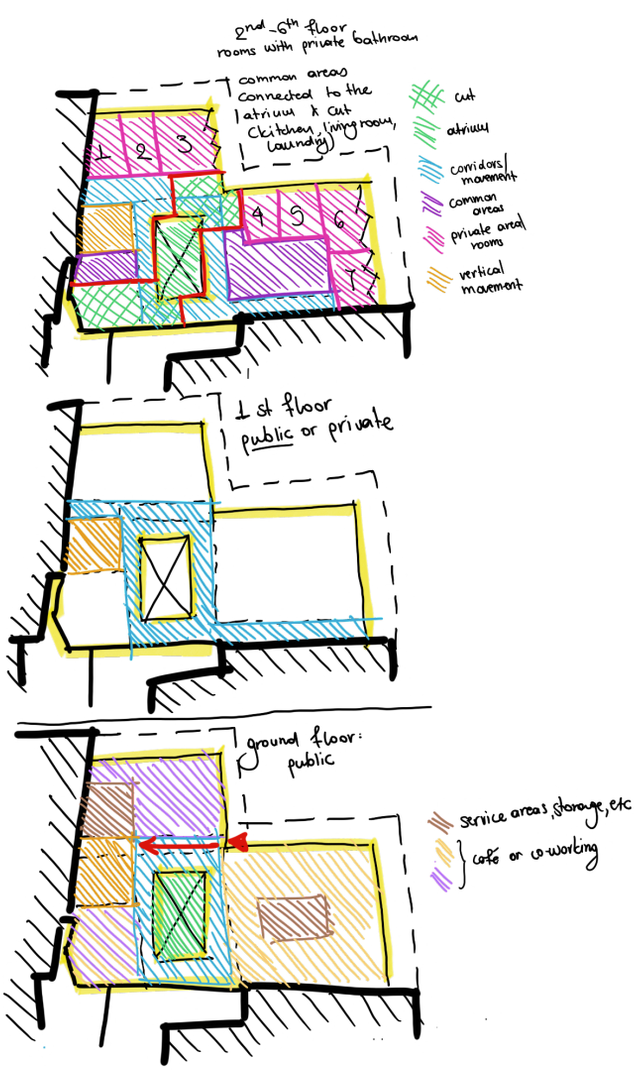
Pic.85: Sketch of the form of the final volume

Other investigations

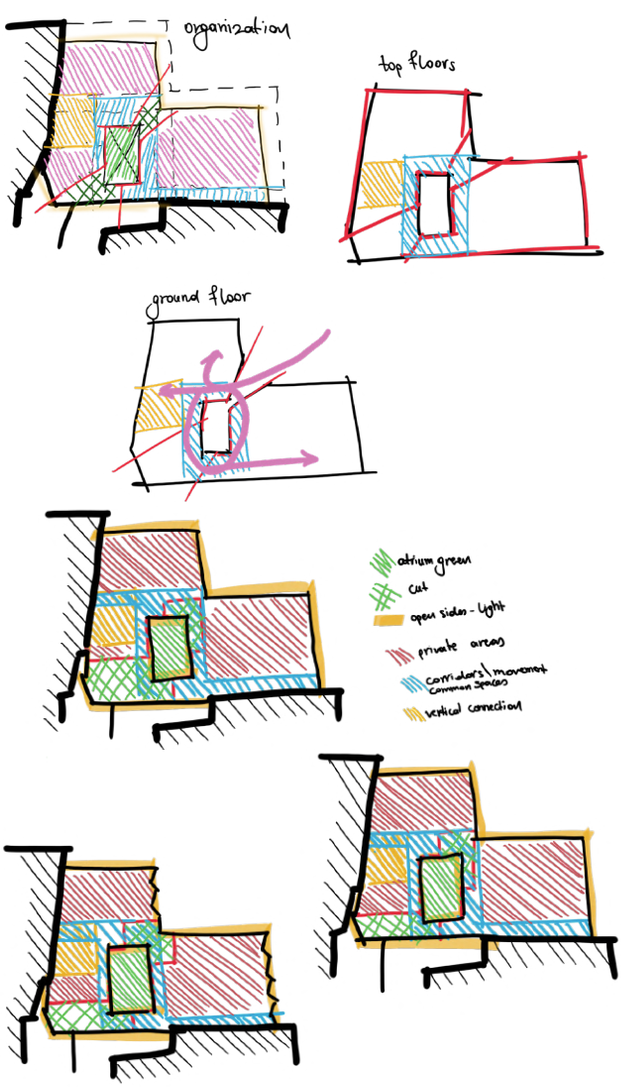
After the final form of the volume was decided further investigations had to be made. These investigations included the final form of the cut, the floor organization and the balconies.



Pic.87: Balcony investigations



Pic.86: Floor organization



Pic.88: Cut investigations

Proposal

Design

The final building is 10 stories tall. The ground floor and the first floor are public hosting a cafe - bar and a work cafe respectively. From the 2nd to the 6th floor there are most of the living places, which include rooms with private bathroom and common kitchen, living area, laundry and storage space. On the last 3 floors the apartments are bigger, and they also include private kitchen and sitting space.

Both densification and the available green space are successfully increased.

For maximum densification the numbers included 60% of the plot coverage, a total of 315 m^2, and 2520 m^2 of buildable surface. The coverage in my proposal is 311,03 m^2, which means I have utilized 98,7% of the available area. The total buildable surface is 2512,75 m^2, which is 99,7% of the maximum allowed buildable area.

In terms of available green space per resident, with a maximum of 47 residents living in the building at the same time, the available green space per resident is approximately 9 m2. As a result, in my proposal I have about 3 times more green space per resident, compared to the average available green space per resident of the city, which is 2,8 m^2, and I am close to the WHO recommended 10 m^2 per resident.

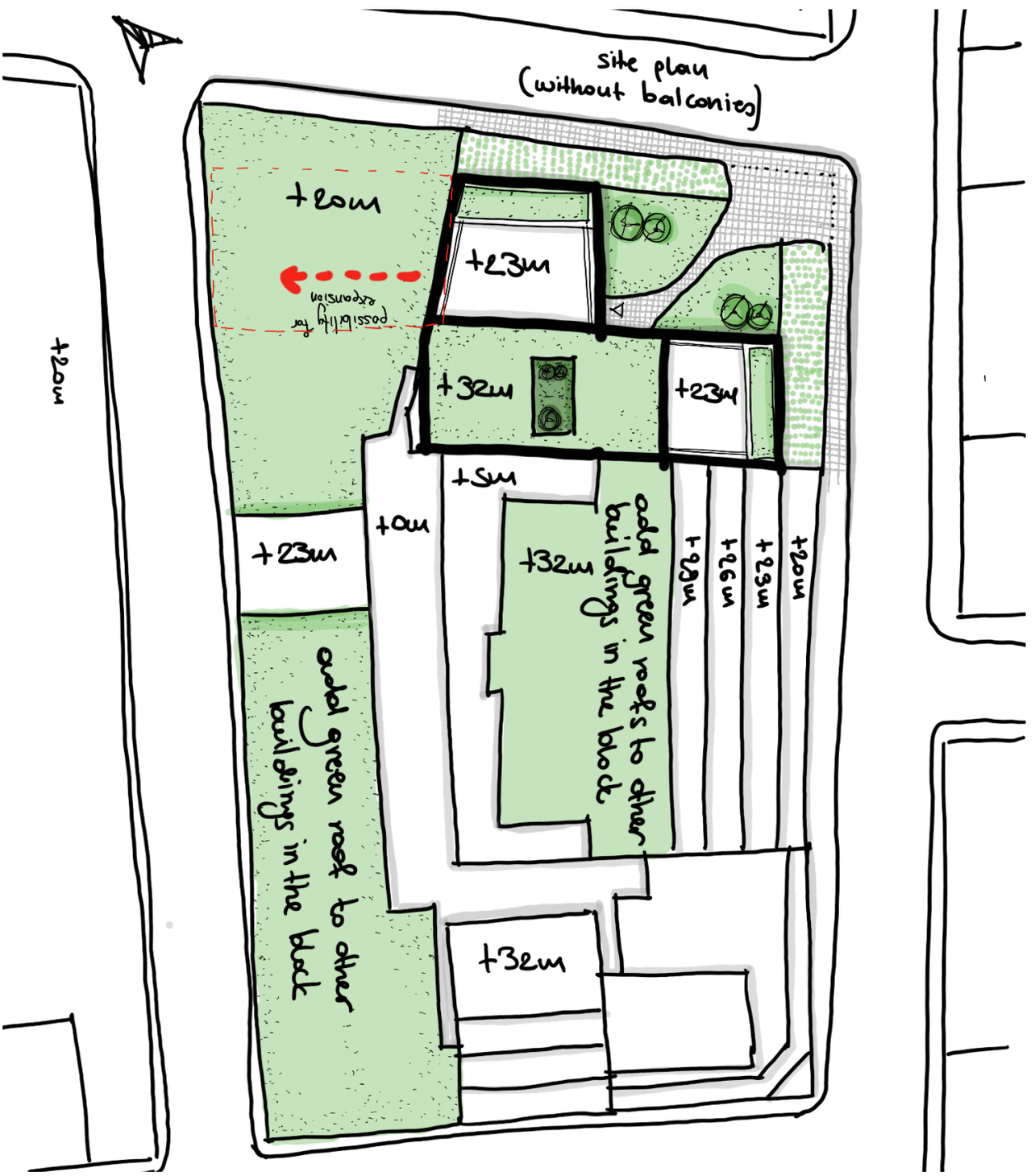
Pic.89: Exterior render

Site plan

Pic.90: Site plan 1:200

The building is developed along the inner edges of the plot. The area in front of it is designed as a green space open for everyone. Right on the corner of the plot there is an area with free soil, surrounded by a sitting block, giving the opportunity to people to stop and seat near the greenery. The rest of the available space is used to create paths with grass paving blocks running along the building.

Based on the Berlin model for the Biotope Area Factor, and calculating only the surfaces, not individual planting elements, I have reached a Biotope Area Factor of 0,63, slightly larger than the recommended 0,6 for the construction of new residential buildings.

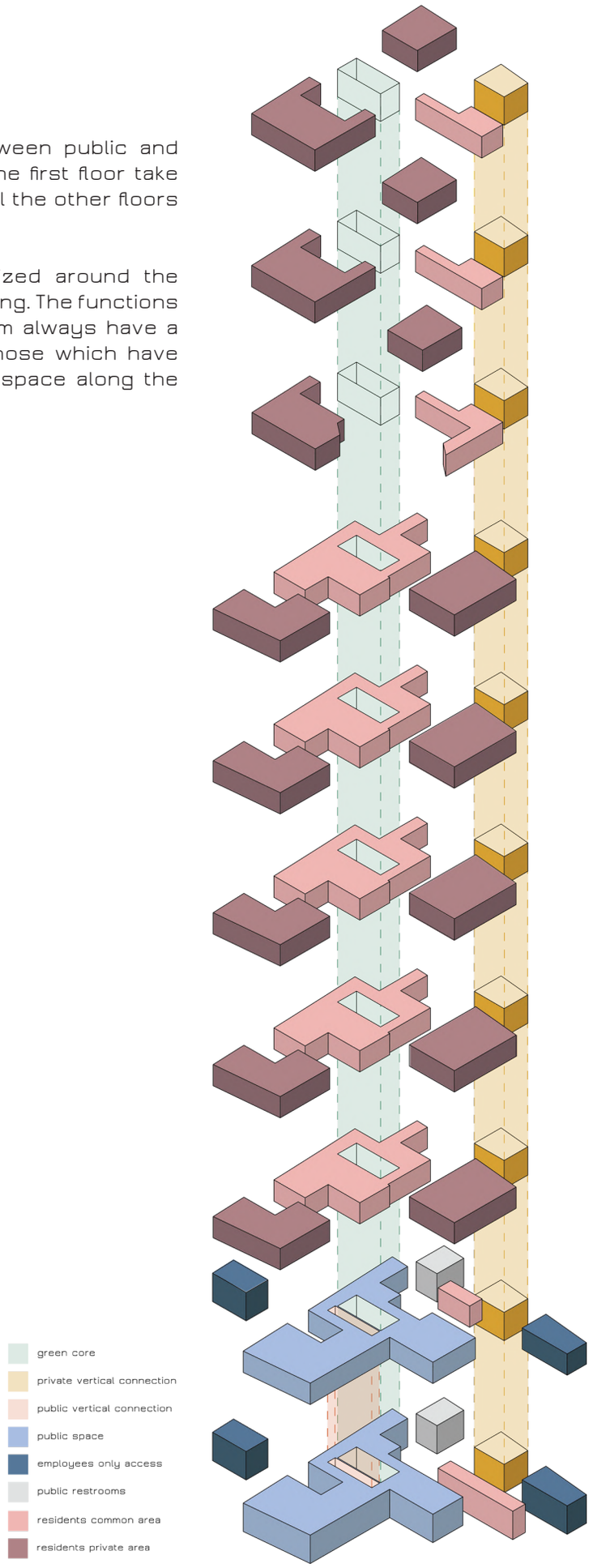


Pic.91: Potential expansion of green areas in neighboring roofs

Organization & Movement

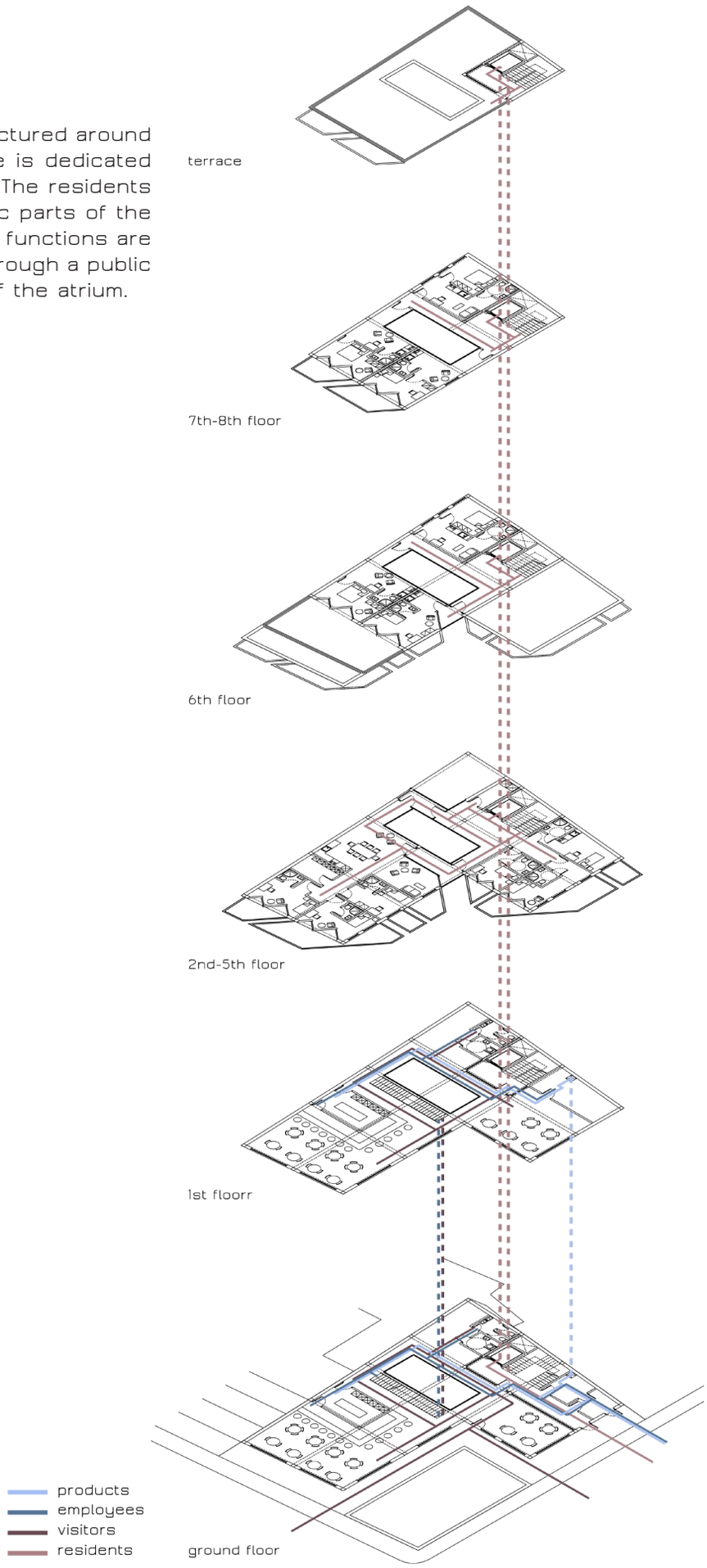
The functions are divided between public and private. The ground floor and the first floor take on the public functions, while all the other floors are dedicated to private use.

The different uses are organized around the atrium, the light core of the building. The functions in direct contact with the atrium always have a more public character, while those which have restricted access take up the space along the building's facade.



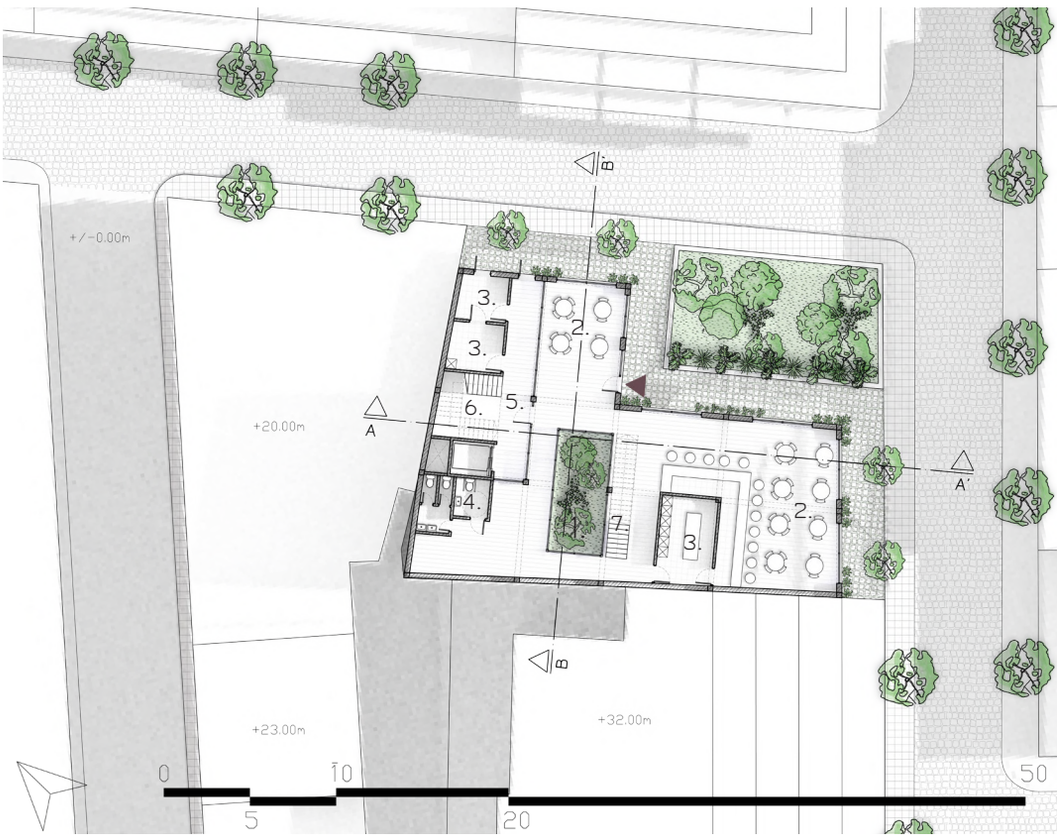
Pic.92: Organization diagram

All horizontal movements are structured around the atrium. The main vertical core is dedicated for private use by the residents. The residents have internal access to the public parts of the building. The visitors of the public functions are moving between the two floors through a public staircase along the longer side of the atrium.



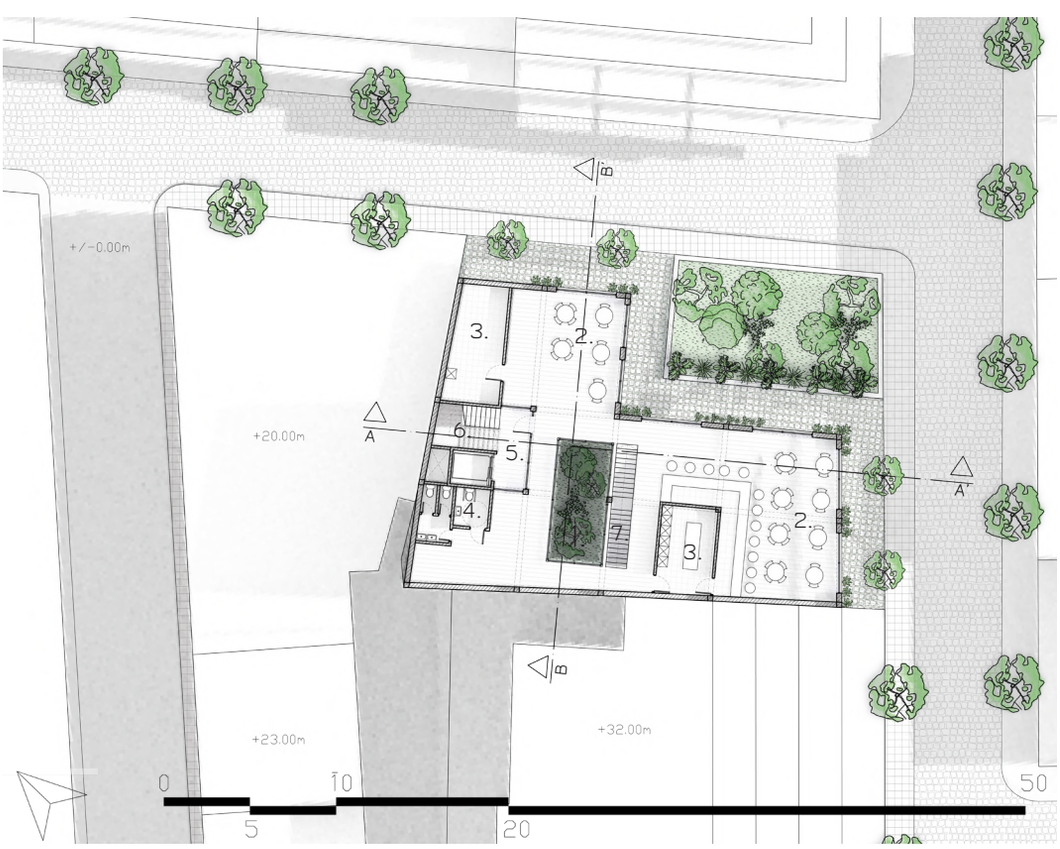
Pic.93: Movement diagram

Floor plans



1. Atrium
2. Cafe/bar
3. Cafe/bar helping spaces
4. Toilets
5. Residents access corridor
6. Residents vertical connction
7. Public staircase

Pic.94: Ground floor

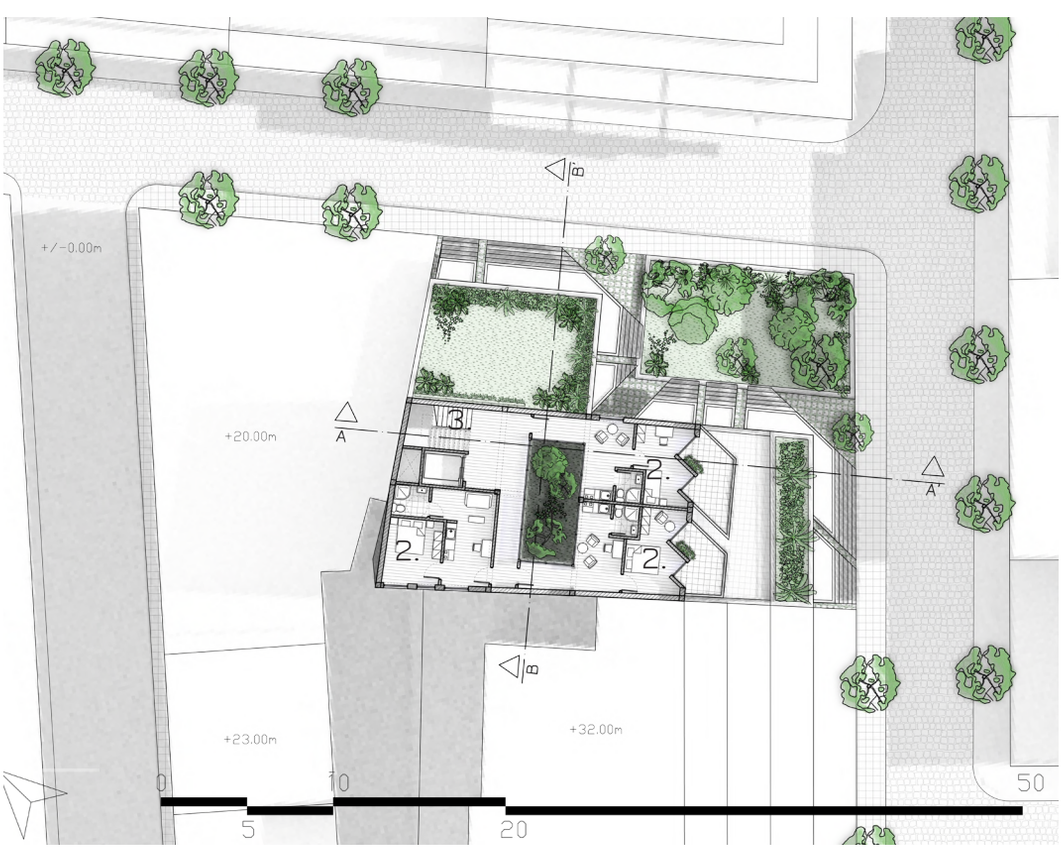


1. Atrium
2. Cafe/bar
3. Cafe/bar helping spaces
4. Toilets
5. Residents access corridor
6. Residents vertical connction
7. Public staircase

Pic.95: 1st floor

1. Atrium
2. Residents common spaces
3. Residents helping areas
4. Private room
5. Residents vertical connction

Pic.96: 2nd floor - Typical floor

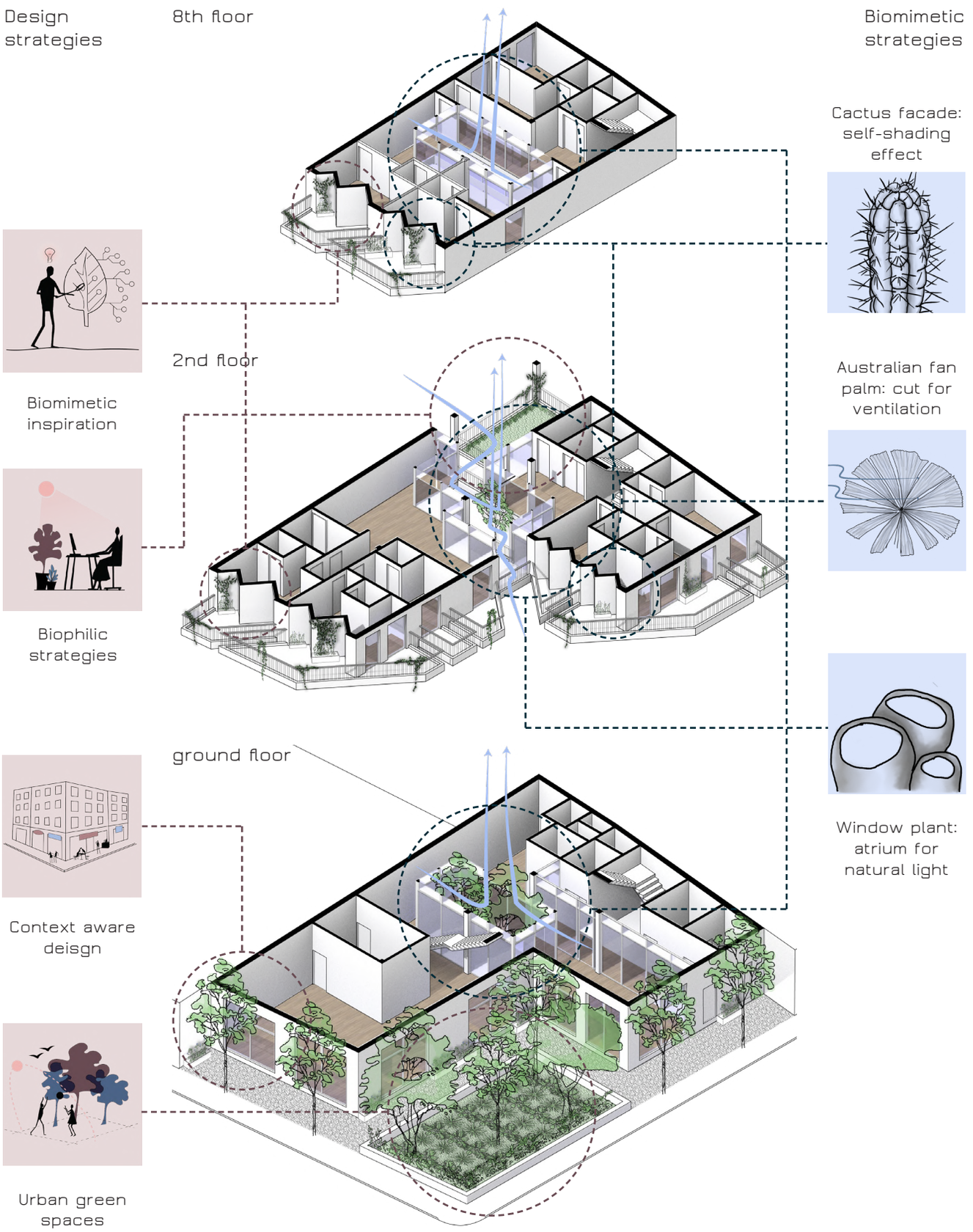


1. Atrium
2. Private apartment
3.. Residents vertical connction

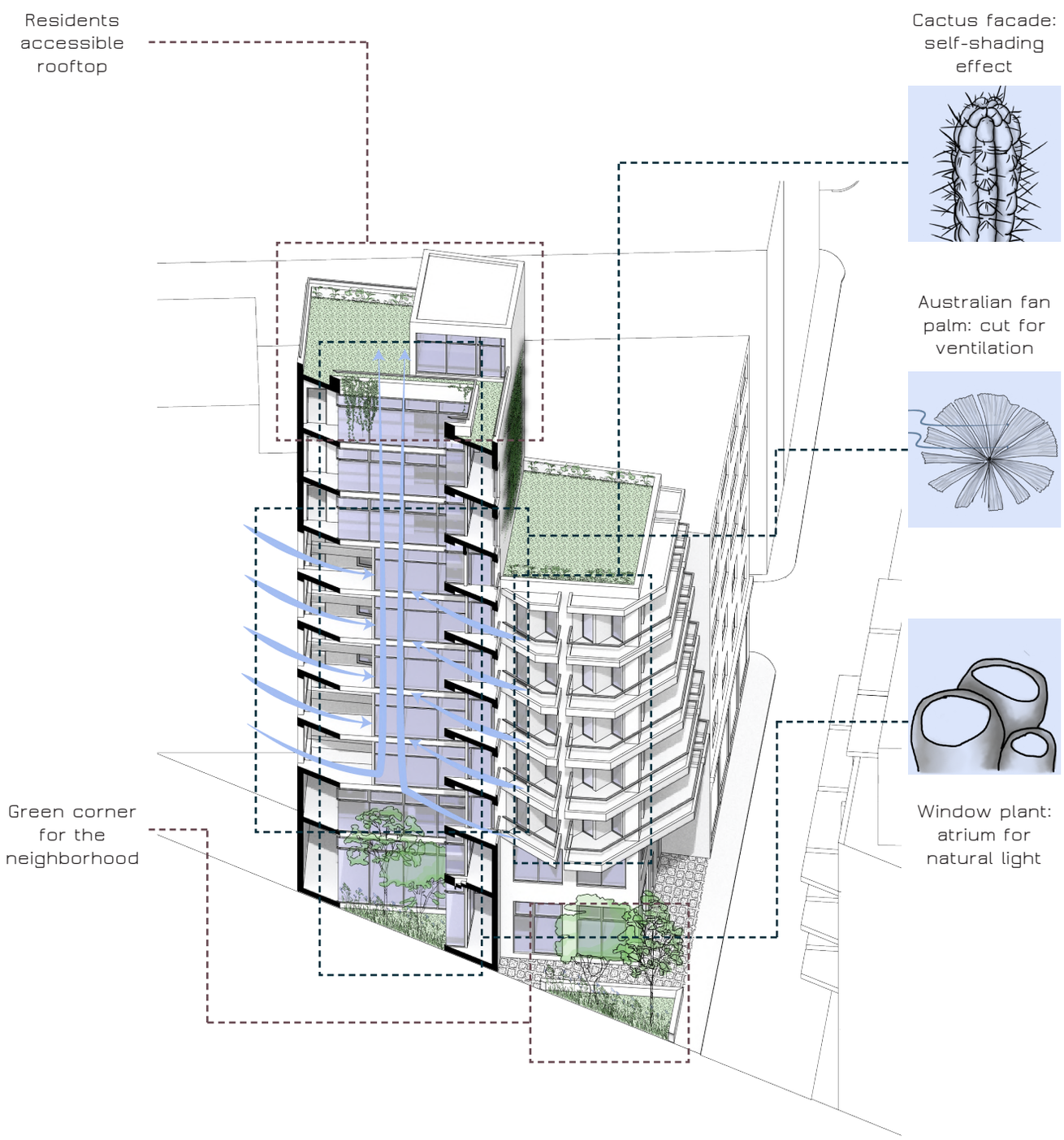
Pic.97: 8th floor - Typical floor

Strategies in the design

The design strategies significantly influenced the design decisions. The following diagram related the design and the biomimetic strategies with each other the floor designs.



Pic.98: Isometric floors



Pic.99: Isometric floors

Elevations

The preexisting conditions in the area, means that the plot has only 2 sides open. It is important to note the relationship of the new building with the older ones.

The facade follows the pattern present in the area. The ground floor and the first floor are public, with large openings and without balconies. While the deviation of the floors (4 meters high ground floor and 3 meters high 1st floor) differs from that of other buildings (usually 5 meters high ground floor and 2,5 meters high mezzanine), the combined height in both cases is the same, 7 to 7,5 meters, giving a continuous line at the base of the buildings.

An important feature in the building's design is the cactus facade, which looks towards V. Hugo Street. The alternating ridges serve a dual purpose. The windows have a direct view of the south, giving access to plenty of natural light, and working as a passive heating system during the winter, while the peaks create shadows that can protect the building from overheating during the summer months.

The facade looking towards Veroias Street is simpler. An important feature from that side are the openings running from the 2nd to the 7th floor which connect directly to the atrium and allow for side light to reach the core of the building and for air to run through the building caring away the heat.

Pic.100: Elevation Veroias str.

Pic.101: Facades organization

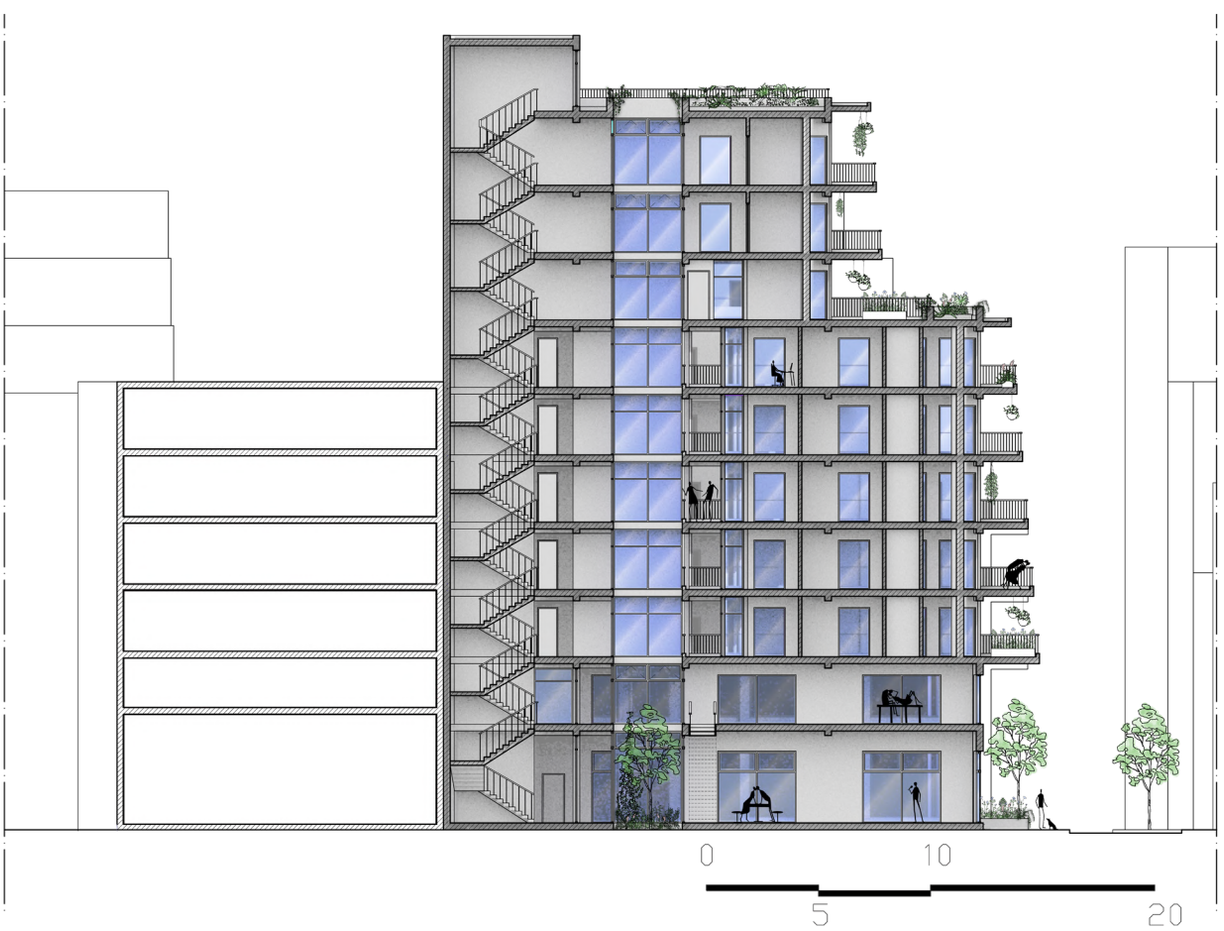
Pic.102: Elevation V. Hugo str.

Sections

The sections highlight the relationship of the new building with those already existing in the area, an important factor to note since the surrounding buildings have different heights, mainly on the spectrum of 20 to 32 meters.

The building is reaching a total height of 35,4 m, that is due to the elevator that gives access to the green roof and is allowed to go above the maximum allowed height. Additionally, the introduction of a green roof allows to go over the permitted maximum height of up to 1 meter. Following the architectural principles given by other buildings in the area, the ground floor is higher, 4 meters, compared to the other floors, but it does not have a mezzanine above it.

Both sections run through the atrium, the core of the building, and a guiding principle for the design since it contributes to the natural lighting and ventilation of the building.



Pic.103: Section A-A´

Pic.104: Section B-B'

Visualizations

A view looking towards the atrium shows the relationship of the spaces with the light-core of the building. Aside from the introduction of more natural light in the building, the atrium also gives the occasional view towards green elements.

Pic.105: Interior visualization

The atrium is closely related to a cut running through the middle of the building. In collaboration with the atrium, the cut allows access to outdoor environments and encourages the residents to come in touch with nature.

Pic.106: Interior visualization

Reflections

Reflecting upon the journey of my thesis, the objectives set, and the questions asked in the beginning of my process have been largely met, especially those related to the two central questions.

My initial, broad, idea of reconnecting people with nature, is examined from the perspective of urban development. With a growing population and the radical expansion of cities, the natural environment is compromised daily. Strategies for the sustainable urban development of cities call for an increase in densification, through transformation, reuse and utilization of misused places within the city limits. Yet, our goal for increased density often has the compromise of other living qualities and urban sustainable development strategies, such as urban green spaces.

Trying to merge these two conflicting strategies has been the main objective of the thesis, to prove that even through densification we can still create spaces which do not compromise living qualities.

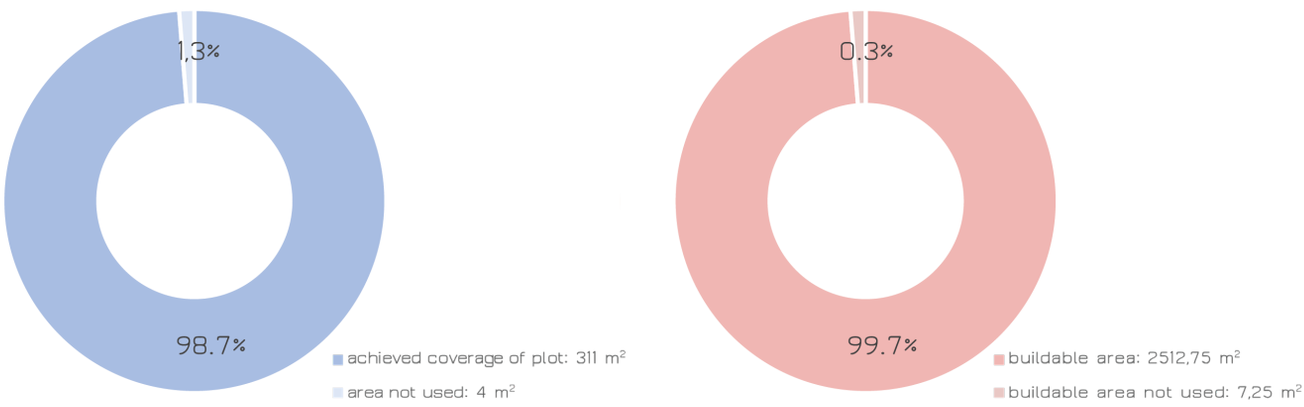
In my design, I reached the maximum allowed square meters in both coverage and buildable area, without compromising the presence of greenery in the area. On the contrary, through my design, I introduced more green spaces, in the form of green roofs, walls, free soil, planters, etc. and I around 9 m² of green space per resident, coming extremely close to the number recommended by the WHO and more than tripling the available green space per resident compared to the average of the city. Using as an example the standards set by the Berling model for the Biotope Area Factor, my design reaches and, slightly, exceeds the standard for the construction of a new residential building, serving as further proof of a successful merge of densification and urban green spaces.

The integration of green spaces should not be limited only to the quantity, but also consider the quality of these spaces. It is important for people to have access to these spaces to find themselves in touch with nature. Other qualities that should be considered are the types of vegetation used, how they relate to the environment and the users, how they develop over time and how they change according to the seasons, since all these can change the perception of the area.

The integration of biophilic and biomimetic strategies supported the merge of densification and urban green spaces, by inspiring unconventional design solutions and introducing through design solutions already present in nature. Through the introduction of green spaces and the consideration of natural lighting and ventilation, the project attempts to imitate nature's inherent sustainability. Examples such as cactus' self-shading ability and the Australian fan palm strategy to avoided overheating, which in this case also serves for enhancing natural light, are only some of the biomimetic attributes incorporated into the building design.

However, there are still areas of the design open for more exploration. Outside of the time frame set by the Master Thesis, further investigation would involve the shape and the materiality of the atrium, inspired by the window plant to further manipulate light's direction and maximize natural light in the building. Similarly, a better study of the angles and the direction of the cactus inspired façade would maximize natural light intake without overheating.

Considering the broader context, the decisions in design and programmatic functions are



Pic.107: Densification charts

tailored to the character and the needs of the area, creating a dialogue between the existing environment and future additions. The proposed building is decreasing the density of uses and population in the area but is adding green elements, which are significantly lacking, especially close to the plot.

I used the SDG impact assessment tool to examine my proposal according to the 17 Sustainable Development Goals. According to my self-evaluation the proposal has a direct positive impact in the "Goal 3: Good heal and well-being", "Goal 11: Sustainable cities and communities", "Goal 13: Climate action" and "Goal 15: Life on land", while it has an indirect positive impact to three more goals.

In the end, the thesis successfully addressed the initial questions, while also giving opportunity for future investigations. The investigations and the result of the thesis can contribute to the on-going conversion for sustainable urban development.

Pic.108: IModel photo

Reference & Image list

(n.a.). (2023, March 31). Θεσσαλονίκη - "Μια πόλη με πολύ μικρή αναλογία πρασίνου ανά κάτοικο..." Retrieved January 26, 2024, from dasarxeio.com website: https://dasarxeio.com/2023/03/31/124043/

Ν. 4067/2012. Νέος Οικοδομικός Κανονισμός. ΕΦΗΜΕΡΙΣ ΤΗΣ ΚΥΒΕΡΝΗΣΕΩΣ ΤΗΣ ΕΛΛΗΝΙΚΗΣ. (ΦΕΚ 79/Α'/09.04.2012)

Ν. 4315/2014. Πράξεις εισφοράς σε γη και σε χρήμα-Ρυμοτομικές απαλλοτριώσεις και άλλες διατάξεις. ΕΦΗΜΕΡΙΣ ΤΗΣ ΚΥΒΕΡΝΗΣΕΩΣ ΤΗΣ ΕΛΛΗΝΙΚΗΣ ΔΗΜΟΚΡΑΤΙΑΣ. (ΦΕΚ 269/Α'/ 24.12.2014

ΔΕΠΕΑ/οικ.178581. Έγκριση Κανονισμού Ενεργειακής Απόδοσης Κτιρίων. ΕΦΗΜΕΡΙΣ ΤΗΣ ΚΥΒΕΡΝΗΣΕΩΣ ΤΗΣ ΕΛΛΗΝΙΚΗΣ ΔΗΜΟΚΡΑΤΙΑΣ (ΦΕΚ 2367/ Α'/ 12.07.2017)

(2023, March 17). Census Results of Population and Housing 2021. Hellenic Statistical Authority. Retrieved October 13, 2023, from https://www.statistics.gr/en/home

Alfirević, Đ., & Simonović-Alfirević, S. (2015). Infill architecture: Design approaches for in-between buildings and 'bond' as integrative element. Arhitektura i Urbanizam, 2015(41), 24-39. https://doi.org/10.5937/a-u0-8293

ArchDaily. (2016, April 22). The Edge / PLP Architecture. Retrieved from ArchDaily website: https://www.archdaily.com/785967/the-edge-plp-architecture

ArchDaily. (2013, June 30). CH2 Melbourne City Council House 2 / DesignInc. Retrieved from ArchDaily website: https://www.archdaily.com/395131/ch2-melbourne-city-council-house-2-designinc

AskNature Team. (2016, October 16). Leaf fan optimizes cooling and wind resistance : Licuala ramsayi - AskNature. Retrieved from AskNature website: https://asknature.org/strategy/leaf-fan-optimizes-cooling-and-wind-resistance/

Ateliers Jean Nouvel. (n.d.). One Central Park. Retrieved from Ateliers Jean Nouvel website: https://www.jeannouvel.com/en/projects/one-central-park/

Baumeister, D. (2014). Biomimicry Resource Handbook: A seed Ban of Best Practices. Missoula, Montana: Biomimicry 3.8.

Becker, O. O. (2014). Reading the Landscape. Hatje Cantz Verlag, Ostfildern, Germany

Beatly, T. (2016). Handbook of Biophilic city planning and design. Washington DC: Island Press, Retrieved March 30, 2021, from https://link.springer.com/book/10.5822%2F978-1-61091-621-9

Benyus, J. M. (1997). Biomimicry: Innovation Inspired by Nature. New York, HarperCollins Publishers Inc

Berlin.de Das offizielle Hauptstadtportal. (2020, July 13). BAF – Biotope area factor. Retrieved from www.berlin.de website: https://www.berlin.de/sen/uvk/en/nature-and-green/landscape-planning/baf-biotope-area-factor/

The Biomimicry Institute. (n.d.). Glossary of Terms. Biomimicry Toolbox. Retrieved September 11, 2023, from https://toolbox.biomimicry.org/references/glossary/

CALLEBAUT, D. (n.d.). ARBORICOLE. VINCENT CALLEBAUT ARCHITECTURES. Retrieved January 26, 2024, from https://vincent.callebaut.org/object/180314_arboricole/arboricole/projects

Carstens, A. (2020, November 11). Honeycomb Structure Is Space-Efficient and Strong: Bees and wasps. Ask Nature. Retrieved September 11, 2023, from https://asknature.org/strategy/honeycomb-structure-is-space-efficient-and-strong/

Chong, S., Lobb, E., Khan, R., Abu-Rayya, H., Byun, R., & Jalaludin, B. (2013). Neighbourhood safety and area deprivation modify the associations between parkland and psychological distress in Sydney, Australia. BMC Public Health, 13

City of Melbourne. (2019). Council House 2 - City of Melbourne. Retrieved from Vic.gov.au website: https://www.melbourne.vic.gov.au/building-and-development/sustainable-building/council-house-2/Pages/council-house-2.aspx

City of Thessaloniki. (2021, September 9). Visitor. Retrieved January 26, 2024, from Municipality of Thessaloniki website: https://thessaloniki.gr/visitor/?lang=en

Cohen, Y. & Reich, Y., 2016, Biomimetic Design Method for Innovation and Sustainability. Springer International, Publishing, Switzerland. Retrieved January 11, 2021, https://link.springer.com/book/10.1007%2F978-3-319-33997-9

Cutieru, A. (2020, September 4). Fill in the Gaps: Infill Architecture in Urban Residual Spaces. ArchDaily. Retrieved September 24, 2023, from https://www.archdaily.com/946858/fill-in-the-gaps-infill-architecture-in-urban-residual-spaces

DARRIEUS, M. (2015, October 30). ÉQUERRE D'ARGENT 2013 / MENTION - BABLED-NOUVET-REYNAUD - 20 LOGEMENTS SOCIAUX. Retrieved April 2, 2024, from AMC website: https://www.amc-archi.com/article/

equerre-d-argent-2013-mention-babled-nouvet-reynaud-20-logements-sociaux,27

Davies, N. (2014). Mother NATURE, Designer. Planning: Chicago, 80(3), 13-17, Chicago, American Planning Association, Retrieved October 10, 2020, from https://search.proquest.com/docview/1511124480?accountid=83599, 10/10/2020

Duro, A., & BABLED NOUVET REYNAUD ARCHITECTES. (n.d.). Rue des Orteaux by Babled Nouvet Reynaud Architectes | The Strength of Architecture | From 1998. Retrieved March 14, 2024, from www.metalocus.es website: https://www.metalocus.es/en/news/rue-des-orteaux-babled-nouvet-reynaud-architectes

Hellenic National Meteorological Service. (n.d.). ΚΛΙΜΑΤΟΛΟΓΙΑ, ΕΜΥ, Εθνική Μετεωρολογική Υπηρεσία. Retrieved from www.emy.gr website: http://www.emy.gr/emy/el/climatology/climatology

Hoff, M. (2019, April 5). Lens-Shaped Leaves Harvest Light – Biological Strategy – AskNature. Retrieved from asknature.org website: https://asknature.org/strategy/crystals-draw-sunlight-into-plant/

Hercheletzis, T. (2022, June 18). Πότε δημιουργήθηκε το Σέιχ Σου; Ποιος ποιητής "βάφτισε" το δάσος Κεδρηνό Λόφο;. Retrieved January 26, 2024, from Thesstoday website: https://thesstoday.gr/%CF%80%CF%8C%CF%84%CE%B5-%CE%B4%CE%B7%CE%BC%CE%B9%CE%BF%CF%85%CF%81%CE%B3%CE%AE%CE%B8%CE%B7%CE%BA%CE%B5-%CF%84%CE%BF-%CF%83%CE%AD%CE%B9%CF%87-%CF%83%CE%BF%CF%85-%CF%80%CE%BF%CE%B9%CE%BF%CF%82-%CF%80/

Iliadis, N. (2022, May 21). Θεσσαλονίκη, μια πόλη με ελάχιστο πράσινο - Πώς κατανέμεται ανά περιοχή. VORIA Η οικονομική e-εφημερίδα. https://www.voria.gr/article/thessaloniki-i-poli-me-to-elachisto-prasino---pos-katanemete-ana-periochi

Kellert, S. R. (2018). Nature by design: the practice of biophilic design. New Haven: Yale University Press.

Kellert, S. R., Heerwagen, J. H., & Mador, M. L. (2008). Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life. John Wiley & Sons, Inc., Hoboken, New Jersey.

Kritikou, D. (2022, September 15). Λαδάδικα - Εκεί που έχει την αφετηρία της η ιστορία της πόλης. Retrieved January 26, 2024, from ThessNews website: https://www.thessnews.gr/thessaloniki/deth/deth2022/ladadika-ekei-pou-echei-tin-afetiria-tis-i-istoria-tis-polis/

Kwon, O.-H., Hong, I., Yang, J., Wohn, D. Y., Jung, W.-S., & Cha, M. (2021). Urban green space and happiness in developed countries. EPJ Data Science, 10(1). https://doi.org/10.1140/epjds/s13688-021-00278-7

Lippsett, L. (2017, August 31). Shape shades and enhances heat radiation : Cactus Family. Retrieved from AskNature website: https://asknature.org/strategy/shape-shades-and-enhances-heat-radiation/

Logements expérimentaux rue Orteaux Babled-Nouvet-Reynaud. (2021, July 7). Retrieved April 2, 2024, from Paris Promeneurs - Decouvrir l'architecture et l'histoire de Paris website: https://paris-promeneurs.com/logements-experimentaux-rue-des-orteaux/

Mak, T. W., & Shu, L. H. (2004). Abstraction of Biological Analogies for Design, CIRP Annals, 53(1), p.117-120, Retrieved March 27, 2021, from https://www.sciencedirect.com/science/article/pii/S0007850607606581

Mohajeri, N., Walch, A., Smith, A., Gudmundsson, A., Assouline, D., Russell, T., & Hall, J. (2023). A machine learning methodology to quantify the potential of urban densification in the Oxford-Cambridge Arc, United Kingdom. Sustainable Cities and Society, 92. https://doi.org/10.1016/j.scs.2023.104451

Pawlyn, M. (2016). Biomimicry in Architecture. London, RIBA Publishing

Pawlyn, M. (2016a). 'Soft and hairy' architecture: why designs should embrace nature. FT.com: London, London, The Financial Times Limited, Retrieved October 10, 2020, from https://search.proquest.com/docview/1838650508accountid=8359

Pearce, M. (n.d.). Council House 2 Building. Melbourne. Retrieved from www.mickpearce.com website: https://www.mickpearce.com/CH2.html

Pelczynski, J., & Tomkowicz, B. (2019). Densification of cities as a method of sustainable development. IOP Conference Series: Earth and Environmental Science, 362(012106). https://doi.org/10.1088/1755-1315/362/1/012106

PLP Architecture. (n.d.). The Edge, Amsterdam, The Netherlands – PLP Architecture. Retrieved from PLP Architecture website: https://plparchitecture.com/the-edge/

Rovalo, E. (2019). iSites: Nature Journaling for Biomimicry. Missoula, Montana: Biomimicry 3.8.

Schorcht, M., Mathias, J. , & Krüger, T. (2023). Where are cities under pressure? – An indicator for measuring the impact of building changes on

urban density. Ecological Indicators, 149, 110142-110142. https://doi.org/10.1016/j.ecolind.2023.110142

Simon, D. (2016). Rethinking Sustainable Cities: accessible, green and fair. Policy Press.

Tan, P. Y., & Jim, C. Y. (2017). Greening Cities. [electronic resource]: Forms and Functions (1st ed. 2017.). Springer Singapore.

Taylor, L., & Hochuli, D. F. (2017). Defining greenspace: Multiple uses across multiple disciplines. Landscape and Urban Planning, 158, 25-38. https://doi.org/10.1016/j.landurbplan.2016.09.024

TR Hamzah & Yeang. (n.d.). Solaris. Retrieved from TR Hamzah Yeang Sdn Bhd website: https://trhamzahyeang.com/portfolio-item/solaris/

Tsigganas, T. (2020, October 5). Θεσσαλονίκη: Μανόλιες, φλαμουριές, σοφόρες και πλατάνια κατά της ατμοσφαιρικής ρύπανσης. Retrieved January 26, 2024, from dasarxeio.com website: https://dasarxeio.com/2020/10/05/87092/

Vattam, S., Helms, M., & Goe, A. (2008). Compound Analogical Design: Interaction between Problem Decomposition and Analogical Transfer in Biologically Inspired Design. at Gero, S., Goel, A., Design Computing and Cognition '08, Berlin, Springer, Retrieved March 27, 2023, from https://link.springer.com/book/10.1007/978-1-4020-8728-8, 27/3/2021

Verheij, J., Ay, D., Gerber, J.-D., & Nahrath, S. (2023). Ensuring Public Access to Green Spaces in Urban Densification: The Role of Planning and Property Rights. Planning Theory & Practice, 24(3), 342-365. https://doi.org/10.1080/14649357.2023.2239215

Wilson, E. O. (1984). Biophilia. USA, Harvard University Press, https://fliphtml5.com/yseht/azrx/basic, 30/3/202120. World Commission on Environment and Development (WCED), 1987, Report of the World Commission on Environment and Development: Our Common Future, United Nations, Retrieved March 6, 2021, from, https://sustainabledevelopment.un.org/ content/documents/5987our-common-future.pdf

Pic. 5: Waddington, R. (2016). Supertrees, Singapore (27428306290). In Wikimedia Commons. Retrieved from https://en.m.wikipedia.org/wiki/File:Supertrees,_Singapore_%2827428306290%29.jpg

Pic. 6a: Rsa. (2009). JRW-500 V2 in Himeji. In Wikimedia Commons. Retrieved from https://commons.wikimedia.org/wiki/File:JRW-500_V2_inHimeji.jpg

Pic. 6b: Laitche. (2015). Common kingfisher, October 2015, Osaka VI. In Wikimedia Commons. Retrieved from https://commons.wikimedia.org/wiki/File:Common_kingfisher,_October_2015,_Osaka_VI.jpg

Pic. 12: Hyde, R. (2008). Council House 2, Design Inc, 2007. In flickr.com. Retrieved from https://www.flickr.com/photos/roryrory/2799210178/

Pic. 19: Guillaume, C. (2013). 20 logements sociaux, Babled-Nouvet-Reynaud Architectes (BNR), 2013. Rue des Orteaux, Paris. In flickr. Retrieved from https://flic.kr/p/ghhaoK

Pic. 20: Guillaume, C. (2013). 20 logements sociaux, Babled-Nouvet-Reynaud Architectes (BNR), 2013. Rue des Orteaux, Paris. In flickr. Retrieved from https://flic.kr/p/ghhaoK

Appendix

SDG Impact Assessment Tool

The SDG impact assessment tool is created in Sweden and is used to visualize the results of self-assessment on projects and how they affect the SDGs. The 17 Sustainable Development Goals, set on the United Nations 2023 Agenda, aim for worldwide sustainable transformation.

The SDGs should be implemented by different countries, but they are also a framework that can be utilized in any activity. An assessment of the impact of the SDGs depends on the different aspects of each project and on the person completing the evaluation. The results are subjective and open for revision. Despite that, SDG impact assessment tool can help get a better understanding of a project, of its strengths and weaknesses.

I am using the SDG impact assessment tool to evaluate my thesis idea compared to the 17 sustainability goals. According to my evaluation, my project has a direct positive effect on four out of 17 goals. And an indirect positive effect in 3 more. My design proposal has no impact to the other 10 goals.

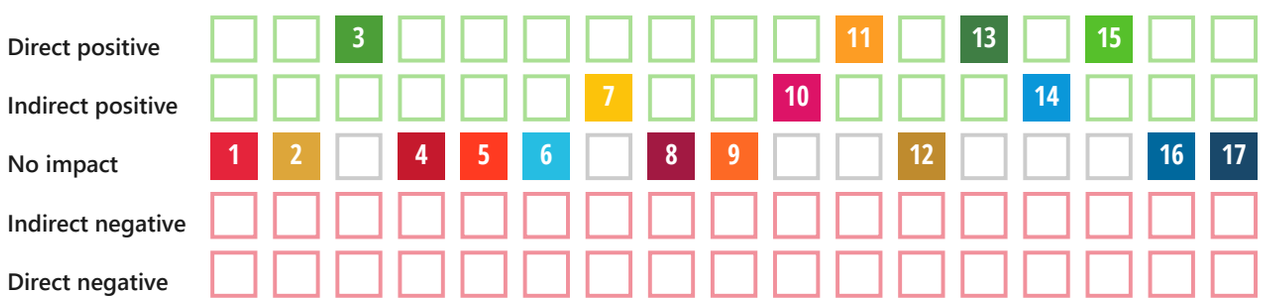
Direct positive impact analysis

The design increases the available green space per resident closer to the WHO standards. I incorporate biophilic aspects into the design. Biophilia is based on evidence that people are happier, healthier, and more productive when they are in contact with nature.

The project creates a sustainable infill building. It increases densification, without compromising on green spaces. It a balance between the two and introduce a new logic in building.

The project is developed for educational purposes, in a realistic context. It investigates the implementation of densification and urban green spaces in a single design. The design considers local policies while addressing several of the 17 SDGs.

Instead of expanding on untouched natural land, the project promotes densification. I incorporate green elements in my design to introduce more green spaces in the city. The project strengthens biodiversity within the urban environment.



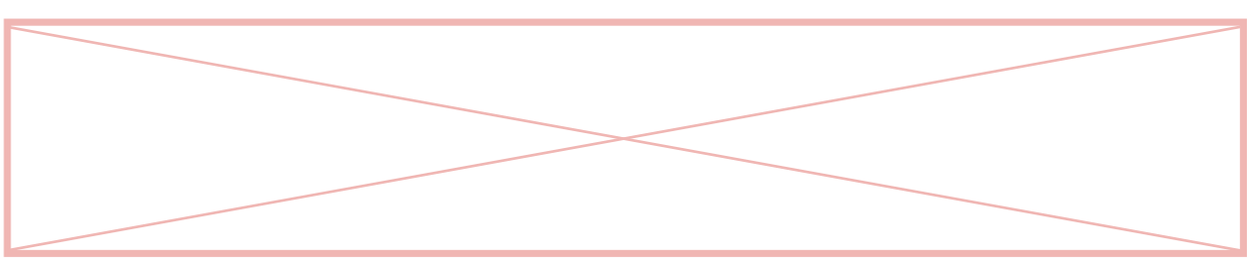
Pic.108: SDG Impact Assessment Tool

Direct Positive

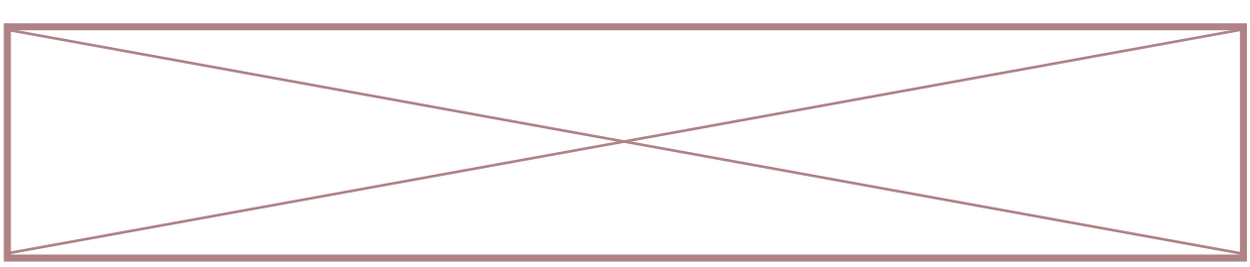
Indirect positive

No impact

Indirect Negative



Direct Negative



Pic.109: SDG Impact Assessment Tool with the names of the goals