Green High Five:
Vertical Gardens along the Egnatia Corridor

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Perrotis College
Agriculture · Environment · Life Sciences

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Abstract

Thessaloniki, Greece is densely packed with buildings and lacks room for typical green spaces. This project assessed the feasibility and value of incorporating vertical gardens on walls along Egnatia Corridor in Thessaloniki. Citizen questionnaires, spatial analysis, and expert interviews yielded design preferences, potential locations, and suitability factors for vertical gardens. We developed an interactive map and framework of criteria to select garden sites using spatial analysis and proposed four conceptual designs for vertical gardens along the corridor.

Vertical Garden - London

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Executive Summary

Urban green spaces provide many benefits to the environment, population, and economy. Vegetation can improve air quality as well as insulate buildings to increase the efficiency of heating and cooling systems (Davis, Ramirez, & Pérez, 2016). People tend to rank themselves as happier and healthier in areas where more green spaces are present, and they experience decreased blood pressure and decreased irritation from noise pollution (Dzhambov & Dimitrova, 2014). Green spaces attract more customers to businesses, and consumers have reported being more likely to spend more time and money in establishments with greenery (Wolf, 2005). These benefits make green spaces in cities desirable.

Thessaloniki is the second largest city in Greece. It is densely populated by buildings, leaving little area for green spaces. In downtown Thessaloniki, Egnatia Street is the cultural and economic backbone. After the destruction caused by the Fire of 1917, the city, particularly Egnatia, was rebuilt with large, mixed-use buildings (Papastathis & Hekimoglou, 2010). Extensive construction work has been taking place since 2006 to build a metro system, and this project isn't expected to be completed until 2020 or later. The densely packed buildings and long-term construction have given Egnatia Street a reputation as an unfinished, visually unappealing region of Thessaloniki.

Resilient Thessaloniki is a plan to develop the city to improve quality of life as well as become economically resilient and environmentally conscious. Many of the potential projects suggested in the plan include construction of new green spaces, often in the form of green roofs and walls (City of Thessaloniki, 2017). The lack of greenery in Thessaloniki, the current construction on Egnatia Street, and the city's recognition of the need for green spaces suggests an opportunity for improvement of green spaces in the city.

Vertical gardens are an option for incorporating greenery in urban areas that lack the room for typical green spaces. Green walls have previously been implemented in cities throughout the world to filter air, decrease the urban heat island effect, increase insulation of a building, reduce noise pollution, and improve the aesthetics of an area (Urrestarazu, Fernández-Cañero, Franco-Salas, & Egea, 2015).

Project Goal and Research Objectives

The goal of this project was to assess the feasibility and value of integrating vertical gar-

dens along Egnatia Street in Thessaloniki, Greece. We followed three main objectives in order to complete this goal.

1. Gauge stakeholder interest in vertical gardens. Stakeholders included citizens of Thessaloniki, city officials, and vertical garden experts. We conducted interviews with stakeholders and distributed questionnaires in-person to citizens and online to college students to determine people's opinions of Egnatia Street, learn about people's aesthetic preferences, and identify which sectors, public or private, are best suited to initiate a project of this scale.

2. Identify sites and provide spatial analysis tools. We identified potential vertical garden sites using spatial analysis and in-person site visits. Spatial analysis was done by considering current green space data, foot traffic around Egnatia Street, and AirBnB price data to locate areas that could most benefit from incorporation of more greenery. Site visits were conducted to verify potential locations. A website was developed and includes an interactive map to allow future researchers to access these data sets.

3. Develop conceptual designs and siting framework. Using citizen engagement, expert interviews, and in-person site visits, we developed conceptual designs and a siting tool. Citizen engagement led to conclusions about what aesthetics of vertical gardens people most prefer. Interviews with various stakeholders identified design limitations, common pitfalls, and design suggestions necessary to consider for conceptual design mockups. The siting tool was used in conjunction with the interactive map to assess the appropriateness of previously identified potential locations. Demographic layers corresponding to sections in the siting tool were compared and taken into consideration using the interactive map to select these demonstration sites, and conceptual designs were created for four potential sites.

Benefits and Challenges of Vertical Gardens in the Thessaloniki Context

Construction of vertical gardens has the potential to provide economic benefits by increasing foot traffic in commercial areas or increasing desirability and value in residential areas. Citizen engagement concluded that people prefer to go to areas with green spaces, and interviews with the Municipality of Thessaloniki and the Department of Landscape Architecture of the Municipality suggested that foot traffic would increase in areas that are already busy as well as in areas with low activity.

Citizens want green space along Egnatia Street because they believe it would improve the current aesthetics. Spatial analysis revealed that very little green space currently exists in the region around the Egnatia Corridor as shown in Figure i. Questionnaire responses indicated a desire for more green space along Egnatia and dissatisfaction with the current levels of green space. Background research about the Resilient Thessaloniki Plan as well as an interview with the Municipality confirmed that the city agrees with citizens that this area could be improved.

The main feasibility factors of a site are its structural and spatial characteristics as well

the building's usage and number of owners. Many residential and mixed use buildings in Thessaloniki are owned by multiple people, which can make construction projects more complicated. Focusing on single-owner buildings such as hotels and private hospitals could simplify the initiation of vertical garden projects. Interviews with local stakeholders suggested that the city likely does not have the resources to implement vertical garden structures, so the private sector would be a better investment source for such a project.

Other practical considerations identified by stakeholders include the load bearing capacity of potential walls, accessibility for regular maintenance, and chosen plant species.

Figure i: Green Space Proximity Map. 200 meter radius area accumulation map of green space, created based on recommended green space proximity. Brighter green indicates a higher total area of green space and whiter indicates a lower total area of green space within that radius.

A Siting Tool and Framework for Site Selection

These findings were compiled into a framework for site selection to determine feasibility and appropriateness of potential sites for implementation of a vertical garden as shown in Figure ii. Each category includes specific indicators necessary for determining the suitability of a potential site, and certain indicators can be weighted more or less depending on the specific situation. Layers on the interactive map (greenhighfive.eu, description in Appendix E) each fall under specific consideration factors. The interactive map can be used to evaluate specific sites based on these factors, allowing future researchers to evaluate the suitability of specific vertical garden sites.

Example Sites for Vertical Gardens

Using the site selection tool and website, we identified four potential vertical garden sites along Egnatia Street. Each of these sites met some of the indicators outlined in Figure iii. Below, we present a brief description of each building, presenting photos of the building as it currently appears alongside an edited image depicting a conceptual design for a vertical garden for that site.

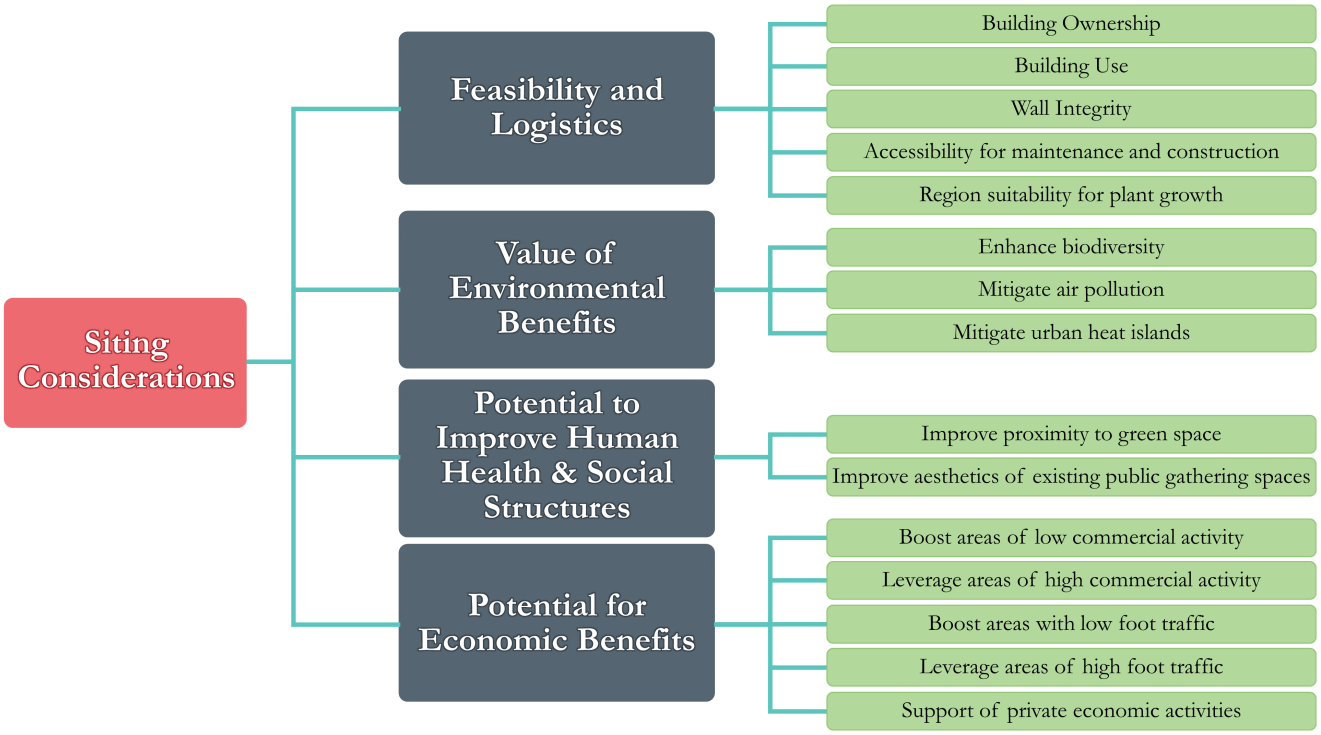

Figure ii: Site Selection Framework. Siting framework developed from findings. Used to determine the feasibility and appropriateness of potential sites for implementation of vertical gardens.

Figure iii: Potential site 1. A hotel on Egnatia Street (left) and a design mockup for a potential vertical garden design for that site (right).

Figure iv: Potential site 2. A mixed use tower located on 48 El. Venizelou (left) and a potential mockup for a potential vertical garden on that site (right).

Figure v: Potential Site 3. A commercial segment of a mixed use building on Egnatia (left) and a potential vertical garden design for that site (right).

Figure vi: Potential Site 4. Department of Health building located on Egnatia (left) and a vertical garden design for that site (right).

Implementation Strategy

The implementation of vertical gardens could be carried out in phases. Municipality representatives and vertical garden experts in Thessaloniki expressed their concerns that the city lacks the resources to pursue this project and the private sector is better suited for it. Implementation is most likely to occur in phases, starting first with privately owned buildings, later moving onto some municipality buildings and university buildings.

Two more suggestions focus on government involvement and maintenance. If the private sector begins construction of vertical gardens as recommended, the local government could provide financial incentives to encourage continued implementation of an extensive network of gardens by the private sector. Another concern about vertical garden projects is that most problems arise when maintenance is not done thoroughly and regularly, so to minimize this risk, a maintenance plan should be established at the start of a new vertical garden project. This would mitigate problems that can occur after construction.

Authorship

The authorship of the report is described in the table below. A single team member was assigned the task of drafting a section and editors electronically suggested edits. The author of a section usually went through to accept or decline suggested edits, but the task was sometimes assigned to another person. Team members avoided accepting their own suggested edits so as to get multiple opinions on changes. Major changes made to sections were discussed in person in small groups or as a whole team. Most sections are significantly different than they were when an author originally drafted them, but the initial authors typically took ownership of their sections and were actively involved in the editing process of them.

Section	Primary	Primary Edi-	Secondary Edi-
Abstract	Olivia	All team mem-	
Executive Summary	Olivia	Ray	Hannah/Tomás
1. Introduction	Tomás	Hannah/Olivia	Ray
2. Background			
2.1 Benefits of Green Spaces in Cities			
2.1.1 Environmental Benefits	Ray	All team members	
2.1.2 Health Benefits	Ray	All team members	
2.1.3 Socioeconomic Benefits	Tomás	All team members	
2.2 The Composition of Thessaloniki			
2.2.1. Urban Development and Formation	Hannah	All team members	
2.2.2. The Egnatia Corridor	Tomás	All team members	
2.2.3. Resilient Thessaloniki	Olivia	All team members	
2.3. Vertical Gardens			
2.3.1. Types of Vertical Gardens	Olivia	All team members	
2.3.2. Vertical Garden Case Studies	Olivia	All team members	
2.3.3. Design Considerations	Hannah/Ol-	All team members	
3. Research Objectives			
3.1. Objective 1 - Gauge Stakeholder Interest in Vertical	Hannah	Hannah/Olivia/	Tomás
3.1.1. Method 1: Interviews with Expert Stakeholders	Hannah	Hannah/Olivia/	Tomás
3.1.2. Method 2: Citizen Engagement Questionnaires	Hannah	Hannah/Olivia/	Tomás

3.2. Objective 2 - Identify Sites and Provide Spatial Analy-	Hannah/Ray	Hannah/Olivia/	Tomás
3.3. Objective 3 - Develop Conceptual Designs and Siting	Hannah/Ray	Hannah/Olivia/	Tomás
4. Suitability Factors for Urban Vertical Gardens along the Egnatia Corridor			
4.1. Potential for Economic Benefits	Olivia	Hannah	Ray
4.2. Value of Environmental Benefits	Olivia	Hannah	Ray
4.3. Potential to Improve Human Health and Social Struc-	Olivia	Hannah	Ray
4.4. Feasibility and Logistics	Olivia	Hannah	Ray
4.5. Siting Tool and Interactive Map	Olivia	Hannah	Ray
5. Applying the Framework to the Egnatia Corridor in Thessaloniki			
5.1. Promising Sites and Design Mockups for Vertical	Olivia	All team members	
5.1.1. Potential Site 1 - “Hotel El Greco”	Olivia	All team members	
5.1.2. Potential Site 2 - “48 El. Venizelou Residential	Olivia	All team members	
5.1.3. Potential Site 3 - “Studio Optic”	Olivia	All team members	
5.1.4. Potential Site 4 - “Department of Health Building”	Olivia	All team members	
5.2. Implementation Challenges and Next Steps	Hannah/Ray	All team members	
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1. Introduction

There are many benefits to urban green spaces. They can improve biodiversity, combat air pollution, reduce noise pollution, and counter the urban heat island effect (Wolch, Byrne, & Newell, 2014). Additionally, green spaces provide physiological and psychological health benefits. Studies have shown a link between green space in one's living environment and perceived general health and overall happiness (Maas, Verheij, Groenewegen, de Vries, & Spreeuwenberg, 2006).

Urban areas tend to lack green space and biodiversity (Lepczyk et al., 2017). Congestion and overpopulation in cities often coincides with a severe lack of open spaces, parks, or any green spaces at all (Targa, Felipe, Moose, William, & Estupinan, Nicolas, n.d.). The city of Thessaloniki, Greece has a lower proportion of green space than many other cities in the world (UNOCHA, 2018). The Egnatia corridor of Thessaloniki is the economic and cultural backbone of the city, and it is particularly unvegetated and densely developed. The addition of green space could have positive socioeconomic impacts for the area.

In 2018, Thessaloniki adopted the Resilient Thessaloniki plan to increase the resiliency of the city (City of Thessaloniki, 2017). The plan calls for an increase in green space as part of an attempt to create a more sustainable and resilient urban area. It identifies the Egnatia Corridor as a focus for revitalisation and specifically mentions vertical gardens as an option for greenifying neighborhoods.

Vertical gardens are one potential solution for integrating green spaces into highly urban areas (Carpenter, 2008). Plants can be placed vertically on walls rather than on the ground in areas that lack real estate for typical green spaces (Revell & Anda, 2014). Vertical gardens have been implemented successfully in many other cities (Manso & Castro-Gomes, 2015; Rayner, Raynor, & Williams, n.d.; Shiah & Kim, 2011; Wong et al., 2010b).

The goal of the project was to assess the feasibility and value of integrating vertical gardens along the Egnatia Corridor in Thessaloniki and create recommendations for sites and varieties of vertical gardens. Using spatial analysis and questionnaires, we built an online spatial analysis tool, identified potential sites for vertical gardens, and developed conceptual design mockups for four of those sites. Potential sites were included in the interactive map with different data layers to aid in site selection and provide future researchers and designers with a starting

2. Background

In this chapter, we first discuss the environmental, health, and economic benefits of green spaces in urban areas. We then describe the history of the urban development of Thessaloniki specifically related to the lack of green spaces and open areas. This section also discusses the current state of Thessaloniki with a focus on the Egnatia Corridor and a municipality plan to make the city more resilient. We then move into a discussion of vertical gardens as a solution to the lack of vegetation in urban areas, explore types of these gardens, and elaborate on case studies of urban vertical gardens in different cities. Lastly, we discuss design considerations, using an example of park design guidelines and design constraints.

2.1. Benefits of Green Spaces in Cities

In this section, we elaborate on the different categories of benefits green spaces provide. We begin with environmental benefits, move on to physical and psychological health benefits, and conclude with socioeconomic benefits.

2.1.1. Environmental Benefits

Green spaces improve the ecology of a city, from reducing carbon in the air to reducing energy usage ("Project EverGreen," 2016). China installed a green space that produces up to 60 kg of oxygen a day, improving the air quality in the surrounding area (Gupta, 2018). Green roof installations and roadside green spaces can reduce the effects of noise pollution, which about 80 million people in the European Union suffer from. They can also combat the Urban Heat Island Effect (Dzhambov & Dimitrova, 2014). A wall mounted urban garden can insulate a building from outside temperatures, saving energy and costs on heating/cooling (Davis et al., 2016). These benefits not only improve the environment, but also life for those living within the city.

Even though cities are often portrayed as static environments, the design of a city can influence the underlying ecosystem, which can affect the city's sustainability. For example, keeping a stable bee population is important for biodiversity and ecological health, as they are major pollinators for agriculture and flowers (Rucker, Thurman, & Burgett, 2012). Designing a greener city with many species of plants and pollinators increases the overall environmental quality and the health of an ecosystem as a whole.

2.1.2. Health Benefits

Cities are often viewed as a backdrop separate from human health, but people are greatly impacted by their surroundings. A 2006 study conducted in Amsterdam, Netherlands, found that green spaces passively contribute to the overall health of those in

proximity to the spaces. The study demonstrated that in a sample of people living where 90% of their environment consisted of green spaces, only 10.2% of them ranked themselves as generally unhealthy, compared to 15.5% of people in a 10% green space environment. (Maas et al., 2006). In a study where green spaces were incorporated next to major freeways, residents living in direct proximity experienced a significant decrease in the negative effects of noise pollution from traffic as compared to before the green spaces were constructed (Dzhambov & Dimitrova, 2014). Reported health increases noticeably when there is a large amount of green space within a 3 km radius around a person's house (Maas et al., 2006). Increasing the amount of green spaces in a 1 km radius strengthens the effect, but more so in highly urban areas (Maas et al., 2006). Fuller et. al found in their study that adding green spaces with a variety of plant species noticeably increases the wellbeing of residents (Fuller, Irvine, Devine-Wright, Warren, & Gaston, 2007). These studies suggest that it is more impactful to increase the ratio of green space to urban space, rather than just increasing the direct proximity.

2.1.3. Socioeconomic Benefits

Green spaces can impact the economic and social climate in an area. Positive environmental aspects can contribute to social well-being and reducing municipal spending on environmental issues. Factors such as energy savings, filtration of air, and stormwater runoff reduction all contribute to the socioeconomic impacts (McPherson, 1992).

Local businesses can experience direct, non-external economic benefits from green spaces. Greener surroundings attract customers and business. Consumers in the United States report a willingness to spend an extra 9-12% in business centers with vegetation and an extra 8.8% in strip malls with vegetation (Wolf, 2005). Business owners in Los Angeles state their first priority in selecting a location for their business is the presence of green space (Gearin & Kahle, 2006). The increase in commerce for local businesses is a benefit to the local economy.

Green spaces provide a center for community involvement and social unity. Green spaces can improve social cohesion by creating areas of free and accessible public amenities, gathering places, stress-relieving pockets of nature, and locations for community activities (Kazmierczack & James, n.d.). The first three mechanisms are directly related to the presence of green spaces, while the last requires citizen involvement. Citizen involvement improves the social impact of a green space and improves the resiliency of the space itself; green spaces that have community involvement have a greater lifespan and impact (Ravetz, 2002).

Even though urban green spaces provide socioeconomic benefits, many cities still fail to incorporate them into their infrastructure. This can be due to a number of reasons, but for Thessaloniki in particular, this is due to its urban development. We will discuss this in the next section.

2.2. The Composition of Thessaloniki

In this section, we will discuss how the urban development of Thessaloniki impacted the present day organization of the city, with a focus on its lack of green spaces. This is followed by a discussion specifically about the Egnatia Corridor. We conclude by introducing the Resilient Thessaloniki plan, part of which suggests increasing the amount of greenery in the city.

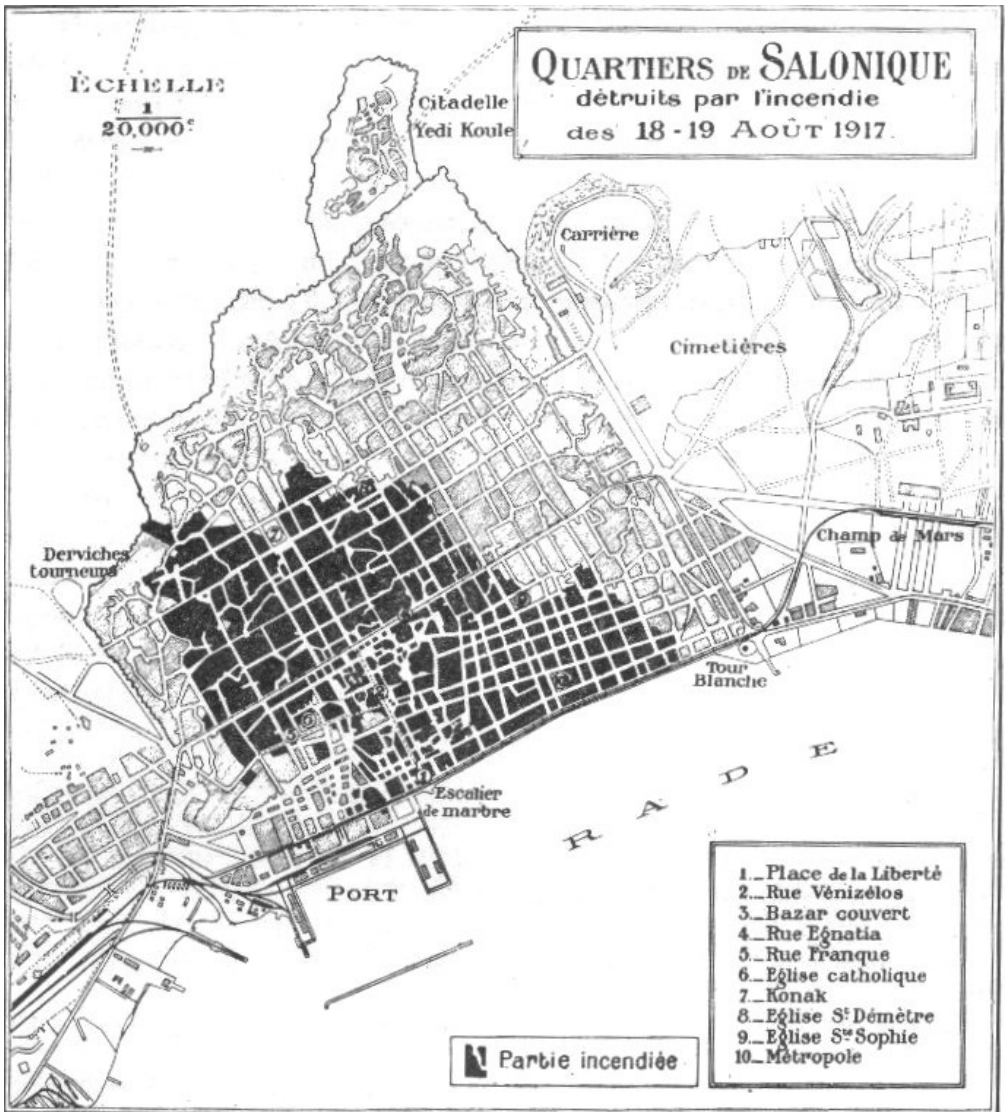


Figure 1: Map of the Great Fire Damage. The area destroyed by the Great Fire of 1917. (Wikimedia Commons, 1917)

2.2.1. Urban Development and Formation

Thessaloniki is the second largest city in Greece, comprised of densely populated building plots packed into tight blocks, leaving little open space throughout the city. One major reason for this organization is the Great Fire of 1917, a natural disaster that destroyed most of the city center. The shaded blocks in Figure 1 show the spread of building plots that were destroyed by this fire, totalling to about one square kilometer of the city. After the fire, the municipal government adopted the International Commission for the New Plan of Thessaloniki as an attempt to reorganize and rebuild the city (Gemenetzi, 2017). This plan split the center into new building plots that citizens could purchase at auctions, dividing Thessaloniki into a collection of individually owned plots of land. The new landowners took to rebuilding, while the city attempted to coordinate the process (Vilma, 1997).

This rebuilding process was halted in 1922 when the end of the war between Greece and Turkey caused an influx of refugees from Asia Minor. The rapid and significant population increase created a need for new settlements. The city attempted to intervene and organize the urban space, but

the short planning time hindered the city's ability to successfully organize the project (Gemenetzi, 2017). This led to the newly established building plot owners quickly creating housing for the refugees, resulting in the densely packed buildings that are still present in Thessaloniki today, as demonstrated in Figure 2 (Vilma, 1997).

Under the antiparochi housing model established around 1929, land owners gave plots of land to construction companies to build apartment buildings in exchange for ownership of some of the apartment units (Avdelidi, 2017). This rapid, unmonitored construction established the current cityscape of Thessaloniki with many buildings of similar height and appearance, all constructed closely together with multiple owners, leaving little space for other types of structures. Because of this, there is a lack of greenery and open spaces within the city limits. Figure 3 compares the amount of green space per capita in four different cities around the world and a World Health Organization recommended minimum. This figure shows that Thessaloniki currently has 2.1 m2 of green space per capita, while the recommended minimum is 9 m2 (UNOCHA, 2018).

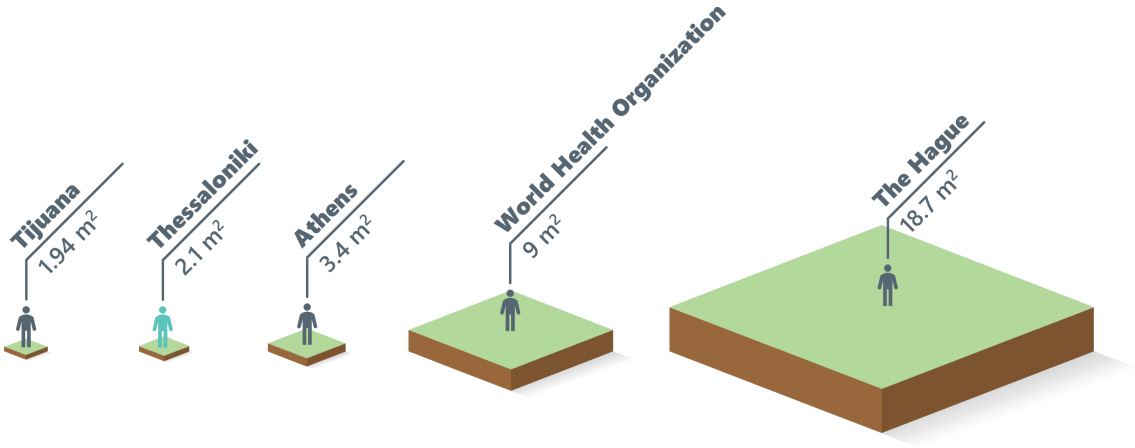
2.2.2. The Egnatia Corridor

The Egnatia Corridor is a cultural and economic backbone of downtown Thessaloniki, and it is outlined in Figure 4. It remains the most active area in the city, spreading beyond its original borders and including several of Thessaloniki's most important cultural and historical monuments.

After the Great Fire of 1917, the Egnatia corridor was narrowed and filled with large, mixed-use and multi-owner buildings constructed through the antiparochi model. (Papastathis & Hekimoglou, 2010). Present day Egnatia has been a site for protracted construction in Thessaloniki (Roukouni, Basbas, & Kokkalis, 2012; Saliara, 2014). The city is working to extend the metro system, and they expect nearly 250,000 passengers

Figure 2: Aerial View of Thessaloniki. (Wikimedia Commons, 2016)

Figure 3: Green Space per Capita City Comparison. A graphic showing the per capita area of green space in four different cities plus the World Health Organization minimum green space recommendation. There were more cities included in this data set with significantly more greenspace, such as New York with 654 m2 and Detroit with 2096 m2 (UNOCHA, 2018).



to utilize the new system daily. This project began in 2006 but has faced many delays, and it is not expected to be completed until 2020 or later (European Commission, n.d.). Between the density of the street and the near constant construction of the metro and surrounding areas, the Egnatia Corridor has gained a reputation among Greeks as the unattractive and unfinished center of the city (Achillas, Vlachokostas, Moussiopoulos, & Banias, 2011). The completion of the construction provides an opportunity to revitalize the area around the Egnatia Corridor, creating a more attractive, accessible, and economically sustainable area of the city (Xifilidou, Karanikolas, & Spatalas, 2012).

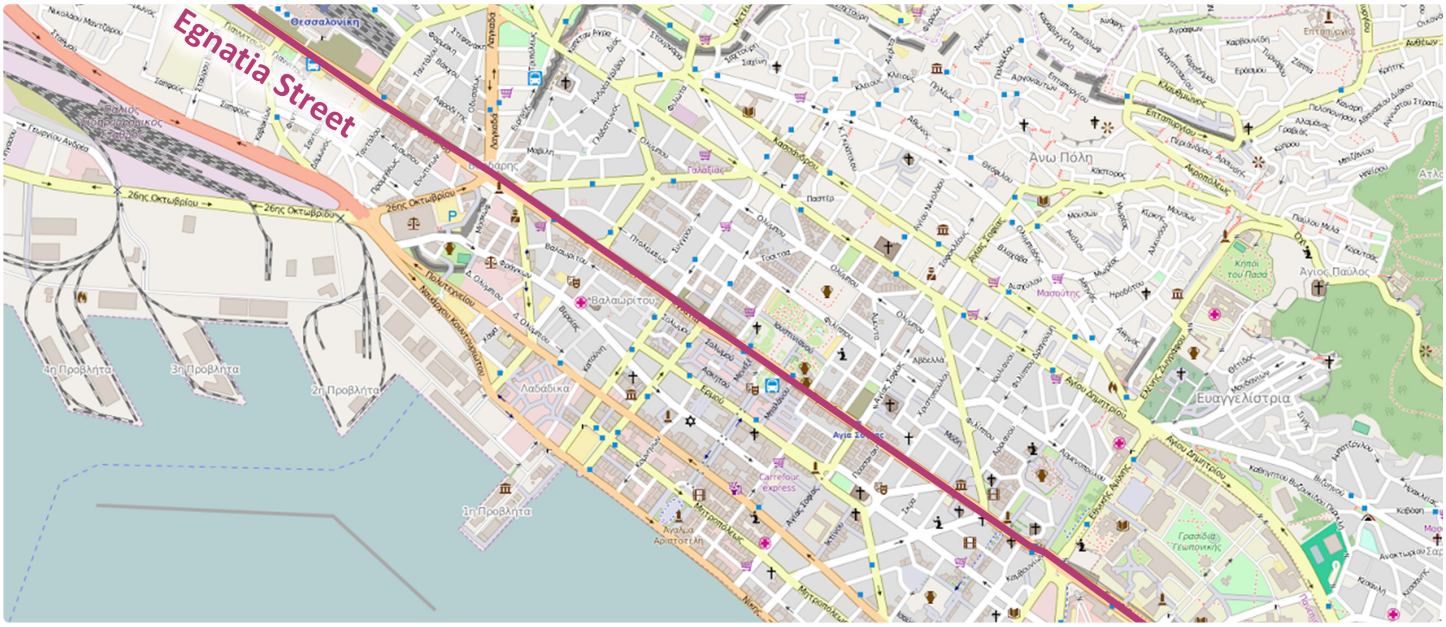


Figure 4: Map of Egnatia Corridor. The purple line shows where the Egnatia Corridor runs through the city of Thessaloniki.

Figure 5: The Goals of the Resilient Thessaloniki Plan. (City of Thessaloniki, 2017)

2.2.3. Resilient Thessaloniki

In 2014, the city of Thessaloniki was chosen to be a member of the cohort of 100 Resilient Cities because of its history of disorganized city planning. The plan consists of a long-term strategy intended to be completed by 2030 to connect cities with one another and address the many challenges urban areas face (City of Thessaloniki, Metropolitan Development Agency of Thessaloniki, 2017). The plan defines a model for a holistic city strategy that involves many sectors, including municipality, non-profit, private, and citizens. The intention of the strategy is to develop a city that is good for its people while strengthening the urban economy and not abusing its natural resources. Resilient Thessaloniki is divided into four main goals, shown in Figure 5. These goals are broken into 30 objectives and over 100 actions in order to create solutions to problems on a local and a metropolitan scale.

Many objectives of the 100 Resilient Cities plan are specifically related to increasing greenery in urban areas. To address the first goal of shaping a thriving and sustainable city, one action suggests raising money to fund projects that improve air quality, such as building green walls and surfaces that absorb pollutants (City of Thessaloniki, Metropolitan Development Agency of Thessaloniki, 2017). Another objective proposes implementing green infrastructure to mitigate the urban heat island effect and manage stormwater in ways such as green walls or private balcony gardens. Other actions in the plan advocate installing green walls and roofs on schools and municipal buildings specifically to retain rainwater, reduce runoff, and filter heavy metals out of rainwater. Green infrastructure plays a large role in many objectives of the plan, and vertical gardens are often cited specifically because they are best suited for dense urban areas.

2.3. Vertical Gardens

Vertical gardens, like the one shown in Figure 6, are a solution to the lack of vegetation in urban areas with limited room for traditional green spaces. This type of structure allows for the introduction of green space to an area that lacks real estate for typical green space while still providing the associated benefits. Vertical gardens can be flexibly installed into many types of spaces, some adding less than 1 meter of width to a structure (Wong et al., 2010a). Green walls can range from plants freely growing up the side of a building to large support structures built to hold plants up in the air. Ecologically, vertical gardens provide habitats for plants, animals, and insects in areas where humans occupy the space and leave these organisms without a place to grow and live (Urrestarazu et al., 2015). Green walls have also been installed to filter the air, cool

Figure 6: A Vertical Garden. A picture of a living wall, a subtype of vertical garden. (Wikimedia Commons, 2012)

Figure 7: Green façades. A direct green façade (left) and an indirect green façade (right). (Wikimedia Commons, n.d.-b, n.d.-a)

an area affected by the urban heat island effect, decrease humidity, or increase the insulation of a building to conserve energy when heating or cooling (Urrestarazu et al., 2015). Social benefits include reducing noise pollution, increasing aesthetic appeal, and increasing psychological and physiological health (Dzhambov & Dimitrova, 2014; Fuller et al., 2007; Tsunetsugu et al., 2013).

2.3.1. Types of Vertical Gardens

Green façades, as shown in Figure 7, are a low-maintenance way to install plants into an area without a bulky support structure. These vertical gardens are typically built using climbing plants and small supports such as trellises or mesh structures to guide growth up a building (Wong et al., 2010a). Green façades can be direct or indirect. Direct refers to plants that attach directly to the wall, but they are only compatible with certain wall types and can cause significant damage to buildings in extreme cases (Rakhshandehroo, Mohd Yusof, & Deghati Najd, 2015). Indirect refers to green façades with a structure that is free-standing or keeps the plants from directly attach the plants to the wall. An example of these are modular trellises as seen in the picture on the right in Figure 7, which are panels made from wires to direct the growth of climbing plants (Rakhshandehroo et al., 2015). The plants used grow vertically naturally, so there is less maintenance required than other types of vertical gardens (L. Perez Urrestarazu et al., 2015).

Living walls are another kind of vertical garden that are often larger, heavier and more maintenance intensive. Living walls can attach in panels, planters, mesh, or troughs, and they require an irrigation system and waterproof backing to protect the wall they are placed on from damage (Urrestarazu et al., 2015). An example of a living wall can be seen in Figure 8. Small and medium sized plants can grow in this type of vertical garden, which allows for much more diverse plant selection (Wong et al., 2010a). Additionally, living walls usually incorporate pre-grown plants; therefore, plant species can vary more than in a green facade. Living walls require more protection and maintenance for this reason (Timur & Karaca, 2013).

Balcony or terrace gardens, like the one shown in Figure 9, offer a more affordable, alternative solution to the lack of vegetation that provides many of the same benefits vertical gardens provide. They can consist

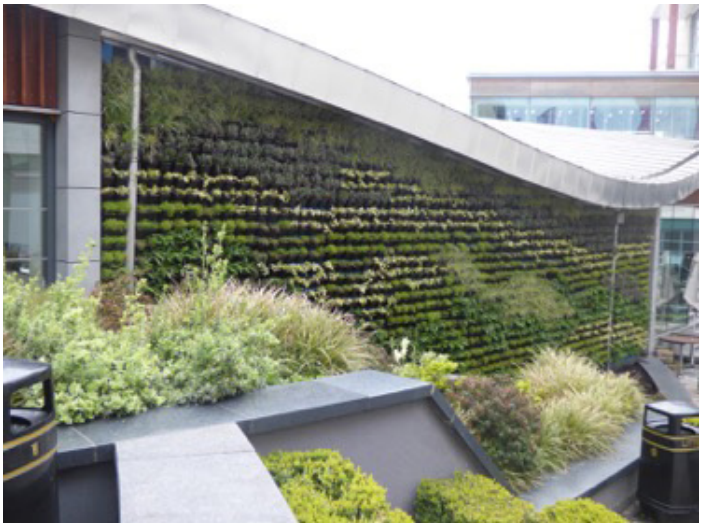


Figure 8: Living Wall. A living wall installed on the outside wall of a building. (Flickr, 2018)

Figure 9: Balcony Garden. (Pxhere)

of the aforementioned types of vertical gardens placed on balcony walls or traditional potted plants placed systematically along the terraces. The benefits of balcony gardens were examined in India, and these gardens provided citizens with personal farming opportunities, privacy from neighbors, and the aforementioned effects of green spaces (Vazhacharickal, 2014). Because this type of garden is placed on private balconies instead of walls, projects are typically citizen engagement initiatives. A list of types of vertical gardens, their benefits, their drawbacks, and images of examples of each can be found in Appendix A.

2.3.2. Vertical Garden Case Studies

To illustrate the ways in which vertical gardens have been implemented and the measurable effects they can provide, we will present case studies from other cities.

Zurich's MFO Park Vertical Garden installation shown in Figure 10 successfully makes use of a cable and wire-rope net setup in a densely settled urban area (Wong et al., 2010b). Plant species were carefully chosen, taking into account seasonal changes, resistance to sunshine, and growth rate. This example follows a design process that consistently engaged the public and focused on the aesthetics of the design.

Singapore has also incorporated a variety of vertical gardens. The Singapore Botanic Garden, which is pictured in Figure 11, installed a green façade built with steel cables and climbing plants. Because this structure is low to the ground, maintenance costs are minimal. It took a great deal of time for the wall to be fully covered because the climbing plants grew slowly (Wong et al., 2010b). There was also a living wall constructed at the Botanic Garden made from a modular panel system with a special substrate, and fully grown plants were placed in the structure (Wong et al., March 1, 2010c). The green façade had much less required maintenance, but it took a while to fully grow. The living wall could be installed using mature plants, so there was no waiting period; however, it is heavier and requires more upkeep. This case study highlights the fact that certain vertical garden types are better-suited for different situations.

Figure 10: Zurich's MFO Park. Cable and wire-rope net vertical garden. (Wikimedia Commons, 2010)

Figure 11: Singapore Botanic Garden. (Blogspot, 2014)

2.3.3. Design Considerations

The European Office of the World Health Organization released a publication in 2017 that outlined the importance of urban green spaces and offered a recommended planning process. The guide explains how to plan urban green spaces, design them, and ensure proper community engagement. Each section focuses on the importance of involving the community in the design process. When approaching how to plan an urban green space, it is important to understand the end goal, who will use it, and who will be affected by it. In the design phase, the guide emphasizes being able to respond to diverse needs by continuing community engagement. The guide's last section focuses on ensuring community engagement, which reiterates the importance of community participation during the planning phase (Manso & Castro-Gomes, 2015; WHO, 2017).

The Economic Commission for Europe published a Spatial Planning guide that gives guidelines for spatial planning and mentions that spatial planning processes will fall within a regional government. An area that the guide expands on is the advantages of involving stakeholders early on in the process. Stakeholders in spatial planning include the affected general public, as well as any groups contributing to the project, and engaging them can incorporate more viewpoints to improve the overall planning process (Economic Commission for Europe, 2008).

Location needs to be thoroughly considered before any plans for installing a vertical garden are made because human accessibility impacts construction, maintenance, and potential for benefits. In order for a green wall to be installed in a certain location, the space must be accessible for maintenance crews and in close proximity to citizens (Carpenter, 2008). If people are unlikely or unable to be near the potential site for a vertical garden or observe the structure, the benefits will be negligible (Carpenter, 2008). The weight of the structures is another factor that impacts location planning for vertical gardens (Carpenter, 2008). Without extensive consideration about how to bear the weight, there is potential that the entire structure will fail.

Arguably, one of the most important considerations is cost. The biggest contributors to high costs are irrigation systems, support systems, and diverse plant types (Carpenter, 2008; Rakhshandehroo et al., 2015). Cost of vertical gardens can vary over a wide range depending on the specific design of the structure (Bass & Baskaran, n.d.; Burhan & Karac, 2013; Timur & Karaca, 2013).

Plant selection needs to be considered before the exact kind of support is selected for a vertical garden. The designer must choose what kinds of plants they want because the size and weight of the plants determine what kinds of supports are necessary (Urrestarazu et al., 2015). Trellises can support climbing plants, planters can support small plants, and panels with soil substrates can support larger plants (Wong et al., 2010a). If a designer has less of a preference on plant type and size, they can choose the best support for the chosen area and work backwards to decide the plant species.

The lack of vegetation in Thessaloniki paired with the construction that is underway along Egnatia Street provides an opportunity for green space implementation. Vertical gardens are a viable option for this congested urban area. In the following chapter, we elaborate on a plan to assess the feasibility and value of integrating vertical gardens into Thessaloniki, Greece, focusing specifically on Egnatia Street.

3. Research Objectives

The goal of this project was to assess the feasibility and value of integrating vertical gardens along the Egnatia Corridor in Thessaloniki. To achieve this goal, we established the three research objectives shown in Figure 12.

We completed each objective using stakeholder engagement, spatial analysis, and site visits. This chapter expands on the three objectives to explain the importance of each for the scope of this project and the data collection and analysis strategies.

Figure 12: 3 Research Objectives for this project

3.1. Gauge Stakeholder Interest in Vertical Gardens

The purpose of this objective was to gauge a variety of stakeholders' interests in vertical gardens along the Egnatia Corridor. We used research questions to focus the data collection methods for this objective. The questions were as follows:

1. Which sectors might be interested in being involved in a vertical garden project in Thessaloniki?
2. What role might these different sectors play in the implementation of gardens?
3. Would people prefer to go to an area with vertical gardens?
4. Would people spend more time along the Egnatia Corridor if it had more gardens?
5. Would people prefer to make purchases at a business with vertical gardens?

In order to gain insights into these questions, we utilized two different data gathering methods. We will describe these methods in the following subsections.

3.1.1. Interviews with Expert Stakeholders

To understand the broader scope of this research project, we gathered input from a variety of expert stakeholders from different sectors. We interviewed at least one stakeholder from each of the education, municipal government, private industry, and nonprofit sectors. From these expert stakeholder interviews, we hoped to learn about past greenification efforts in the city. Additionally, we hoped to gather specific information about the Egnatia Corridor. We wanted to know the interviewees' experiences, areas that they believe need to be revitalized, and what positive impacts, if any, they

believe green spaces would provide for the social and economic climate. We also wanted to know what level of interest each sector had in being involved in a vertical garden implementation project.

A list of general interview questions was developed for each interview with a set protocol to follow. Most interviews were conducted in English and followed a semi-structured style, with the exception of one interview that was conducted in Greek with Dr. Avraam Mavridis as the primary facilitator. We had a list of questions with the higher priority questions highlighted and allowed the conversation to flow, prompting with follow up questions to clarify any responses or ask for further elaboration. Answers to each question were recorded by one notetaker, and there was a secondary notetaker who took general notes. The interview protocol can be found in Appendix B. Sample interview questions from the different interviews can be found in Appendix C.

3.1.2. Citizen Engagement Questionnaires

We also developed a questionnaire for citizens that spend time along the Egnatia Corridor, students of Aristotle University, and students of the American Farm School. The students of Aristotle University make up a large portion of Thessaloniki's population, so engaging with this population was of interest. We developed this questionnaire to gather public opinions about the look and feel of the Egnatia Corridor as well as their interest in greenification efforts in the city of Thessaloniki. Lastly, we hoped to learn whether or not they would be more likely to spend time on Egnatia Street if it contained more greenery.

We utilized an in-person and online version of the questionnaire, both of which had English and Greek versions. The in-person questionnaire allowed us to focus some of the questions to the specific area where the questionnaire was given, as well as ask follow up questions and engage with the respondents. The online questionnaire was able to collect more responses, as it was easier to distribute. The questions from these questionnaires can be found in Appendix C.

For in-person questionnaires, we started with a greeting and brief introduction in English, if possible, or used a memorized Greek phrase. We received support from a Greek student from Perrotis College, and he was able to communicate with people in Greek and gather more feedback. The questionnaire protocol can be found in Appendix D.

The online questionnaire was a self-administered electronic Qualtrics Research Suite survey. As mentioned before, the questionnaire was distributed to students and faculty of Aristotle University and the American Farm School. This questionnaire was the same as the in-person version, besides one question that was about the Egnatia Corridor as a whole rather than a specific area. One limitation to the online questionnaire is that it was distributed to colleges, so the responses were limited to college-aged students. The online questionnaire received a total of 164 responses, while the in-person questionnaire yielded 20.

3.2. Identify Sites and Provide Spatial Analysis Tools

The focus of this objective was to find relevant data sets and potential vertical garden sites to aid informed vertical garden implementation in the future. We considered citizen input, the current locations of green spaces, and demographic spatial data. In order to fulfill this goal, we proposed a set of research questions:

1. What are people's preferences for vertical garden locations?
2. Which sites are appropriate for implementation of vertical gardens?
3. What data sets could be used to inform the selection of vertical garden sites?
4. How can the data sets be compared and analyzed by both us and future researchers?
5. Which areas along the Egnatia Corridor are frequented most by pedestrians?
6. Are the potential locations accessible for maintenance?

To answer these questions, we utilized questions about liked and disliked areas of the region around the Egnatia Corridor from the questionnaire described in Section 3.1. We used this information as one set of data, combined with other data sets that will be explained in the following paragraphs, to use spatial analysis to identify potential vertical garden sites.

Spatial analysis found areas for prospective vertical garden sites based on the locations and density of existing green spaces, as well as the concentration of citizens in certain areas. To complete this, we utilized

Figure 13: Axes along Egnatia. Map showing the six axes where pedestrian data was collected.

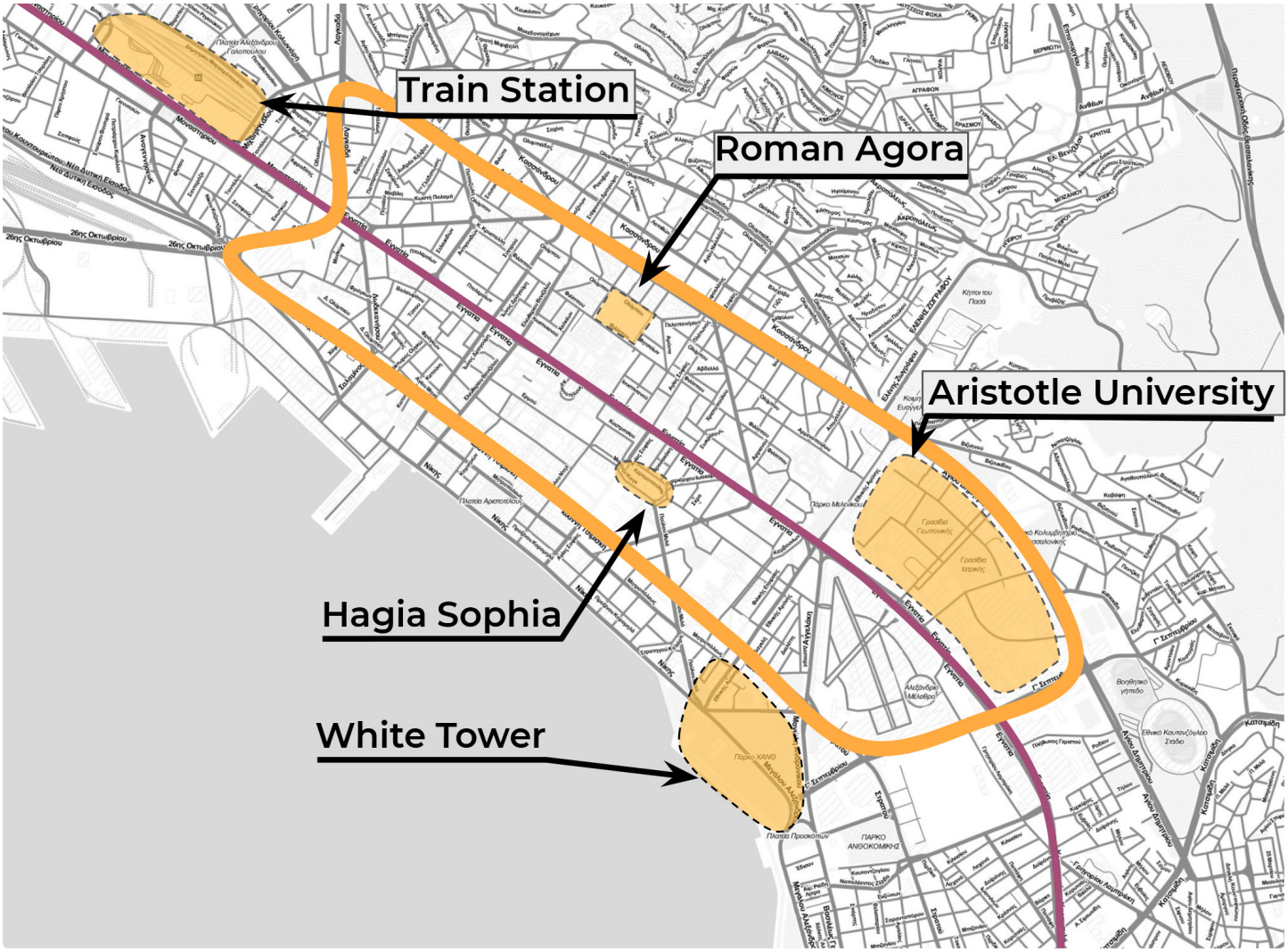


Figure 14: Map showing the the area of interest (orange) and Egnatia Street (magenta) as well as several well known landmarks.

data from three different sources: the City of Thessaloniki, Inside AirBnB, and the project "Mapping the Complexity and Future Vision of the Egnatia Corridor."

Data from the City of Thessaloniki was used to identify green spaces and later perform specific analysis of the concentration of these spaces in the region around the Egnatia Corridor ("GIS Thessaloniki," 2019). This data consisted of every building plot in the municipality and its rough usage. In this research, green space categories were "Urban Green Spaces," "Tourism and Recreation," and "Local Neighborhood Center" (translated from Greek). A green space proximity map was then created in the programming environment Mathematica. This proximity map was made by drawing a circle around every building plot and totalling all of the green spaces that had their center points in the circle for each plot. The previously totaled area of green space for each plot was then mapped to colors; whitest plots corresponded to the least amount of green space around them and greenest corresponded to the most green space. This type of map shows the proximity of particular building plots to green spaces while also weighting larger green spaces over smaller ones.

An organization called Inside AirBnB provides well formatted and aggregated data from the main AirBnB website ("Inside

Airbnb," 2019). This data was used to create a heatmap of rental prices in the region around the Egnatia Corridor as an indicator of tourist activity and general wealth in the area. This data was useful for identifying upscale sites in areas of high tourist desirability.

One of the outcomes from the project "Mapping the Complexity and Future Vision of the Egnatia Corridor" was measured pedestrian volume over six major axes perpendicular to the Egnatia corridor (Duffield, Galdámez, González, & René, 2019). These axes can be seen in Figure 13. This data added another layer to the site consideration because higher pedestrian traffic can be a favored or disfavored attribute for a potential site based on the goal of the particular vertical garden project.

The area of interest for conducting spatial analysis along the Egnatia corridor can be seen to be outlined in orange in Figure 14.

We also visited potential sites for vertical gardens. These visits were conducted by walking a path around the area of interest surrounding Egnatia Street and taking geotagged pictures of potential sites. Emphasis was put on the suitability of the building for a vertical garden and the variety of sites. In total, 47 sites were visited. We made a cursory analysis of the buildings' structure, and buildings that appeared to be obviously unmaintained and unsuitable were not considered. Sites that did not have room for maintenance for potential gardens were not considered. Building use (i.e. apartments, hospitals, storefronts, etc.), amount of owners, and location were considerations for site variety. A large variety of sites allows future researchers to have access to a large breadth of potential sites.

Taking all of this data into consideration, we created an interactive map on a website that allowed for analysis of all relevant data sets. All of these aforementioned data sets represent a layer on the interactive map, and they can be overlayed to explore the relationships between them. The website link is greenhighfive.eu, and an explanation of the website can be found in Appendix E.

3.3. Develop Conceptual Designs and Siting Framework

The purpose of this objective was to develop conceptual designs of vertical gardens and a vertical garden site selection tool using the relevant information we gathered in previous objectives. By creating conceptual design recommendations, we outlined options for implementation that could be used to assist in future planning of the project if it moves forward. The site selection tool was used to assess the appropriateness of a potential vertical garden location and could be used more in the future. The research questions for this objective were as follows:

1. What types of gardens do people prefer?
2. What general type of structure would be feasible in the determined locations?
3. What limitations do certain locations provide for designs?
4. What technical considerations will impact designs?
5. What common design pitfalls prevent the implementation of vertical gardens?
6. What are the financial considerations of vertical garden implementation?

To answer these questions, we drew on findings related to vertical garden design and preferences of aesthetics from the interviews and questionnaire described in Section 3.1 and the site visits described in Section 3.2. Using literature and those findings, we identified key factors for selecting vertical garden locations.

We incorporated those factors into a siting framework, specifying potential sources of information for each factor, to serve as a tool for vertical garden site selection. Using the site selection tool and the interactive map as described in Section 3.2, we chose four potential sites for vertical gardens along Egnatia Street and developed conceptual designs for each. The interactive map was used to compare the various demographic layers with the potential sites. We picked sites that had different uses as well as those that were in different areas of wealth, pedestrian traffic, and green space density. The data layers of the map were compared to select various sites for different benefits.

The conceptual designs were created using Photoshop, an image editing software. We used pictures of buildings along the Egnatia Corridor that we took during site visits and edited them to show what a vertical garden would look like on each of the four locations. These mockups visually represented the potential that vertical gardens have to enhance the current aesthetics of the Egnatia Corridor.

Vertical Garden - London

4. Suitability Factors for Urban Vertical Gardens along the Egnatia Corridor

In this chapter, we describe factors that influence the selection of sites for vertical gardens. We begin by presenting findings related to the potential economic benefits. Second, we discuss the environmental benefits that an urban greening project could provide. We then explain potential improvements to human health and social structures. We follow this with a discussion about feasibility and logistical considerations for site selection. Lastly, we explain how all of these factors are combined to make a tool to aid in site selection for vertical gardens and explain the results of using those tools for sites along Egnatia Street.

4.1. Potential for Economic Benefits

The addition of green spaces around Egnatia Street has the potential to benefit the economy in various areas surrounding the Corridor. Studies suggested that green surroundings can be successful in bringing more customers and business to an area (Kathleen L Wolf, 2005). Questionnaire responses further confirmed this suggestion. As shown in Figure 15, 84.8% of questionnaire respondents agreed or strongly agreed that they would be more likely to go to an establishment that contains gardens than one without. This suggests an increase in patronage for an establishment that implements a vertical garden and could therefore correlate to an increase in the economic activity for the surrounding area.

One limitation all findings related to questionnaire responses is the age bias that exists in the data. 62% of questionnaire responses were from people aged 18-30, while only 13% of the Greek population falls within this age bracket (Piraeus, 2014). Because young people are more supportive of environmental causes, it is possible that a more representative age distribution would show lower support for the integration of green space (Hersch & Viscusi, 2006). This should be considered for all questionnaire response data throughout this section.

Similarly, 87.8% of respondents agreed or strongly agreed that they would be more likely to go to a location with green spaces than without. These responses are visually represented in Figure 16. This question differs from the last because it aimed to gauge if there would be an increase in foot traffic to an area with more green spaces, which could bring in more economic activity. The positive responses to this question suggest the possibility of an increase in foot traffic in an area that incorporates vertical gardens.

Incorporating vertical gardens in areas that experiences high foot traffic provides an opportunity to increase the current economic activity in that area, and incorporating vertical gardens in areas that experience low foot traffic could increase

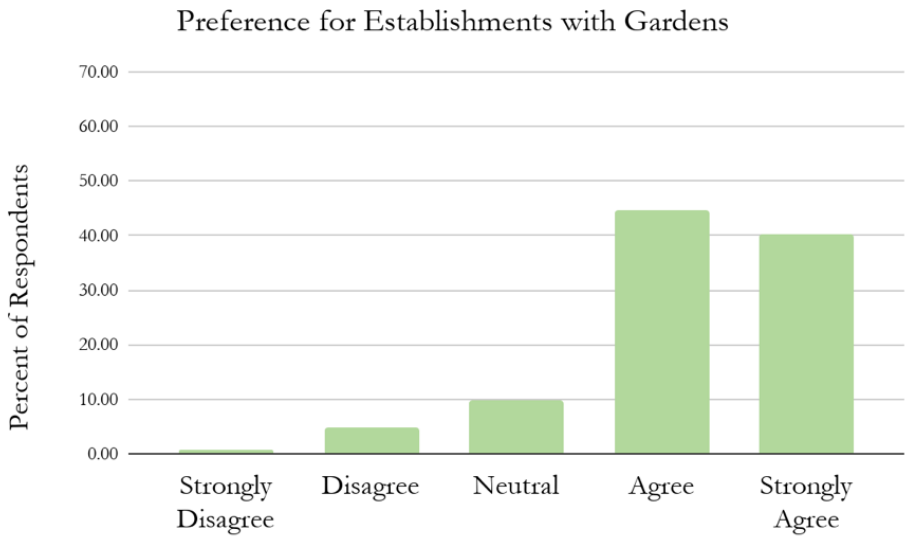


Figure 15: Bar Graph of Preferences of Establishments with Gardens. Graph showing responses when respondents were prompted with the statement "I would be more inclined to go to an establishment with gardens than one without.". Number of responses (n)=164.

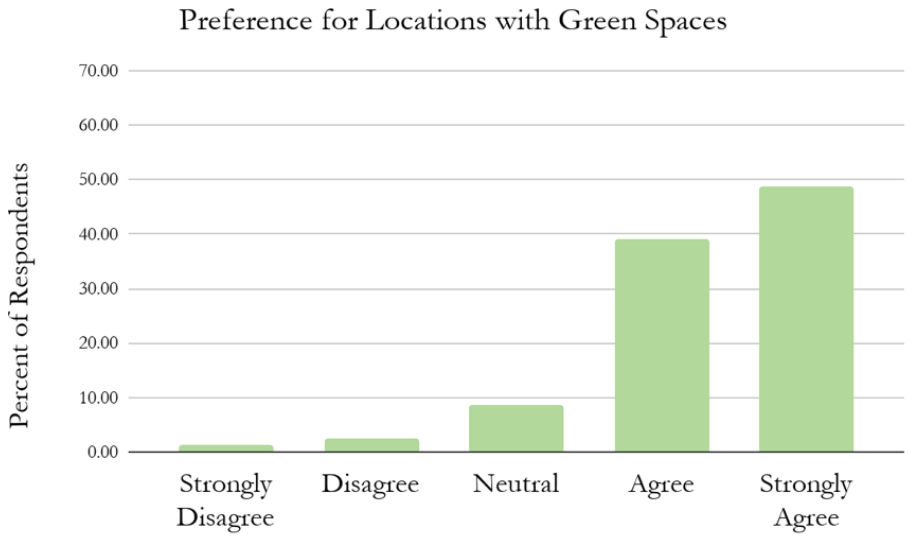


Figure 16: Bar Graph of Preferences of Locations with Green Spaces. Graph showing responses when respondents were prompted with the statement "I would be more inclined to go to a location with green spaces than without." n=164.

economic activity by increasing interest in that area. Interviews with a Consultant of Urban Resilience of the Municipality of Thessaloniki and a representative involved in the planning of a vertical garden from the Department of Landscape Architecture of the Municipality both suggested that implementing vertical gardens in areas of Thessaloniki that experience heavy foot traffic could allow vertical gardens to gain exposure and popularity. Aristotle Square is an area along Egnatia that experiences high foot traffic, as represented by the darker red lines the map shown in Figure 17 (Duffield et al., 2019). Once vertical gardens are better known as a way to increase greenery in a dense urban area and their benefits are appreciated and acknowledged, they can be introduced to areas that are less busy and draw more people to those areas. Areas of lower foot traffic are highlighted in the lighter pink color in the map in Figure 17. Increased foot traffic and time spent at a location could be expected to lead to an increase in commercial activity.

Implementing vertical gardens on residential buildings has potential to increase desirability to live there and the value of the residence. Based on questionnaire responses, various interviews, and AirBnB pricing data, it is evident that respondents

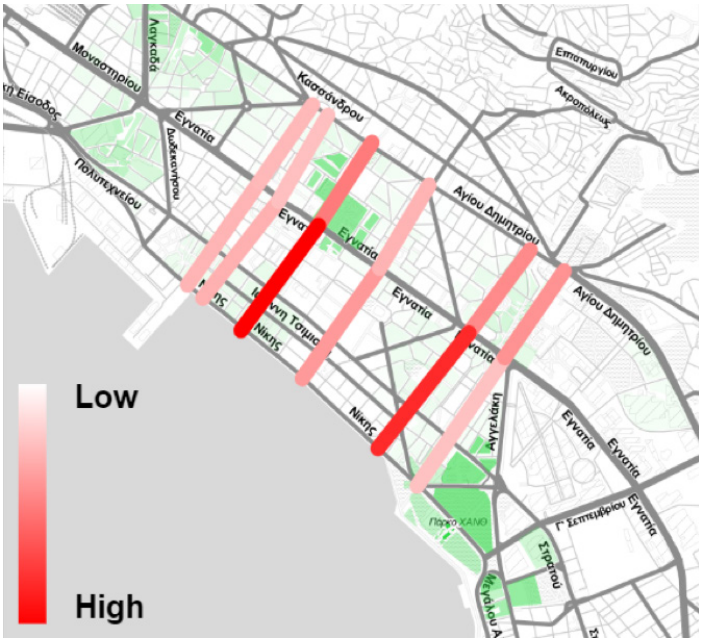


Figure 17: Foot Traffic Map. A map that shows the relationship between foot traffic along six major axes and the amount of green space on Egnatia. Brighter red indicates more foot traffic in that general area.

appreciate green spaces and see the value in increasing the amount of green spaces in Thessaloniki. The map on the left in Figure 18 is a heatmap that shows the average cost of rental apartments advertised on AirBnB in March, 2019, in areas around Engatia Street. The map on the right in Figure 18 is a map that shows the density of green spaces in an area. There is a correlation between areas with more green spaces and higher AirBnB prices. This suggests that green spaces could increase the value of an area and the properties located there.

An interview with the Consultant of Urban Resilience of the Municipality highlighted the fact that many residential buildings contain small balcony gardens, suggesting that people want vegetation around their living spaces. Because this desire for green space exists and there is a correlation between AirBnB property values and nearby green spaces, incorporating greenery—particularly vertical gardens—has potential to increase the property value of many residential buildings.

4.2. Value of Environmental Benefits

Increasing the amount of greenery in a highly urban area can have many positive environmental effects. The green-shaded areas on the map in Figure 19 show where green spaces currently exist around Egnatia Street in the area of interest. The green spaces shown are the building plots identified by the Municipality of Thessaloniki to be in the categories of "urban green spaces," "tourism and recreation," or "local neighborhood center." The green spaces in this area are sparse and small in size, and there are very few located on the Corridor itself. Many of the green spaces are located outside of the highly urban area of the city or around the edges of the area of interest.

The Municipality of Thessaloniki acknowledges the environmental benefits that come from increasing biodiversity in the city. Proposals of plans to increase biodiversity have been welcomed by the municipality in the past. Members from Callisto, an NGO focused on wildlife conservation, explained their experience working with a community group, the Neighborhood Initiative of Alexandros Svolos, to gather data about the environmental benefits from incorporating pocket parks in urban areas. The community group proposed the inclusion of a pocket park into the city in an area that partially included municipality land, and the city had a positive response to the plans. The municipality was willing to have this kind of project carried out, especially because there were other organizations involved in planning, funding, and implementation. The Consultant of Urban Resilience from the Municipality also expressed similar feelings, saying that the city would appreciate more green spaces even though they are not currently involved in many initiatives to do so. The Resilient Thessaloniki Plan acknowl-

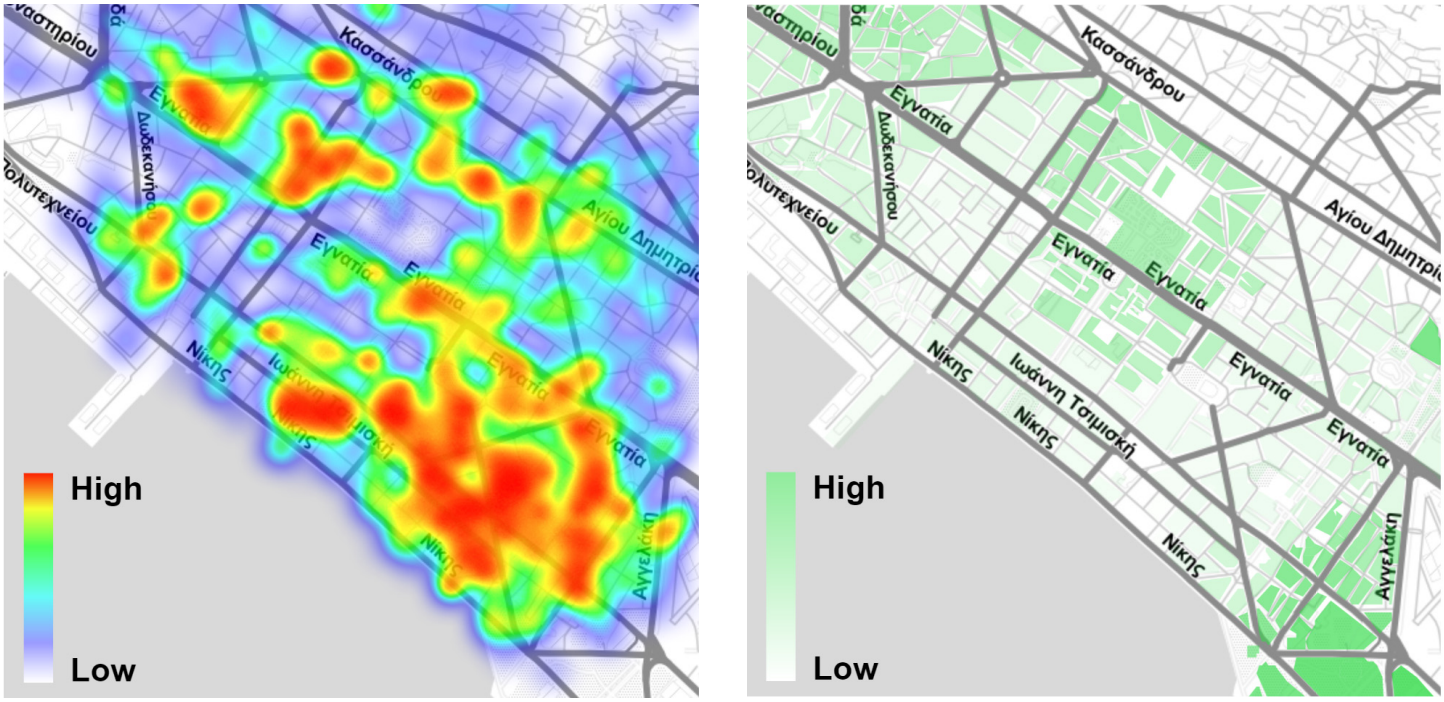


Figure 18: AirBnB Price Data Heat Map. Left is a heatmap of AirBnB prices and right is the 400m radius proximity green space map. Completely white areas on the left map indicate no listings are available there.

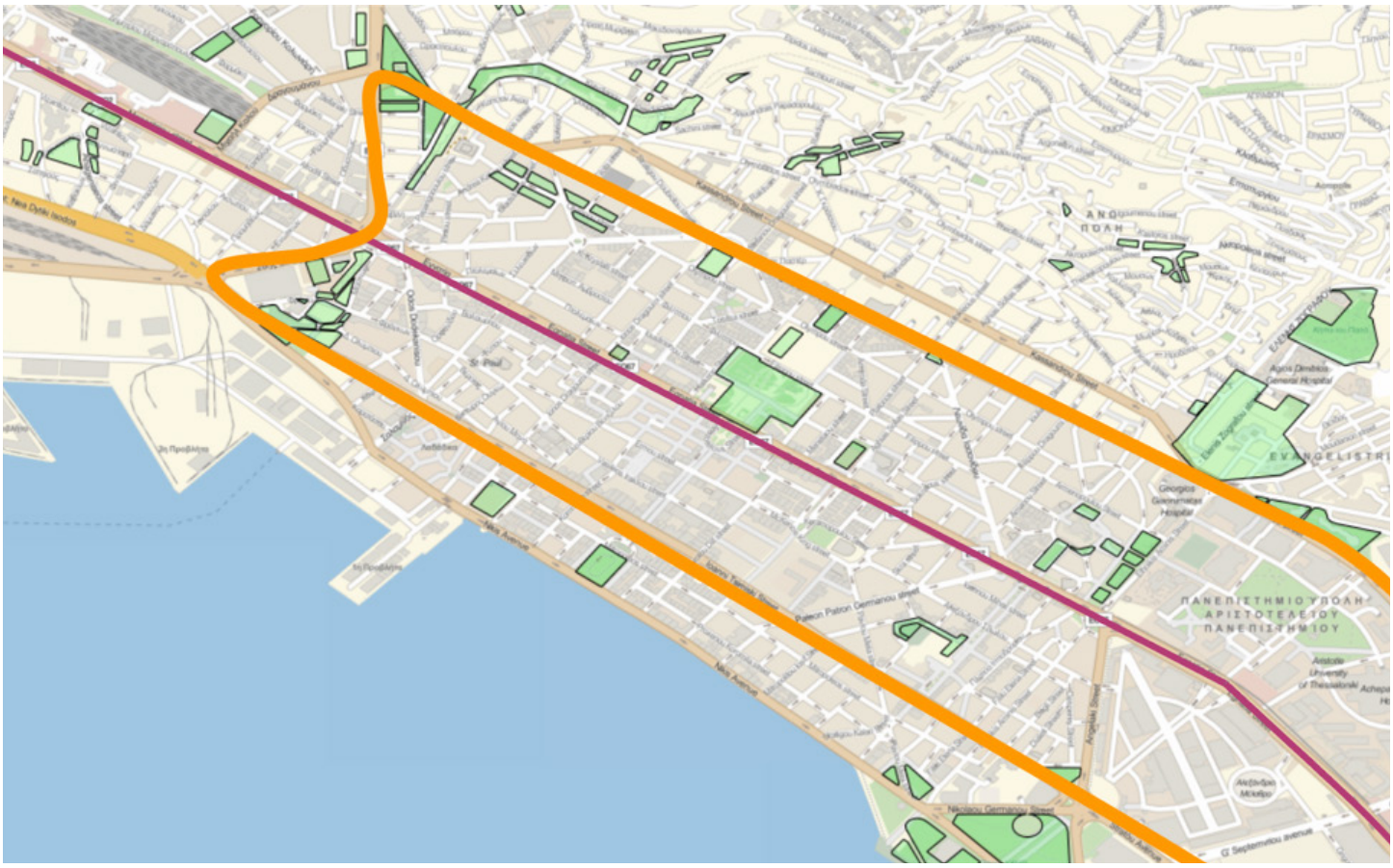


Figure 19: Map of Green Spaces in the region around the Egnatia Corridor. Egnatia Street is traced in purple, and the area of interest is outlined in orange.

edges the benefits of biodiversity as well. This provides a promising opportunity for an urban greening project that contributes to increasing biodiversity.

4.3. Potential to Improve Human Health and Social Structures

Incorporating vertical gardens along Egnatia Street in areas that are currently far from green spaces and are known to be be social areas has the ability to improve citizen health, happiness, and social structures in the surrounding area.

There is an uneven distribution of green space around the Egnatia Corridor; green space is limited to Aristotle Square and the edges of the area of interest near Democracy Square, while the rest of the region is noticeably lacking greenery. The edges of the area of study have much more green space than anywhere in the study area, besides the middle near Aristotle Square,

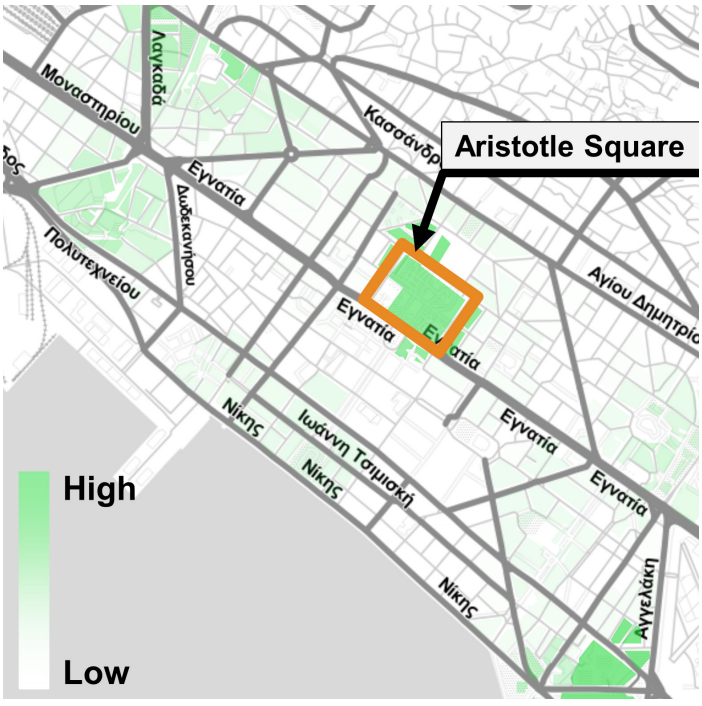


Figure 20: Map Showing Aristotle Square. A 200 meter green space proximity map outlining Aristotle Square on Egnatia Street.

which has a moderate amount. Aristotle Square is a central location in the city as seen in Figure 20. The maps in Figure 21 were generated by adding up all of the green area in a circle around each property plot. In this map, a property plot is a building or group of buildings the city has surveyed. Each plot's total area of proximal green space is signified by its color. Brighter green indicates a higher total area and whiter indicates a lower total area. The images in Figure 21 differ in that they use a different radius to calculate proximal green spaces. The map on the left represents a 200 meter radius and the map on the right represents a 400 meter radius, and both illustrate the uneven distribution of green space in this region of Thessaloniki. The maps show a very low concentration of green space in the central locations of the city besides Aristotle Square. A higher concentration of green space exists on the outermost edges of the Egnatia district, showing the uneven distribution. Importance of proximity to green space was elaborated on in Section 2.1.2 and emphasizes the need for a more evenly distributed amount of greenery in Thessaloniki. In order to provide the most health benefits, vertical gardens can be placed in these regions with lower green space concentration.

Two limitations exist for the way in which these maps were made. Data that was used for green space analysis is not entirely up to date or accurate because a geographical survey is only performed once every few years. Also, the Municipality of Thessaloniki did not include certain green spaces in their data sets. For this reason, green spaces that are publicly owned or were not surveyed when the data was created are not included in the green space proximity maps. Additionally, green space proximity was calculated using distances from buildings to the center of each green space for computational purposes, and that approximation limits accuracy in the results.

Figure 21: Green Space Proximity Maps. 200 meter radius (left) and 400 meter radius (right) area accumulation map of green space created based on recommended green space proximity. Brighter green indicates a higher total area and whiter indicates a lower total area.

A majority of questionnaire respondents believe green spaces would improve the aesthetics of Egnatia, which they currently view negatively. Citizens do not currently enjoy the aesthetic of the Corridor. When asked if they see a benefit to there being more green spaces on Egnatia Street, 92.1% of respondents answered either "Agree" or "Strongly Agree". Figure 22 shows how questionnaire respondents rated the amount of greenery on Egnatia Street on a scale of 0 to 10, 0 being poor and 10 being excellent. As can be seen in this figure, the most common answer was 2, and a majority of the responses fell between 1 and 5, demonstrating that citizens recognize the lack of green spaces along Egnatia Street. The Resilient Thessaloniki Plan references the fact that greenery would increase the attractiveness of the city. This was also suggested in an interview with a representative from the Department of Landscape Architecture of the Municipality who was involved in the planning of a vertical garden built during the summer of 2018. She shared with us the positive responses citizens had to the installation of this vertical garden and the new look of the area. She mentioned that the department observed an increase in the number of people walking through the area where their building is located and a noticeable number of people stopping to look at the wall and take pictures.

Incorporating green spaces along Egnatia Street could provide more sites for social cohesion for citizens. Green spaces provide gathering places for people. During in-person questionnaire distribution and site-visits to Egnatia, we observed that people tend to congregate in and spend time in current green spaces. These are the locations where people stop to sit, converse, eat a meal, and more. Inclusion of more green spaces in Thessaloniki, particularly in the busy center along Egnatia Street, would increase the number of sites for these types of interactions and in turn could increase social cohesion of the citizens.

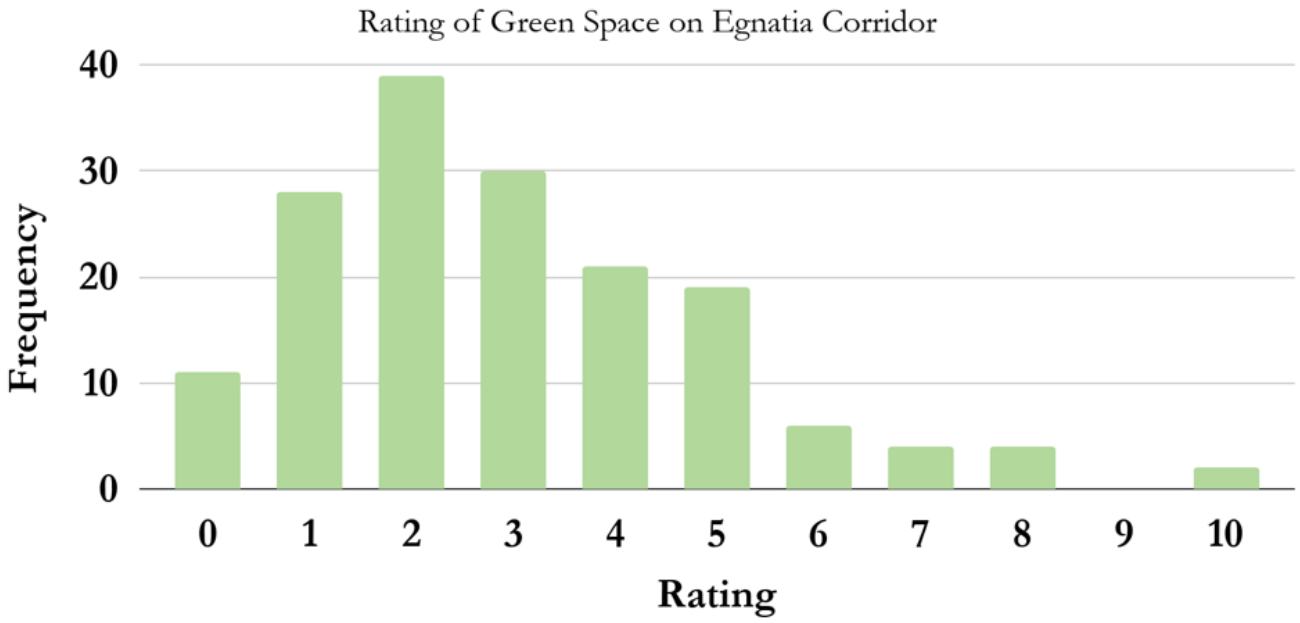


Figure 22: Bar Graph of Egnatia Green Space Rating. Questionnaire respondents were asked "On a scale of 0-10, how would you rate the amount of greenery on the Egnatia Corridor?" The plot above represents the responses, showing that the most common answer was 2. The number of respondents was 164.

4.4. Feasibility and Logistics

Feasibility factors of a vertical garden site include structural and spatial characteristics of the site as well as the number of building owners and its usage. The former impacts the ability for a building to actually support a new structure, whereas the latter affects the funding received for such a project and the implementation process that would be used.

Many buildings in Thessaloniki have multiple owners, complicating construction projects involving a building's exterior. This was pointed out during an interview with the Consultant of Urban Resilience from the Municipality. For this reason, multi-owner apartment buildings are less feasible locations for the initial implementation of a vertical garden project. Alternatively, hotels are an example of single-owner buildings that were easily identifiable and could be considered as target locations for implementation of vertical gardens. Municipal buildings are another easily identifiable category of single-owner buildings, but other restrictions were identified for these buildings.

The Municipality of Thessaloniki may not have the resources or capacity to implement vertical gardens along the Egnatia Corridor. The private sector is more likely to be able to take on the task of incorporating vertical gardens along Egnatia Street. The interview with a Consultant of Urban Resilience suggested that the city does not have the resources to take on construction and maintenance of a large scale vertical garden initiative. Vertical garden construction can be a costly project. This interview also suggested that the private sector is better suited for this task, and an interview with the CEO of Vita Verde concluded similarly. The representative from Vita Verde also suggested that the municipality would be using its resources more effectively by focusing on improving current green spaces in the city before moving onto incorporating new ones. These considerations further influence the

Figure 23: Potential Walls for Vertical Gardens. Examples of potential walls for vertical garden implementation in Thessaloniki. The walls with large blank spaces have the potential for vertical gardens. The walls with smaller blank spaces and numerous balconies have the potential for smaller vertical gardens or balcony gardens.

types of buildings that could be considered for potential sites.

Newer, well-maintained walls along Egnatia Street are more likely to have the load-bearing capacity to support a vertical garden, but viability has to be determined on a case-by-case basis. Many buildings in Thessaloniki are old, and they are not able to support a heavy structure. An interview with the CEO of Vita Verde suggested that walls that are old or mostly glass are usually not suited to support vertical gardens. Promising sites are ones that appear to be newer or better-maintained. However, internal structural analysis, with the focus on the particular garden being considered, needs to take place on every site before vertical garden construction can start. Some examples of potential walls can be found in Figure 23.

High walls and narrow alleyways should be avoided in the initial phases of long-term vertical garden implementation. A wall must be accessible for construction and maintenance in order to be able to support a vertical garden. A site is not viable if the wall it is built on cannot be easily accessed for routine maintenance. The CEO of Vita Verde as well as a representative from Callisto explained that maintenance is typically where problems happen with greening projects, because

Figure 24: Examples of Accessible Sites for Vertical Gardens. Potential vertical garden sites in Thessaloniki based on maintenance accessibility. The walls with large blank spaces have the potential for vertical gardens. The walls with smaller blank spaces and numerous balcony gardens have the potential for living walls or balcony gardens.

if owners neglect the maintenance needs of a vertical garden, the wall can become overgrown, die, and fall apart. Accessibility can greatly affect the cost and frequency of maintenance, and therefore the success of a vertical garden. This was considered when site visits were conducted, and potential locations can be seen in Figure 24.

The chosen plant species must grow well in Thessaloniki's climate, grow well in the particular conditions of the chosen site, and have conditions appropriate for a vertical garden. A species' foliage density, water consumption, sunlight needs, and maintenance requirements must be considered. The CEO from Vita Verde explained that plant selection is based mostly on the amount of sun or shade the wall receives, as well as what plants will grow in a given region. Representatives from the Department of Landscape Architecture also emphasized this point, explaining how all of the plants in their living wall were chosen because they naturally grow well in Greece and have similar water needs. Table 1 summarizes many of the considerations used to make decisions

Table 1: Plant Species. Details about plant species that grow well in Greece. The first four listed species are the ones growing in the Department of Landscape Architecture's Living Wall (Gardenia, n.d.).

Plant Species	Ideal Conditions	Water Needs	Maintenance	Foliage Density
Pittosporum tobira nanum	• Full sun or part shade • Medium moisture, well-drained soils • Average, slightly acidic, moderately fertile soil • Drought tolerant once established • Soil type: chalk, loam, sand	• Low, average	• Low, average • Regular trimming to maintain compact shape	• Height: 30 – 60 cm • Spread: 30 – 60 cm
Nandina domestica	• Full sun to part shade • Average, moist, well-drained soils • Acid, alkaline, or neutral soil • Drought tolerant once established • Soil type: chalk, clay, loam, sand	• Average	• Low • Generally pest and disease free	• Height: 120 – 240 cm • Spread: 60 – 120 cm
Rosmarinus officinalis prostratus	• Full sun, tolerates light shade • Poor, well-drained soils • Acid, alkaline, or neutral soil • Drought tolerant once established • Soil type: chalk, loam sand	• Low	• Low • Virtually disease free	• Height: 30 – 60 cm • Spread: 60 – 90 cm
Euonymus japonicus elegant aureus	• Full sun to full shade • Average, medium moisture, well-drained soils • Acid, alkaline, or neutral soils • Soil type: chalk, clay, loam, sand	• Average	• Low	• Height: 60 – 90 cm • Spread: 3- 60 cm
Myrtus communis	• Full sun, light shade • Moist, well-drained soils • Acid, alkaline, or neutral soil • Drought tolerant • Soil type: chalk, clay, loam, sand	• Low, average	• Low • Virtually disease and pest free	• Height: 240 cm – 3.6 m • Spread: 240 cm – 3.6 m
Nerium oleander	• Full sun • Average, medium moisture, well-drained soils • Acid, alkaline, or neutral soil • Soil type: chalk, clay, loam, sand	• Low, average	• Low • Light pruning for shape • Virtually disease free	• Height: 180 cm – 4.5 m • Spread: 180 cm – 3 m

about plant species, specifically for the species used in the Department of Landscape Architecture's wall, which are the first four plant species listed, as well as other species that grow well in Greece's environment.

4.5. Siting Tool and Interactive Map

In this final section of the chapter, we present a framework for site selection to determine the feasibility and appropriateness of potential sites for implementation of a vertical garden along Egnatia Street. Figure 25 depicts this site selection tool. The are four main categories are shown in the gray boxes. More specific indicators related to each category are shown in the green boxes all the way to the right. These are some of the main indicators that could be used to assess the appropriateness of a potential site. Site selections can be framed by taking into consideration a variety of these indicators, weighing certain ones more or less depending on the specific situation. In some situations, some indicators may not weigh into the consideration at all. The interactive map can be used to visualize some of these indicators. Layers can be hidden and made visible, allowing for the comparison between many sources of data.

This framework along with the interactive map (greenhighfive.eu, description in Appendix E) was used for selection and identification of potential locations for vertical gardens on Egnatia Street. Each layer on the interactive map fits into one of the siting tool factors. These layers and their associated siting tool factors were used to assess the feasibility of each site. Design demonstrations and mock-ups were then created for four locations, which can be found in the following chapter.

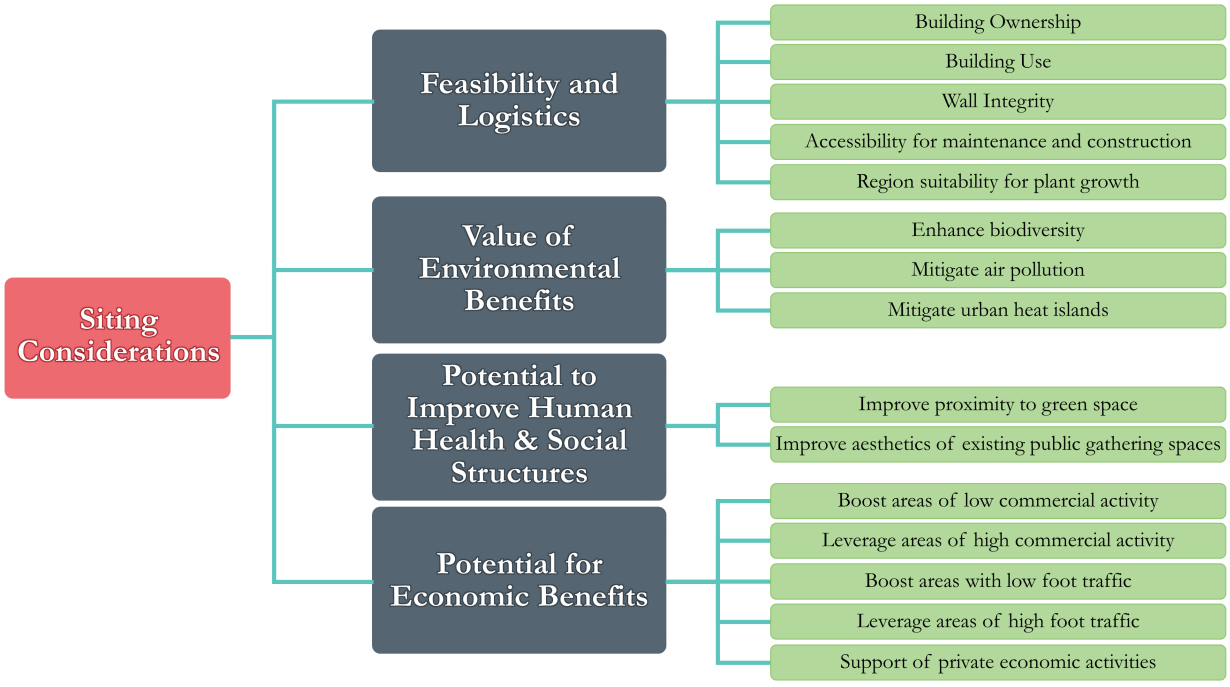


Figure 25: Site Selection Framework. A framework for vertical garden site selection based on the various findings outlined in the previous sections of this chapter.

5. Conceptual Designs and Future Work for Vertical Gardens

The following section describes four sites along Egnatia Street that were identified as potentially suitable for vertical gardens. We describe each site's features and present mockups of vertical gardens for each location. We then discuss process recommendations for the implementation of vertical gardens and opportunities for further research.

5.1. Promising Sites and Design Mockups for Vertical Gardens

We use the site selection framework and spatial analysis described in Section 4 to identify suitable sites for vertical garden placement. Four potential sites are described in the following subsections, and a link to a map including all 47 identified prospective sites can be found in Appendix E. The four potential sites are all located along Egnatia Street and correspond to the numbers on the map shown in Figure 26.

After identifying feasible sites, we created general design mockups to show how a vertical garden would impact the aesthetics of the area. These basic designs for vertical gardens will be helpful to generate interest and work toward implementation of this project. Examples of these mockups can be found following the explanations of site selections.

Mockups were made using Photoshop by overlaying existing vertical garden images on pictures of the sites. Gardens were selected that fit the aesthetic preferences of the respondents to our questionnaires, including gardens with thick foliage and colorful elements.

Figure 26: Map of Potential Vertical Garden Sites. A map showing the location of the four potential sites as described in the following sections, and pins indicate the type of establishment for each site.

5.1.1. Potential Site 1 - "Hotel El Greco"

Balcony gardens could be implemented on the extensive network of balconies on the front of this building. The building is medium sized, and there is a clear area in front for construction and maintenance. The building facade looks well maintained, which suggests it would be able to support a new structure. Since this site is a hotel, the building is likely to have only one owner, easing the planning and investment stage.

There is potential for economic benefit if this location were to implement a vertical garden. Because this location is a hotel, it could experience an increase in foot traffic and customers. This location is currently in an area that sees lower activity than other places along Egnatia, as identified through foot traffic data. Attracting more people and making the building more attractive could make this hotel more competitive against other hotels in the area.

Introducing a vertical garden here also has environmental benefits. This site is far from traditional green spaces, so incorporating vegetation here would provide greenery that has potential to increase biodiversity, mitigate air pollution, and reduce urban heat island effect. Implementing a vertical garden here would also help to increase people's proximity to greenery and improve the aesthetics of the area. Placing a vertical garden far away from traditional green spaces proportionally increases its positive effects.

To show the impact a vertical garden could have, a potential design mockup is shown in Figure 28 next to the picture of the potential site.

Figure 27: Design Concept 1. Potential Site 1 (left) and its design mockup (right)

5.1.2. Potential Site 2 - "48 El. Venizelou Residential Tower"

This residential building appears to be feasible for supporting a vertical garden. The building looks relatively new and well-maintained, which suggests that it would be able to support a heavy structure such as a vertical garden. Vertical gardens spanning the full height of the building could be maintained from the balconies. Additionally, there is plenty of room in front of the building for construction and maintenance accessibility. Balcony gardens could be another option.

Because the building is on Egnatia Street, there are expected economic benefits. A vertical garden has potential to increase foot traffic in this area of Egnatia that already sees high activity as determined through foot traffic data. The stores around this location could experience economic benefits. The residential building could see an increase in property value and desirability to live there, as well. As an added benefit, since the building is located in an area that already experiences fairly high foot traffic, a vertical garden could receive a lot of attention, possibly increasing acceptance of vertical gardens as a whole.

There are also expected environmental benefits that come with choosing this location. This location is not directly in contact with other green spaces, so this site could benefit from having a vertical garden to increase biodiversity and potentially decrease the urban heat island effect to some degree.

Figure 30 shows the potential design mockup alongside the original picture of this locations.

Figure 28: Design Concept 2. Potential Site 2 (left) and its design mockup (right)

5.1.3. Potential Site 3 - "Studio Optic"

Although this building appears to be mixed-use, which might suggest multiple owners, it could still be a suitable location for vertical garden implementation. Focusing only on the bottom area would centralize construction to one building owner, but the other owners would likely need to be consulted if a vertical garden construction project were to be carried out. The blank walls are low to the ground and there is space in front of the site, which would allow for easy construction and maintenance.

This is a commercial segment of a mixed use building, so it could experience the increased foot traffic and commerce that is expected from the implementation of a vertical garden. This storefront currently experiences medium foot traffic. Increasing the attractiveness of the building could increase the value of the residences located above as well

From an environmental standpoint, this business is located in an area removed from other green spaces. The area could benefit from an increase in biodiversity, and vertical garden implementation could accomplish this. Since this area lacks greenery already, incorporating a vertical garden here would also help to increase citizen proximity to green space. This could improve the look of the area and produce some of the benefits that humans receive from natural environments.

The comparison of the original site picture to its design mockup can be seen in Figure 32.

Figure 29: Design Concept 3. Potential Site 3 (left) and its design mockup (right)

5.1.4. Potential Site 4 - "Department of Health Building"

There are many physical characteristics and ownership details that make this location feasible. This is a single-use building which suggests that it will only have one owner. The outside walls appear to be maintained well, which indicates that the building has potential to support a fairly heavy structure. Although the building has many floors, a vertical garden could be constructed exclusively on the lower floors to make construction and maintenance easier. The garden could extend far upwards if the wall is strong enough and maintenance is still possible at a higher height. Because the building is owned by the municipality, a project here is unlikely to occur until the municipality is able to invest in new green space initiatives.

A vertical garden on this building could increase foot traffic in the surrounding area, and this could increase commercial activity for the area. This may not be a main benefit the building owners would be concerned with, but it could still provide this change.

This building is located away from green spaces in Thessaloniki, which means it could be beneficial for the environment to implement a vertical garden here. A vertical garden in this area could greatly increase biodiversity, and, depending on the size, it could help with the urban heat island effect and mitigate air pollution. It could also provide many human health benefits.

The mockup of a potential vertical garden next to the original picture of the site can be seen in Figure 34.

Figure 30: Potential Site 4 (left) and its design mockup (right)

5.2. Implementation Challenges and Next Steps

We discussed some considerations for vertical garden implementation in Section 4.4. Based on these findings, we present suggestions regarding how to move forward with a vertical garden project in Thessaloniki around the Egnatia Corridor.

The implementation of vertical gardens in Thessaloniki could be carried out in phases. A visual representation of the phasing process is found in Figure 35. As discussed in Section 4.4, the Municipality may not have the resources to take care of the currently existing green spaces in Thessaloniki, so the addition of more green spaces could be beyond the city's means and be better suited for the private sector to initiate. Examples of private sector vertical garden sites are listed in Figure 35, in the Phase 1 portion. There are some limitations on a private sector project that were discussed in Section 4.4. One limitation is that apartment floors typically have many different owners, which means that whole apartment buildings should not be prioritized for the first round of site recommendations; however, single residential units or commercial segments can be targeted.

At some point in the future, there is potential for the public sector to get involved with this initiative, in which case there is a chance to expand the types of buildings that vertical gardens can be implemented on. A few examples of Phase 2 building types are also listed in Figure 35.

To motivate the private sector, the local government could provide incentives for the construction of vertical gardens. Incentives could provide motivation to individuals and corporations to implement vertical gardens due to upfront costs and maintenance costs. Some of these incentives may include tax breaks, energy savings, water discounts, or other monetary benefits. Government support for these efforts to increase greenery could encourage the project to grow.

Maintenance plans should be established before construction of vertical gardens begins. The CEO of Vita Verde and representatives of the local government described how issues with vertical gardens arise when the maintenance of a garden is neglected. For this reason, creating maintenance plans at the beginning can help ensure that the space will not be neglected. These plans can include a contract with a company or training seminars for residents or workers of a particular site.

5.3. Further Research

Questionnaire responses and interviews identified multiple areas where more data and research could be incorporated to further motivate the implementation of vertical gardens. Incorporating different data sets into the pre-existing data would allow for a more specific understanding of the complexity of certain benefits for Thessaloniki, as described in the siting tool.

Analyzing more data sets would allow more informed vertical garden placement. The following data sets would help to identify potential sites.

Air pollution, noise pollution, and urban heat index data: These data sets would allow siting decisions to be made strategically in order to maximize the positive environmental impacts of a vertical garden site.

Real time foot traffic data: This would entail pedestrian analysis of more places along Egnatia than the current 6 axes in order to identify more areas that experience high or low foot traffic. More detailed data would allow more site-specific selection criteria, whether the goal is to increase foot traffic or increase the vertical garden's exposure to visitors.

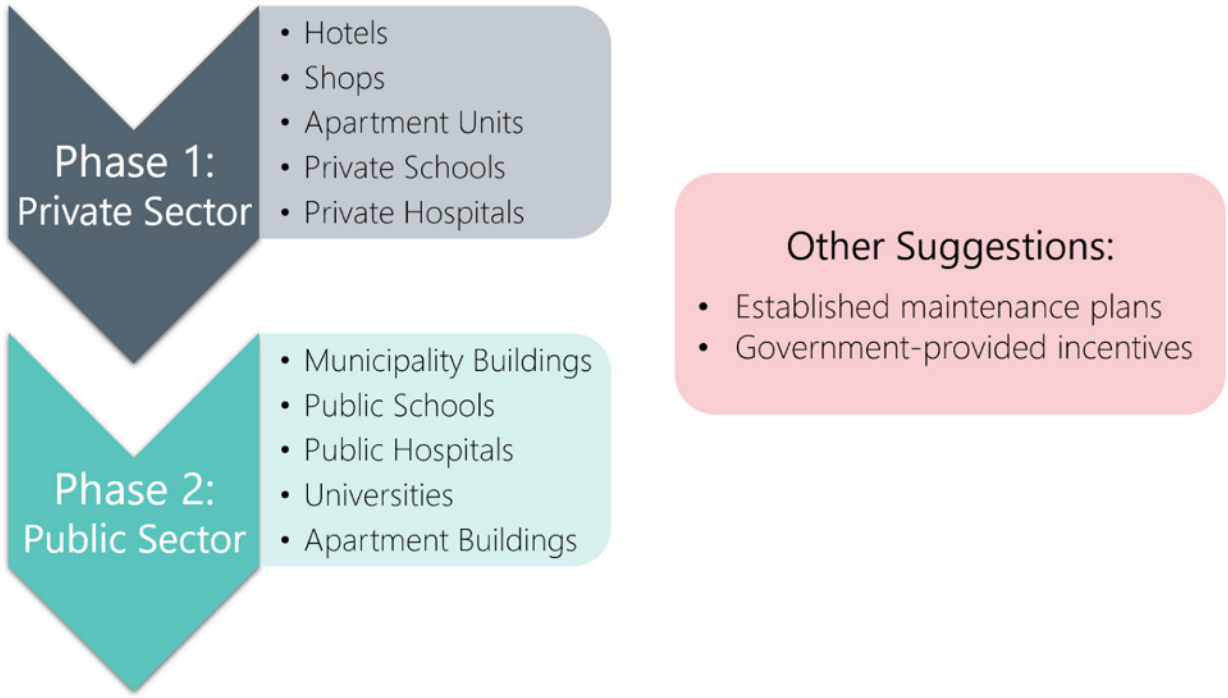


Figure 31: Phasing and Suggestions. A graphic visualization of the idea of phasing for implementation of vertical gardens in Thessaloniki around the Egnatia Corridor.

Building Ownership: More detailed lists of single-owner buildings vs. multi-owner buildings as well as the usages of each would make site decisions easier. Currently, some assumptions are made about ownership and usage, and some buildings are excluded due to a lack of information.

Residential population data: Identifying sites with high population density would allow a potential project to focus on areas that would affect the largest number of people and spread the most awareness of vertical gardens.

Crowdsourced green space review data: This data would give an overview to the current state of green spaces in Thessaloniki and help assess the benefits of adding more in a particular area.

The reason some of this data is not included in this phase of the project was due to limited availability of certain data sets. The Hellenic Statistical Authority and Google do not allow the free usage of their data. The government requires a high fee to use their population data, or it requires a lengthy research application process. Google has a restrictive license on detailed satellite data and does not allow the usage of their foot traffic data, which made it infeasible to use for this research. Accessing this information would allow for more comprehensive analysis. Adding these various data layers would allow for a more detailed use of the siting framework that was presented in Section 4.5.

Comparisons to other cities in Greece and around the world could further motivate the installation of vertical gardens in the region around the Egnatia Corridor. Doing a similar analysis on other cities with more green space would give a baseline reference for the Thessaloniki data. These references would further highlight the lack of green space and encourage the implementation of new vertical gardens along Egnatia Street.

The current analysis would be more accessible to other researchers on the ArcGIS and ESRI platform. Currently the data is on its own website, found in Appendix E. The website is publicly accessible, but GIS researchers have specialized tools to work with these standard platforms. Other researchers would be able to more easily use and expand upon the data if it were to be on these standard and openly accessible platforms.

One last suggestion for future research is that **there is value in promoting education about vertical gardens as well as advertising the vertical garden that currently exists at the Department of Landscape Architecture of the Municipality.** Educating citizens about vertical gardens and the range of benefits that they can provide to a city could motivate the initiation of this project and make people from the private sector interested in being involved. This could be done through programs hosted by the Department of Landscape Architecture specifically related to teach citizens about their wall, or through events put on by other groups near the wall to promote what vertical gardens can do for the aesthetics of an area.

Vertical Garden - Hong Kong

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Appendix A:
Menu of Vertical Garden Types

Green Facade - Direct

Green Facade - Indirect

Living Wall - Panel System

Living Wall - Cloth System

Living Wall - Active System

Balcony Gardens

Green Facade - Direct

Description

Climbing plants attach directly to the wall they are growing up.

Pros

Little to no support structures needed

Low maintenance

Cons

Can damage a wall, only compatible with certain wall types

Limited species can be used

Can take a long time for plants to grow and fill in the green wall

Green Facade - Indirect

Description

Climbing plants with structures to guide their growth and keep them slightly off of the wall they are growing up

Pros

Less likely to damage the wall

Fairly low maintenance

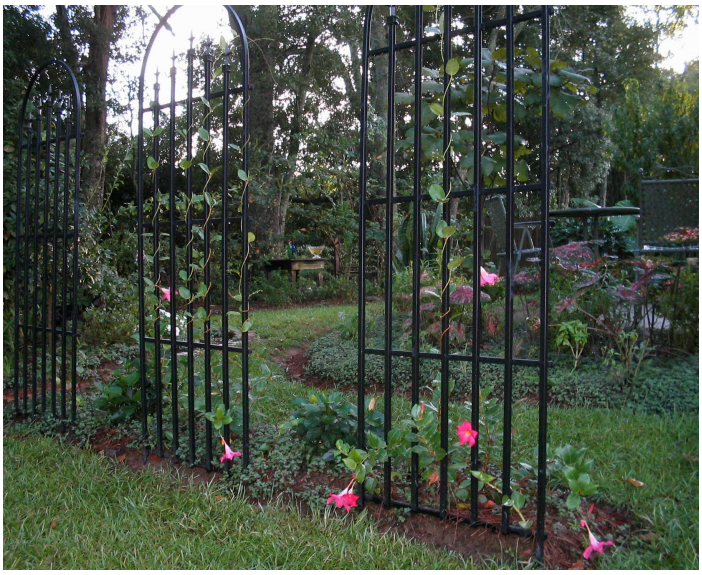
Same can be freestanding without any wall

Cons

Require a support structure

Limited species can be used

Can take a long time for plants to grow and fill in the green wall



Living Wall – Panel System

Description

Panels of plants that hold growing medium get attached to a wall using support structures

Pros

Can host a variety of species

Can use non-climbing plants

Can be larger than most green facades

Plants can be pre-grown and inserted into the wall (decreasing waiting time for growth)

Cons

Are heavier and require more bulkier support systems than green facades

Require maintenance (pruning, watering, etc.)

Can be more expensive

Living Wall – Cloth System

Description

Pockets made of cloth/ felt that hold growing substrate and plants and get attached to a wall using support structures

Pros

Can utilize hydroponic systems to decrease maintenance (do not use a substrate and plants are rooted straight into the system)

Can host a variety of species incl. non-climbing plants

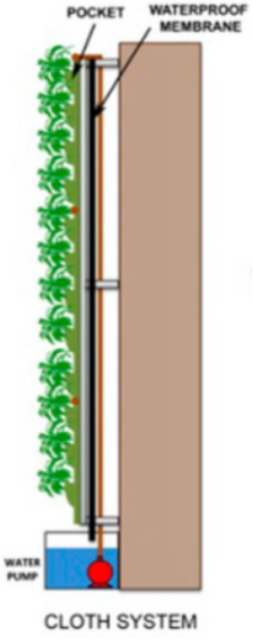
Can be larger than most green facades

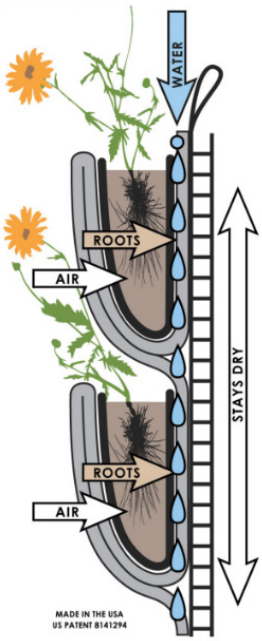
Cons

Are heavier and require more bulkier support systems than green facades

Require maintenance (pruning, watering, etc.)

Can be expensive





Living Wall – Active System

Description

Panels hold the growing media and plants slightly off the wall so that air can be forced through it and then collected to supply the building it is on

Pros

Can cool, filter, and humidify air for a building

Can host a variety of species

Can be larger than most green facades

Cons

Require an expensive support and air collection system

Are heavier than green facades

Can be more expensive

Require a large/supportive wall to host the structure

Balcony Gardens

Description

Hanging or potted plants placed on balconies

Pros

Require less intense support systems (typically)

Can be small and easily maintained by the owners of the balcony

Increase individual involvement with gardens

Can increase amount of greenery in an area without a big project maintained by one person

Cons

Are limited to places with balconies

Require individual maintenance/would likely be private projects

Cannot be as large/impressive as many vertical gardens

Do not provide insulation benefit green walls do

Appendix B: Interview Protocol

Identifying who to interview:
Scheduled interviews with organizations identified by Dr. Avraam Mavridis. Dr. Mavridis was the one who contacted all organizations.

Conducting the Interview:
a. Instructions to the interviewer (opening statements):
We are three students from Worcester Polytechnic Institute in Massachusetts, USA completing a project with Dr. Mavridis focused on assessing the feasibility and value of integrating vertical gardens or other greenery systems along Egnatia Corridor and create recommendations for sites and varieties of vertical gardens.
If the interviewee was interested, we provided further explanation of our project

b. The key research questions to be asked:
- What has your experience been implementing projects/vertical gardens in Thessaloniki?
- What are some suggestions you have for this project based on your past experience?
- Are there any problems you foresee for us that we might not be aware of?
- Are you already considering/working on a project related to vertical gardens in Thessaloniki?
- *More specific questions were developed for each interview based on who was being interviewed. These are examples of some general questions that were used in multiple interviews.*

c. Probes to follow key questions:
Are there any problems you foresee for us that we might not be aware of?
→ Do you have suggestions about how to overcome these?
Are you already considering/working on a project related to vertical gardens in Thessaloniki?
→ Would any of the work we are doing be relevant/interesting to you?
Follow up questions were asked depending on the interviewees responses to a question. They were usually intended to gather more information and allow the conversation to continue naturally.

d. Concluding messages for the interviewer:
"Thank you for taking the time to meet with us today and share your thoughts with us. Your feedback will play a role in how this project develops. If you come up with any other input, feel free to contact our group or Dr. Mavridis to share it with us."
Phrasing along these lines were used to thank an interviewee for meeting with us and providing us with useful information before leaving the interview.

Notes taken during the interview were included in a separate observation document

Appendix C: Sample Questionnaire

Introduction:

Our names are Hannah, Olivia, Raymond, and Tomás, and we are all students from Worcester Polytechnic Institute in Massachusetts, USA working under Dr. Mavridis at Perrotis College. We are asking you to participate in a survey that has the ultimate goal of assessing the feasibility and value of integrating vertical gardens into the city center of Thessaloniki along Egnatia street, from Democracy square (also known as Vardaris Square) up to and including the University of Macedonia. We believe that through direct citizen engagement in this project, we can propose a plan that will benefit the public. This survey is completely anonymous, but it does include a few questions relating to demographics. This survey is voluntary and you may withdraw at any time. If the data is published, individual responses will be kept anonymous. We ask that you answer honestly, and we thank you for taking the time to participate in our survey.

What are vertical gardens?

Vertical gardens are structures that can be placed up walls of buildings that hold plants. They can consist of vines growing up walls, support structures holding larger plants, or hanging vegetation fall over the side of balconies. Some example pictures can be seen below.

These questions were given with response options from 1 to 5, 1 corresponding to strongly disagree and 5 corresponding to strongly agree:

- I think the area around me right now is an attractive area of the city.
- I see a benefit to there being more green spaces on Egnatia Street
- I see a benefit to there being vertical gardens on Egnatia Street
- I think people would vandalize a new public garden on Egnatia Street
- I would be more inclined to go to an establishment with gardens than one without
- I would be more inclined to go to a location with green spaces than without
- Do you believe vertical gardens will contribute to the socioeconomic status of the region

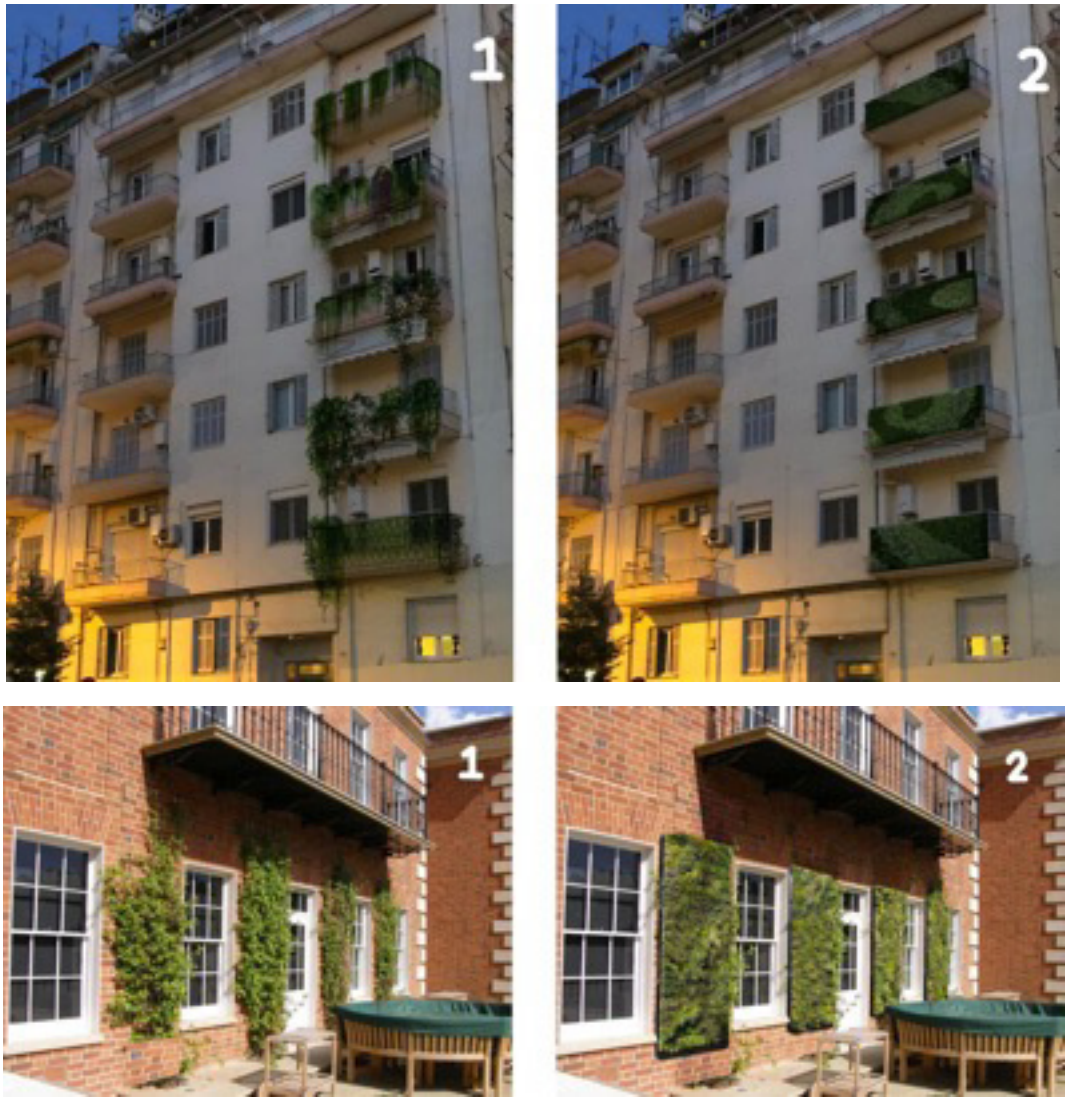
These questions were given with response options from 0 to 10, 0 being a poor rating and 10 being a good rating

- How would you rate the amount of greenery on the Egnatia Corridor
- How well do you think that the Egnatia Corridor provides adequate shading?

These questions were given with the map below:

- What numbered region of the Egnatia Corridor do you most enjoy walking through?
- What numbered region of the Egnatia Corridor do you least enjoy walking through

For the following pictures this question was asked: Select the option below that represents your preference between the two images. Options were "Strongly Prefer 1," "Prefer 1," "Neutral," "Prefer 2" and "Strongly Prefer 2."



These questions were given with the map shown to the right:

- Based on the map below, what numbered region is your home located in? If you prefer not to answer, you can skip this question. (If the person did not live in the region shown, they could skip this question)
- (If the person works in the region) Based on the map below, what numbered region is your work located in? If you prefer not to answer, you can skip this question. (If the person did not work in the region shown, they could skip this question)

Demographic Questions, these were all skippable in both versions of the survey:

- What is your age? (Response Options: “18-30”, “31-45”, “46-60”, “60+”)
- What is your gender? (Response Options: “Male,” “Female,” “Prefer not to answer”)
- If you work along the Egnatia Corridor, how long have you worked in the area? (Response Options: “0-3 years,” “4-8 years,” “9-15 years,” “15+ years”)
- If you live along the Egnatia Corridor, how long have you lived in the area? (Response Options: “0-3 years,” “4-8 years,” “9-15 years,” “15+ years”)
- Do you consider yourself disabled or not? (Response Options: “Yes,” “No,” “Prefer not to answer”)

Appendix D: Questionnaire Protocol

Identifying who to survey:
Walked up to people (typically people sitting in an area), approached business owners, and sent an online survey to Aristotle University (did not include follow up questions and dialogue, but it is still a relevant form of data collection)

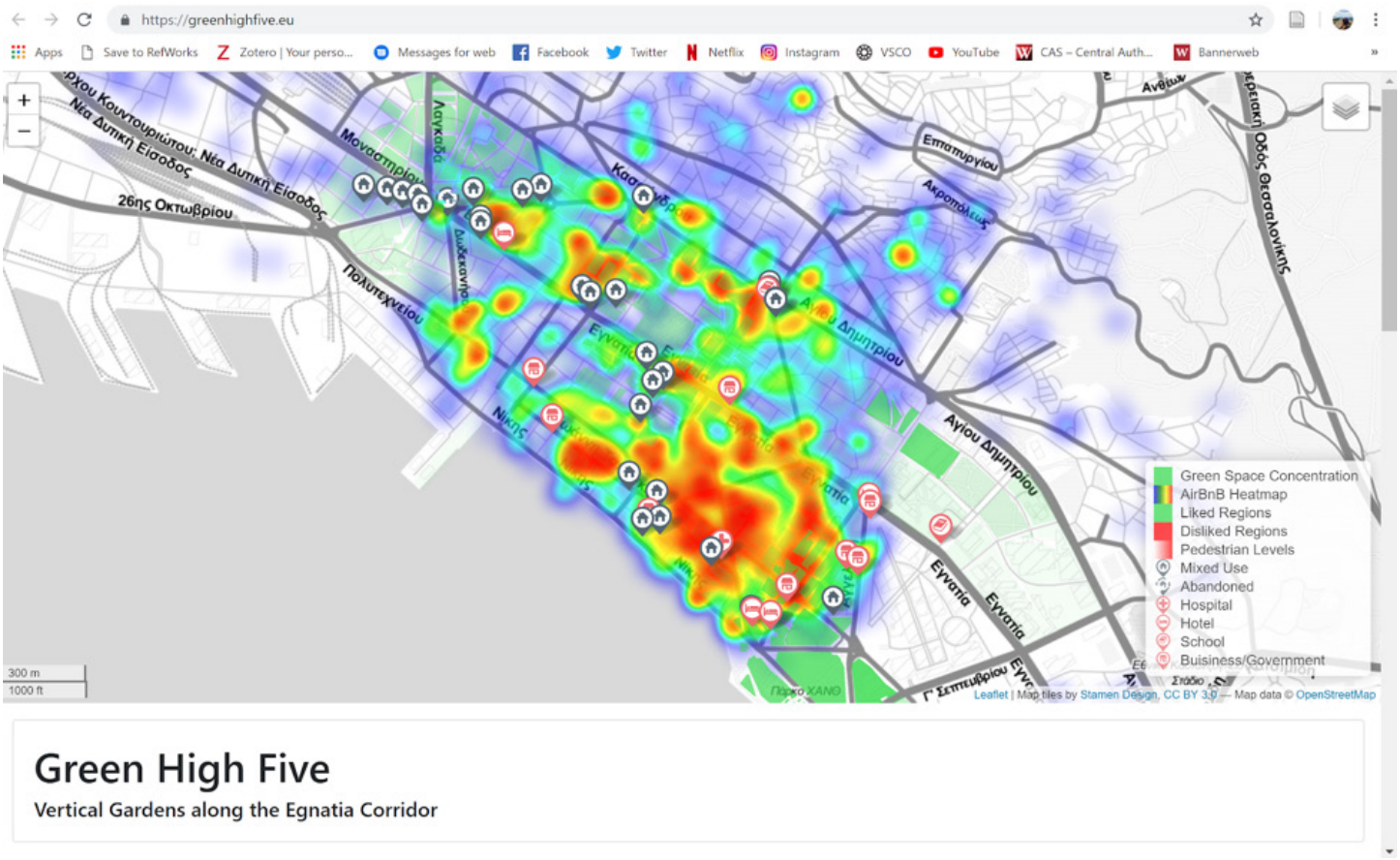
Conducting the Survey:
a. Instructions to the interviewer (opening statements):
"γεια σας, do you speak English? (if yes) We are studying at Perrotis College and are handing out surveys for a project, would you be willing to take the time to fill one out?"
When we had a Greek translator with us, a similar dialogue took place between him and the questionnaire respondents but in Greek
Written at the top of the questionnaire: "Our names are Hannah, Olivia, Raymond, and Tomás, and we are all students from Worcester Polytechnic Institute in Massachusetts, USA working under Dr. Mavridis at Perrotis College. We are asking you to participate in a survey that has the ultimate goal of assessing the feasibility and value of integrating vertical gardens into the city of Thessaloniki. We believe that through direct citizen engagement in this project, we can propose a plan that will benefit the public. This survey is completely anonymous, but it does include a few questions relating to demographics. This survey is voluntary and you may withdraw at any time. If the data is published, individual responses will be kept anonymous. We ask that you answer honestly, and we thank you for taking the time to participate in our survey."
A vertical garden explanation and example pictures were included below this introduction

b. The key research questions to be asked:
Found in the survey in Appendix C

c. Transition messages for the interviewer:
"Thank you for taking the time to complete our survey and share your thoughts with us. Did you find any questions confusing? Do you have any comments about this questionnaire?"

d. Space for recording the interviewer's comments:
Any observations made during the questionnaire or questions/comments from the respondent were noted on the back of questionnaires after they had completed taking it

Appendix E:
Site Link and Description



This website contains an interactive map exploring the possibility of integrating vertical gardens into the region around the Egnatia Corridor of Thessaloniki, Greece. Above, the map contains many data layers collected from questionnaires as well as online sources. Below are a list of sites on the Egnatia corridor where vertical garden implementation could take place. Spatial analysis and some structural considerations were taken into account for this demonstration, but more considerations would need to be taken into account before actual construction.

The site can be found at: https://greenhighfive.eu/