The use of green roofs and living walls to regenerate the urban eco-system and revitalize the public realm.

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ABSTRACT

During the last few decades, global climate change has been occurring due to human activities and the over-exploitation of natural resources. With the acceleration of the global urbanization process, the urban heat island effect, air pollution, rainstorms, and other environmental problems have become increasingly severe in urban areas. The world's population is continually converging on metropolitan areas. Sprawl causes fragmentation of natural and semi-natural areas on the urban fringe (Inostroza et al., 2010, Inostroza et al., 2013), and urban densification decreases the area covered by urban green spaces within a city (Harland & van den Bosch, 2015). To resolve those issues, green roofs and living walls as part of urban landscape design have been increasingly widely favored by urban environmental researchers and designers because they are representatives of sustainable design. Moreover, green roofs and living walls not only can provide a solution to environmental issues, but also can regenerate the biodiversity of urban areas. This thesis will use existing case studies and research results to estimate the positive effects of green roofs and living walls on large-scale buildings in urban environments for the benefit of the biodiversity of ecosystems.

In addition to these ecological benefits, green roofs and walls can offer usable space for people. Green roofs and living walls can be likened to the traditional ‘roof garden’ concept, but when understood as an extension of green roofs and walls, can become an extension of accessible green space from the ground floor onto urban structures to provide more high-
quality outdoor space for people in urban areas and better connections and circulation within and between buildings. The aim is to show how large-scale roof parks can combine amelioration of the environmental problems created by large building complexes with the provision of an accessible and valuable high amenity greenspace for people. Achieving this aim would result in the introduction of elevated green space as an important component of landscape architecture and a valuable component of the urban designer’s toolkit.
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Chapter one: Research Proposal
1.1 Introduction

In recent decades, with the development of globalization, the process of urbanization in different countries has been accelerating, and people have moved into urban areas in pursuit of a better quality of life. According to the United Nations Survey, in 2016 an estimated 54.5 percent of the world’s population lived in urban settlements. Moreover, there were 512 cities with at least 1 million inhabitants globally. In the 2016 World City Report, Joan Clos, Executive Director of the United Nations Human Settlements Programme (UN-HABITAT) and Under-Secretary-General of the United Nations, pointed out that

"between 1950 and 2005, the level of global urbanization jumped from 29% to 49% over the same period by burning fossil fuels resulting in an increase in carbon dioxide emissions of at least 500%, which is clearly an unsustainable development model. Currently, the city's energy consumption in the world accounts for 60% to 80% of the global total; due to energy supply and traffic generated by the total greenhouse gas emissions. We need to act to plan and manage the future long-term sustainable development of the city."

Because of the vast population, public resources are been rapidly consumed to meet the needs of that population. At the same time, the natural green space in urban areas is being transformed into commercial and residential areas, resulting in severe environmental problems that threaten the urban biodiversity. According to a New Zealand report from Land Research “between 2001 and 2009, 590 ha of Auckland’s North Shore City was urbanized, representing a 7% increase in the urban area and a 33% loss in the area of vegetation. The losses were most rapid and wide-ranging on flatter areas.” (Land Research, 2015)
In recent years, New Zealand’s annual immigration number has been increasing dramatically. The data from New Zealand’s statistics department (see Figure 1.1) recorded that the current population of New Zealand is about 4.77 million; last year the net population inflow was 72,000, and 36,795 of them moved into the Auckland region to live and work. In line with this growth trend, the prediction is that there would be over 5 million by 2019. The vast number of immigrants creates a huge resource requirement, which has a significant influence on the urban environment. According to research carried out by Auckland University ecologist, Dr. Margaret Stanley (2015), “the housing crisis means more people, meaning more houses, meaning intensification, meaning a loss of green spaces - and this will only get worse.” Facing a deteriorating living environment and urban eco-system, how to regenerate the urban ecological environment and ensure sustainable urban reconstruction has become one of the primary purposes of human development.

With decreasing green space in urban areas, the development of green roofs and living walls is an essential part of improving the ecological environment of metropolitan regions. How green roofs and living walls can be utilized in large-scale builds (such as shopping malls) so

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Figure 1.1 2017-2018 New Zealand immigration statistics form. Source: Statistics department of NZ
as to contribute to the regeneration of urban eco-systems and the accessibility and agreeability of the public realm will be the principal direction of this research. Furthermore, the research explores using green roofs and living walls to reduce the pressure on drainage systems caused by urban rainstorm water, maintain the temperature of buildings as a means of scaling down energy consumption, and manage the quality of water and air in urban areas.

1.2 Problem Definition

Although Auckland has many kinds of green spaces, the green space which can provide a biodiversity function is limited (Jamie, 2015). According to a report from a team led by Dr. Stanley, the urbanization programme set up by the government and urban planners replaced natural forest with grass and small shrubs to increase high-density residential areas. However, they did not realize the essential value of trees, which can not only provide habitats and food resources of many kinds for the birds but, also and carbon shortage function which can change urban climate and others (Stanley et al., 2010). Dr. Stanley pointed out that “as native fungi and insects are often host-specific to native plants - and native birds also often preferentially feed on native plants - it is more than just trees we loss” (Stanley et al., 2010). Also, birds and other wildlife cannot survive seasonal migration because natural green spaces, such as forests, have been used as a areas for human activities, and this is harmful to urban biodiversity. Jamie Morton, a NZ Herald science reporter, highlighted how “trees can serve as corridors or so-called ‘wildlings’ to help birds and other wildlife move between natural areas” (Morton, 2015).
1.3 Approaches and Methods

For the sustainable development of cities, rational employment of land resources and the use of elevated space have become new methods to increase urban green areas. Green roofs and living walls are widely used in urban architecture around the world. They can improve the performance of buildings in every aspect, Shafique et al argued that

“the green roof shows numerous social, environmental and economic benefits. Significant evidence shows that green roofs can give multiple benefits, such as stormwater management, reduced urban heat island, increased urban plant, wildlife habitat and roof life, enhance the air and water quality and quality of life, decreased the energy consumptions costs of the building, decreased the noise pollution, procreates the recreational activities and increased the green areas and aesthetic value in urban environments” (Shafique et al., 2018)

To resolve urban environmental issues, applying green roofs, and living walls is a practical solution which can contribute to society, the environment, and the economy.

1.4 Aim

This research aims to demonstrate that, in order to enable New Zealand to avoid severe environmental problems which have been produced in other cities globally, urban expansion in New Zealand needs to focus much more on sustainability. When urban sprawl occurs, the original green areas could be maintained by applying elevated green space in metropolitan areas.
1.5 Objectives

The objective of this research is to find a solution to improve the urban environment by increasing green space in an urban area, one which creates a habitat for wildlife, and provides open activity space for the public.

1.6 Research Question

How can green roofs and living walls be used as an integrated part of urban development to increase biodiversity and re-establish the connections between people and nature?

1.7 An Overview of the Methodology and Methods

The Methodology can be separated into two parts; theoretical research and test model design.

The theoretical research will include relevant research about the green roofs and living walls; using landscape to improve the public realm, they can promote community within a city (Osmundson, 1999). At the same time, an analysis will be undertaken to explore the technical benefits of green roofs and living walls such as rainwater management, promote water quality, provide habitat for wildlife (Shafique et al., 2018). There are a range of successful green roofs and living walls around the world that are valuable for this research, for example, Roof park Vierhavenstrip, Chicago City Hall Green Roof, and ASLA Headquarters (Lan, 2016). It is advantageous to analyse these examples because they enable me, the researcher-designer, to learn from their design by attending to the advantages apparent in their design process and trying to avoid the disadvantages.
The goal of the research design is to test the case of a new type of building form that can improve the urban ecological system and enhance the public realm. I will design a multi-type green building in an urban area, using elevated landscapes (green roofs and living walls) to create an extra green space in this urban area which can both provide the ecological function and improve the public realm.

The design process will be separated into three parts: the formation of the first design draft; the promotion of the second design draft; and the overview of the final design.

1.8 Case Study - New Lynn

New Lynn is located towards the west of the Auckland urban area, 10 kilometers to the southwest of the Auckland City Centre ("New Lynn," 2018). In 2010, Waitakere City Council presented a structured plan, and design guide to direct the renewal of New Lynn and envision New Lynn in 2030 as “unique, sustainable, and urban.” (Waitakere City Council, 2010). In this document’s chapter entitled “The mall”, ii was mentioned that the Lynn Mall area would be redeveloped and updated. This provide an excellent opportunity for me to de research as the mall area is an ideal site for the specific research focus.

1.9 Scope

This research discusses the possibility that wide application of green roofs and living walls has significant value for sustainable urban development. The study focuses on their environmental benefits, social functions, and economic efficiency. However, because I did not meet the technical test requirement, the research will focus primarily on the measuring
the performance of green roofs and living walls in terms of the range of temperature, statistics on rainwater collection, and data for biotic population. The research project is mainly focusing on green design roofs and living walls to improve the urban environment.

1.10 Thesis Structure

The thesis follows the structure:

1. Introduction: context, research purpose, research question.
2. Theory research: theoretical context, technical benefits, case studies, literature review.
3. Design preparation: design purpose, design subject, design methods and site analysis.
4. Design process and results.
5. Conclusion.

1.11 Conclusion

The research into green roofs and living walls aims at enabling New Zealand to avoid severe environmental problems when cities sprawl; urban expansion in New Zealand should focus on sustainability. Morton points out that “the low-cost, low-energy business case for green buildings has become increasingly clear, with a dramatic increase in demand - and a corresponding rise - in Greenstar certified and registered office buildings over the past couple of years.” (Morton, 2015).

The objective of this research is to increase urban green space, provide a habitat for wildlife, re-establish biodiversity and improve the urban public realm for the purpose of resolving the environmental issues in the Auckland metropolitan area.
The question is: How can green roofs and living walls be used as an integrated part of urban development to increase biodiversity and to re-establish the connections between people and nature?

To answer this question, the theoretical research on green roofs and living walls is viewed as valuable; therefore, an analysis is carried out as to the technical benefits of green roofs and living walls such as rainwater management, promote water quality, provide habitat for wildlife. (Shafique et al., 2018). To further answer the research question, a design is made for a multi-type building with green roofs and living walls to improve the urban environment. This design shows that green roofs and living walls can use elevated space in an urban area to create extra green space which can offer a biodiversity function to provide a habitat for wildlife.
Chapter Two: - Literature Review
2.1 Introduction

This chapter will illustrate the specific issues arising in urban areas, including environmental and social issues. The ecological problems, such as air pollution, poor water quality and biodiversity damage, will be discussed first, followed by the social question as to whether the public realm or green infrastructure in the urban environment can be improved. The next part of this chapter is one of the solutions for addressing urban problems - using green roofs and living walls. The technical benefits of green roofs and living walls will be canvassed, and there some successful green roofs and living walls around the world will be presented to show their advantages.

2.2 Literature review: environmental issues in urban areas

In the history of human urban development, many countries and regions have suffered from environmental issues because of unsustainable development in cities, which has severely affected people's daily life, become an economic burden, and even threatened human health and vitality. There are several serious pollution events that have happened in urban areas which deserve attention so as to avoid similar issues occurring in the future.

2.2.1 Air pollution

2.2.1a International situation

There are many cities around the world that have been suffered, or continue to suffer from severe air pollution. The World Health Organization estimated that more than 1 million premature deaths annually could be attributed to urban air pollution in developing countries (WHO, 2002). Until relatively recently, there was serious air pollution in Chicago, which led to substantial economic losses and endangered the lives and health of Chicago citizens.
According to the American Lung Association, over 2 million people in Chicago were at heightened risk for health problems resulting from acute exposure to O3 and particulate matters (2007). To deal with the air pollution in urban areas, a large number of green roofs were installed in 300 buildings resulting in a total area of 27.87 ha by June 2007 (Tayler, 2007). These green roofs have significantly improved the Chicago urban air quality. Yang et al. found that “a total of 1675 kg of air pollutants was removed by 19.8 ha of green roofs in one year with O3 accounting for 52% of the total, NO2 (27%), PM10 (14%), and SO2 (7%)” (Yang, Yu, & Gong, 2008). This proved that green roofs could have dramatically contributed to resolving the urban air pollution.

2.2.1b New Zealand situation

Air quality in New Zealand is relatively good compared with other parts of the world, but that does not mean New Zealand’s cities are free of air pollution. There are two main reasons that cause New Zealand’s urban air pollution: the burning of fuels for home heating; and vehicle exhausts. It can be seen in Figure 2.1 that the primary source of air pollution is citizens burning wood and coal for home heating; it contributes 58 percent to annual emissions of human-made particulate matter in the air (MFE,
Another main pollution source is motor vehicle emissions, which can produce PM10, a collective term for very small particles, such as dust, smoke, or fog. This should be particular concern because it is easily inhaled and absorbed into the lungs and causes significant health problems such as heart and respiratory diseases, particularly amongst older people (Stats NZ, 2008).

### 2.2.2 Stormwater issues

#### 2.2.2a International situation

As a result of rainstorms, many cities have suffered from flooding because of the lack of vegetation and urban drainage system overload. In 2012, a severe flood in Beijing wreaked havoc on the city’s transportation systems, and in 2016 floods overwhelmed drainage systems in Wuhan, Nanjing, and Tianjin (Biswas & Harley, 2017). For dealing with urban stormwater issues, the Chinese government introduced the “sponge city initiative” which involves applying roof gardens in building constructions and using it to absorb and reuse the rainwater to reduce the pressure on urban drainage system (Biswas & Harley, 2017). The Shanghai government aims to build 400,000 sq. meters of new roof gardens, which means at least 70% of stormwater runoff should be captured, reused, or absorbed by the ground (Roxburgh, 2017)
2.2.2b New Zealand condition

![Figure 2.2 Photo of New Lynn flooding in 2017. Photo from NZherald.co.nz](image)

New Zealand cities have also suffered from stormwater flooding issues because of the lack of mediating force (such as green roofs and walls) to maintain the stormwater. Flooding issues lead to homes being submerged, traffic jams and even danger to people’s health and life. On 29 June 2016, there was 25.4mm of rainfall at the Auckland region in one hour and that day had wettest June hour in recorded history which caused flooding situations happened in many Auckland regions (NZ Herald, 2016). At least 80 houses across Auckland were affected by flooding, many routes were closed because of flooding, and some citizens were stuck on the top floor of an Onehunga factory due to flooding in that area (NZ Herald, 2016).
Moreover, another problem in the Auckland urban area is about the water quality. In recent years, it has become clear that this issue needs to be attended to. Due to the natural green
space having been narrowed, after the rainstorm the urban drainage system capacity was overloaded so a large amount of sewage flowed into the ocean and polluted the coastline of the Auckland region. In Morton’s report, a surge of brown sediment-laden water gush into the sea from the Auckland urban area, and the sediment remains, settling on the seafloor, and smothering plants and animals that live there including shellfish and seagrass (Morton, 2015).

2.2.3 Biodiversity

2.2.3a International situation

Through the urbanization process, urban biodiversity has undergone rapid damage because of the loss of wildlife habitats. According to Matt Palmer, a senior lecturer of Columbia University, “when the places where animals, plants, fungi, and the myriad other organisms live are converted to other uses (such as agriculture and urbanization), conditions change, and the prior residents often move on or die.” (Palmer, 2012). However, after pristine habitats are destroyed, wildlife can only find new habitats in urban crevices, which, in turn, prompt those species to use green roofs and walls as their new habitat. Stephan Brenneisen argued that well-designed green roofs could provide habitat compensation for rare and endangered species affected by land-use changes, which could be a potential tool for preserving and restoring biodiversity in urban areas (Brenneisen, 2006).

2.2.3b New Zealand situation

In recent years, there have been some environmental issues arising in t of New Zealand cities, and, in that regard, the Auckland metropolitan area is one of the most affected areas in the country. The main problem in Auckland is that the eco-system has been damaged
because natural green space has been narrowed through urban sprawl. Ecologist Dr. Margaret Stanley emphasised how nature exists in cities, so does a vast biodiversity. "We need to be getting people to recognize that there is nature in cities - and all sorts of biota can and should live there" ((Stanley cited in Morton, 2017). The loss of green space leads to the wildlife losing their food resources and habitats.

2.3 Theory Conclusion

Worldwide, there are many cities in different countries suffering from environmental issues since they focus on rapid economic development and neglect the ecological damage. One such example is China, which has seen rapid economic growth since the start of the reform era in 1979. Annual GDP growth averaged 9.6% between 1979 and 2004. Gaoming reported that “during the 1990s, the number of cities in China’s east increased from 315 to 521. Each year, an average of 767.42 square kilometers is built on, with this figure growing at an average of 5.76% every year.” Meanwhile, during this period, the population has grown sharply; vast quantities of resources have been consumed; environmental pollution has worsened; ecosystems have been wrecked; and vast areas of land have been lost (Gaoming, 2007).

In recent years, cities in New Zealand have followed a similar trend. The eco-system in urban areas has been damaged, air quality has decreased, and the water quality issue has had a detrimental impact on coastal wildlife. To avoid the ‘economy first, clean up later’ model happening in New Zealand, city sprawl should follow sustainable development.
2.4 SOLUTION

2.4.1 Green roofs and living walls

In recent decades, green roofs and living walls have become well-known and widely used. With the development of technology, green roofs and living walls technology is becoming increasingly mature, and has prompted related research. The characteristics and functions of green roofs and living walls opinions are viewed differently by various researchers.

2.4.2 Existing research about the features of green roofs and living walls

2.4.2.1 Improving air and water quality.

No one can deny that vegetation can refine the air quality by removing the carbon dioxide and shifting to oxygen. The plants and substrate release water vapor thus humidifying the air. Also, airborne pollutants are deposited in the substrate, on the leaf surfaces of the plant layer, and onto the moist internal surfaces of the leaf and therefore remain on the roof and do not transfer to the stormwater system. Meanwhile, the heavy metals in the air can be absorbed into plants and substrate surfaces.

![Figure 2.4 Monthly uptake of air pollutants by green roofs in Chicago from August 2006 to July 2007](image-url)
2.4.2.2. Reducing storm-water runoff in urban areas.

Storm-rain water places considerable stress on urban drainage systems. To alleviate the pressure of rainwater runoff, the green roof water storage function is deserving of further research. Menten’ et. al.’s research data proved that facing different roof types; their roof runoff was also very different from as high as 91% of the traditional non-green roof to as low as 15% of the intensive green roof (see figure 2.5) (Menten’ et. al., 2006).

![Annual runoff for various roof types as a percentage of the total annual rainfall.](image)

Figure 2.5 Annual runoff for various roof types as a percentage of the total annual rainfall.
Furthermore, Petra et al. pointed out that “green roof retained 12.8% - 100% of precipitation and delayed runoff up to 23 hours depending on the water content of the substrate.” (Petra et al., 2015). This means that green roofs and living walls can play a dramatical role in the urban drainage system. The figure 2.6 above shows the annual runoff of different types of green roofs.

2.4.2.3 Rebuilding the ecological habitat and increasing biodiversity in urban areas.

Although green roofs and living walls cannot replace the ground-based habitat for the biodiversity, they still can provide a living space for some species when their pristine habitat has been ruined because of the urban expansion. There are many benefits when we build green roofs and living walls as wildlife habitats, which include the fact that the various species will be living undisturbed; and free of predators.
2.5 Literature review theory of public realm

2.5.1 Introduction

When urban design processing, the public domain is a significant element that needs to be comprehensively considered because it can provide a setting for community life. The New Zealand Ministry for the Environment (MFE) states that “the public realm includes all parts of the urban environment that people can experience or access - public space and buildings, and those parts of private development that impact on public space.” (MFE, 2018). It is relevant for this research because green infrastructure can provide a high-quality public realm. According to Gong et al.’s research, elderly citizens living in neighborhoods with more green
space have higher levels of participation in regular physical activity, which provide evidence for planning policy to design, preserve, facilitate and encourage the use of green space near homes (Gong et al., 2014).

2.6 Theory of using environmental measures to improve public realm

2.6.1a International situation

World wide, there are many green infrastructures that can provide both the ecological function and public realm. Todd Litman of the Victoria Transport Policy Institute in Canada found that a successful "shopping center or office complexes may become more economically competitive if walking conditions improve" (Litman, 1994). In Rotterdam, there is a roof garden named Roofpark Vierhavenstrip designed by Buro Sant en Co with the municipality of Rotterdam. It is a perfect example to show how the green roof can improve the public realm. According to the Land-8 report, this roof park has two gardens, a playground and each of these is connected by intertwining paths (Land8, 2015).

Figure 2.8 Water stairs of Roofpark Vierhavenstrip. Photo credit: Buro Sant en Co
2.6.1b New Zealand situation

With ongoing urbanization, New Zealand’s urban areas are expanding. At the same time, citizens have more leisure time, so open spaces for outdoor recreation became increasingly important (Kerryn 2010). However, in many city centers, the integrated design of public areas has been mainly concentrated in indoor areas, which leads to the internal and external space experience becoming more negative. The spaces outside the buildings remain without any creative design or the feeling of urbanity, which means safety and diversity in activities are not a given (Land8, 2015). To change this situation, using vertical green space and green infrastructure could contribute to sustainable urban development.

2.7 Precedents for green roofs and walls and how they have improved the public realm.

2.7.1 Introduction

There are many successful green roofs and living walls around the world changing the urban habitat environment in different ways, each of the cases has their own unique characteristics which could be useful for my design. They can provide various kinds of functions, such as a resistance to flooding function, lightweight material selection, improved human activity spaces, and management water runoff issues. Most of the cases can play an ecological role and promote the public realm.
2.7.2 Case study of green roofs and living walls

2.7.2.1 Roof park Vierhavenstrip (resistance flooding function)

Rotterdam, Netherlands / 80,000 m² / design by Buro Sant en Co with the municipality of Rotterdam / 2011-2013

This green roof is created by Buro Sant en Co. together with the municipality of Rotterdam which is located at Delfshaven and Stadshaven, Figure 2.9 Roofpark Vierhavenstrip. Photo credit: Buro Sant en Co Amsterdam, Netherlands.

The idea is to combine and reunite indoor and outdoor urbanity (Lan, 2015). According to the reporter Ruth Coman, the Vierhavenstrip roof park is located on the top of the commercial façade where tall trees and green hedges have been planted. There are some tortuous surfaces and some theme parks to highlight the west side features of the park. The east side part prevails an urban character. This Roof park has three special places: the Mediterranean garden, the playground, and the community garden. It also has a central water staircase and a greenhouse as focal points.

This roof garden not only provides an attractive landscape for the business (a shopping
center), which can be an excellent leisure activities place, but also has the function of protecting the city against floodings. Combining, these features makes the Roof park Vierhavenstrip become a creative and innovative solution to both environmental and social problems. This case can offer the resistance to flooding feature and combine the shopping center and roof park.

2.7.2.2 The Waitakere Central Civic Centre Green Roof 2004

(using light and thin materials using) Waitakere Central Civic Centre / 500 m² / Design by Renée Davies &amp; Landcare Research.

The Waitakere Central Civic Centre Green Roof is a pilot project which is specific to the
New Zealand situation. It is installed on the top roof of the Waitakere Central Civic Centre in Henderson. This green roof features, for example, a drought-tolerant plant cover raised in light, thin (50 to 150 mm deep) 'soil' on a drainage layer and waterproof membrane. This method can relieve the roof weight for the building structure. Moreover, it works so as to balance lightness with moisture retention and build cost.

According to Waitakere City Council introduction, this pilot project’s aim was to find New Zealand native plants to replace these dense, weed-resistant cover, and test their drought-resistance ability. The native New Zealand plants that have been trialled on this green roof include Libertia peregrinans (NZ iris), Festuca coxii (Native tussock), Acaena microphylla (NZ bidibid), Pimelea prostrate (NZ daphne), Selliera radicans, Disphyma Australia (New Zealand...
ice plant), Coprosma acerosa (Sand coprosma), Leptostigma setulose, Dichondra repens ‘piha’ (Mercury bay weed), Calystegia soldanella (Sand convolvulus), Muehlenbeckia complex, Muehlenbeckia axillaris, and Muehlenbeckia ephemerides. (2011) This case suggests a range of both the lightweight materials and native plants to guide the choices for my research. However, for some reasons, this green roof cannot be accessed by the public, something which should be avoided in my design process.

Figure 2.12 The Waitakere Civic Centre green roof

2.7.2.3 The roof garden of the European Patent Office, Rijswijk, The Netherlands, 2001

(human active function). Rijswijk, Netherlands

The European Patent Officer garden cover the underground car park and extension to the existing EPO (European Patent Office) Headquarters (which was designed in 1999, and construction completed in 2001.)
Primarily, the design seeks to accomplish two main criteria: to introduce natural elements into the site; and to provide functional outdoor space for EPO employees. This case can offer idea of the reunion between the building and green spaces. Existing EPO (European Patent Office) Headquarters. Moreover, the entire EPO roof garden been divided become different areas with different types of ecological habitat for various kind of wildlife, such as bees, butterflies and birds, which inspire me as an idea to design a multi-functions green roof for my research.

Chicago City Hall Green Roof designed by Atelier Dreiseitl and Conservation Design Forum on top of the 11 storey Chicago City Hall building, in 2000. In 1995, the city of Chicago suffered from a heat wave which was caused by the ‘urban heat island effect’. At same time, this city had to deal with a stormwater issue because the city’s stormwater and drainage systems are connecting, which means that during a rainstorm, the system overloads, resulting in flooding and sewage pollution.

To deal with those environmental issues, Atelier and Conservation Design Forum designed this pilot project. They chose the Chicago City Hall because the structure is ideal given that is was planned to accommodate the building of additional floors. Moreover, it also provides an excellent opportunity for scientific comparison, because only one half of the symmetrical roof was planted in vegetation and the other half area still retains the original black tar covering. The idea was to use the project to test the benefits of green roofs on air temperature, air quality, and stormwater absorption. This case can demonstrate the regional climate regulation function and provide the
opportunity to examine the difference in performance between the green roof and the traditional roof. It also encourages people to access the green roof.

Figure 2.15 Chicago Green Roof.

2.7.2.5 The ASLA Headquarters Green Roof project, 2006 (energy saving function)


Figure 2.16 American Society of Landscape Architects headquarters green roof

The green roof project on ASLA (American Society of Landscape Architects) seeks to demonstrate the environmental benefits of green roofs. It is located on the rooftop of the
headquarters of ASLA in the heart of Washington D.C. Using the 3,000 square foot roof of the building, the project transformed the roof such that it became a persuasive display of green roof performance that supports an active social area.

This green roof can prove it has a significant thermal insulation function because it decreases heating costs by 10 percent during winter. Another benefit is that the green roof is concerned with storing and recycling rainwater and reducing the energy consumption of the building, and significantly influencing the outdoor and car parking air temperature. This case can offer the idea the temperature regulation to maintain the function of the green roof, which can help to reduce the building’s energy consumption.

2.7.2.6 Musée du quai Branly Greenwall, 2005 (improving air quality)

Paris, France / 8600 sq. ft / Design by Dr. Patrick Blanc

Situated close to the Eiffel Tower, the Musée du quai Branly, known in English as the Quai Branly Museum - nicknamed MQB - is a museum in Paris, France. The museum complex measures approximately 13,000 sf (1,200 m). One of the most significant features in this museum is the stunning 200 m long by 12 m tall green wall covering the entire northwest façade. This case can offer the idea of another kind of building façade which can provide the biodiversity function for wildlife in the urban area.
2.7.3 Case study conclusion

From those cases above, it can be learned that green roofs and walls can provide both environmental functions including stormwater management, climate regulation and reduction in building energy consumption, and social services to combine and reunite the indoor and outdoor spaces to improve the public realm. I could draw on these cases apply in various features in my design process at the same time as avoiding the problems experienced in each case.

2.7.4 Summary of theory for improving public realm.

Green infrastructure is one of the keys to improving the public realm in urban areas, because nature can be used to provide essential services for communities (‘green infrastructure’, 2018). Gong et al.’s research revealed that elderly people living in neighborhoods with more green space participate in more regular physical activity (Gong et al., 2014). The results proved that a community which has a high-quality public realm could be central to improving human outdoor activities and thus be of benefit to people’s health. Because of land in the urban areas becoming rarer, elevated green space such as green roofs and living walls could be a new kind of green infrastructure to improve the public realm.

2.8 Overall Summary.

The green roofs and living walls could be a way to address environmental problems and social issues in urban areas. They have multiple technical functions which can contribute to
sustainable development, such as reducing the rainwater challenges, rebuilding urban ecosystems, improving the air and water quality and decreasing the building energy consumption. (Byrd & Leardini, 2011). There are a large number of successful green roofs, and living walls around the world, each one of them has their own unique features which could be used for reference to guide my research and design process. All of those green roofs and walls highlighted in this chapter can be referred to in particular for learning of their advantages and avoiding deficiencies. Roof park Vierhavenstrip, for example, combined the shopping mall with a green roof which can encourage the public to enjoy the open space (Lan, 2016). Moreover, the Waitakere Central Civic Centre Green Roof used New Zealand local native plants and other light materials to build the green roof (Waitakere council, 2004). However, there some disadvantages I need to avoid in my design process as well. Such as the Waitakere Central Civic Centre Green Roof, a green roof been blocked by the glass wall which cannot allow the public to access there.
Chapter Three: Site Introduction and Analysis.

To re-build the urban eco-system and improve the public realm, designing a site to estimate the function of green roofs and living walls as a form of green infrastructure to address urban environmental issues will be valuable for my research. Thus, choosing a suitable project will be significant for the design process. This chapter will illustrate the selected location for the design process, describe the relevant site information and analysis the context around the project site.
3.1 Choosing a site.

To make a green roof and living wall model for testing the ecological function and expanding the public space to provide an outdoor activity function, the design project site needs to choose a site in an urban area which has enough space for erecting green buildings, providing ecological function and creating outdoor activities space for public. According to Meurk and Hall, to enhance the biodiversity across New Zealand, planning to use smaller habitat patches (1-6ha) in urban areas can provide useful ecological functions (Meurk & Hall, 2006). To meet this requirement, I searched most parts of Auckland’s urban area, looking for a suitable site where the urban environment needs to be improved or which has some environmental problems that need to be resolved.

Several city centers, which met the requirement of addressing the environment and social issues, were considered as the design site, such as Sylvia Park, and the New Lynn area. The latter will be discussed below.

3.2 Biophysical view

I looked at the biophysical context of New Lynn which is marked by a lack of large green spaces for wildlife. In fact, as the economic center of New Lynn, Lynn Mall and its surrounding area have limited green spaces expect aside from community park. To the west side of the Auckland region, the Waitakere area has abundant forest resources to provide habitat for wild animals. However, when the wildlife needs to migrate, they lack transfer links to stay on the way because of urban development occupying the green space. There is also numerous wildlife in the Waitemata Harbor and Whau river regions, but they
are found it difficult to get across the interior to Green Bay due to the lack of migration transfer links. Thus, changing the Lynn Mall area’s environment and creating a green space as a habitat link for wildlife would be valuable for the local biodiversity.

Urban biodiversity is valuable for the urban eco-system and human life quality. The need to protect and restore the biodiversity of New Zealand has long been recognized (Meurk & Hall, 2006). Creating some green buildings as small habitat patches will benefit species migration. According to Meurk & Hall (2006) ‘s research, in urban and rural environments, the smaller habitat patches could be utilized because the reserve areas are constrained by land use and commercial factors. Moreover, Young and Mitchell (1994) and Davies-Colley et al. (2000) calculated that a compact reserve of around 6.25 ha (a 250 x 250 m square) would have an ecological function for wildlife (cited in Meurk & Hall, 2006).

Figure 3.1 The existing habitat and potential habitats in Auckland
3.3 Urban context

In 2010, Waitakere City Council presented a structured plan, and design guide to direct the renewal of New Lynn and envision that in 2030 New Lynn will be “unique, sustainable, and urban.” For the design process, I choose the Lynn Mall area as my research site to design the green building. A Council urban planner described how “the town center core will be a high-density employment hub including the vibrant mixed-used Merchant Quarter sitting alongside the shopping center” (Waitakere City Council, 2010).

In the Council’s document, a chapter entitled “The mall” suggested the Lynn Mall area would be a redevelopment and update. As such, it represents an ideal site for my research, thus providing me with an excellent opportunity.

Figure 3.2 The building footprint of New Lynn centre. Source: Waitakere City Council.
3.4 Analysis of site context.

3.4.1 Land use analysis

The Lynn Mall is in the center of the New Lynn commercial area. It is surrounde by various kind of commercial buildings; on the northern side of the Mall there is a street full of retailers as well as a historical church. Behind them, further north, there is a largely residential zone. The west and south sides of Lynn Mall are mainly mixed-use commercial land-use, including restaurants, car shops, workshops.

According to the Waitakere City Council’s document, in the future, the retail and other mix commercial buildings will be upgraded to become multi- levels buildings, and
the industrial area will be removed to a rural area due to the land rent in the New Lynn central area becoming increasingly expensive.

3.4.2 Main routes analysis

Figure 3.5 The traffic network of the Lynn Mall and surrounding area. Photo by author, Hao Long

The Lynn Mall area also is the transport center for the New Lynn area. There are two main avenues that cross near there: the Great North Road and Clark Street. The west railway line is beside the south side of the Lynn Mall, and New Lynn train station is located on the street corner opposite the Lynn Mall. The convenient transportation system brings advantages to the prosperity of Lynn Mall but also increase the demand for parking spaces.
The route around the Lynn Mall area was not organized very effectively so it always has congestion during the rush hour, which may inconvenience the customers who visit the Lynn Mall area. The one-way route beside the train station, especially needs to be reconsidered and planned. Another place that could be improved the western side of Totara Avenue; it is infrequently used so the land could be considered for some other use and re-organized. Yet another place that could be improved is where that there is a block of retailers between the Lynn Mall and the northern residential area, as well as a historic church. Besides this historic church, there is an opportunity to create a new route for
connecting the residential area and Lynn Mall.

Figure 3.6 The historic church and a potential route beside the church. Photo from google map.

3.4.3 Flooding areas analysis

There are some environmental issues that need to be addressed in the New Lynn area, one of the most significant ones is the flooding issue. Because of the lack of green space as a water storage medium, the Lynn Mall area suffers from stormwater flooding when the urban drainage system overloads after a rainstorm. This results in blocking the traffic in this area and impacts upon the property and lives of the local citizens. The flooding footprint can be found from the northwest corner and southeast corner of the Lynn Mall area, and central
area of the Lynn Mall car parking.

Figure 3.7 The Flooding area of the Lynn Mall and surrounding area. Photo by author, Hao Long

Currently, the northwest corner of the Lynn Mall area is a community park where there have is a sculpture and some street plants. To deal with the flooding issue, the Lynn Mall district should reinforce the drainage system, and the community park could be upgraded to become a rain garden to collects and store the rainwater to reduce the pressure on the
3.4.4 Green space analysis

There are many natural green spaces that can provide for the ecological function in Western Auckland, but in the Lynn Mall area the green space is very sparse. There are only a few community parks which have some trees, grass and shrubs expect the roadside vegetation which could offer limited food resource and habitat for wildlife. Thus, installing green roofs, and living walls would be an efficient solution to improving the local environment and creating a habitat patch alongside urban development.
3.4.5 Public realm analysis

Although there are many shops and restaurants in the central business area of New Lynn, there are not many public activities spaces that can be used by citizens. Most of the land in the New Lynn town center area is used for commercial purposes, including shopping malls, car parking, retail stores, and business workshops, and mostly used by private owners so not accessible to the wider public. Only a few community parks and plazas can be used as recreational areas for the general public, so improving public activities in the area is part of the plan for future urban development.
3.5 The goal of the site should achieve.

Based on the analysis of the distribution of biological habitats in the west part of the Auckland region, it is concluded that it is valuable to establish a small habitat patch in the downtown of New Lynn which could become a transfer station for the biological migration of wildlife. According to Young and Mitchell (1994) and Davies-Colley et al. (2000), 6.25 ha of the green patch could contribute to re-building the urban eco-system (cited in Meurk & Hall, 2006)
Figure 3.10 The method to calculate the habitat patch Source: Young and Mitchell (1994) and Davies-Colley et al. (2000)

On the basis of examining the environment of the surrounding landscape, land use, urban environmental problems and the analysis of the people’s public activity area, the following conclusion is reached: retain existing land use, build a roof park, use the park to increase the urban green area and improve the urban environment, to help solve the problem of stormwater floods, and provide a public leisure place for the citizens.
The design process is a challenging and meaningful one. This process gave me a better understanding of how to follow through with the designing of a green roof and living walls, the organization of each facility’s layout, and an understanding of plant configuration. The entire design process went through three versions of the design. From the initial revision of the relevant design plan of the Waitakere City Council’s plan to the final design of my own independent design, the continuous modification and in-depth research of the design draft in this process gave me a deeper understanding of the field of landscape architecture. Through three different versions of the design plan, I was able to gradually shift the major part of the design propose from the environmental characteristics of the roof garden itself to the ecological features of the roof garden. From the design, it can be see that through the use of plant configuration; the roof garden can create a precious ecological habitat. At the same time, by connecting the roof gardens into loops in various ways, it is possible to effectively increase the public activity space for citizens in urban areas and provide an opportunity for people to connect with nature.
4.1 The original plan comes from.

In the New Lynn urban plan document, there is a chapter entitled “The Mall” which describes the planning of the Mall, it mentions that “as the largest single ownership landholding in the town centre, Lynn Mall and surrounding car parking represents a unique opportunity to change the face of New Lynn”(Waitakere City Council, 2010, P. 135). So, the local government plans to change the layout of the Lynn Mall precinct, maintain and upgrade the internal streets into a wider street network with car parking. Meanwhile, this area will move towards being a multi-use complex with a range of uses including residential, offices, entertainment and leisure, and which transforms the original Lynn Mall into several smaller buildings so as to build new commercial areas(Waitakere City Council, 2008, p. 40).
Another New Lynn urban regeneration framework document presented by the Waitakere City Council and published in 2008, illustrated that the planner should create an integrated mix of retail, commercial and residential land uses within the town centre linked through safe and
legible pedestrian and cycle connections and provide a primary and secondary system of public open spaces in each precinct in the town centre (Waitakere City Council, 2008). This plan indicates the current Lynn Mall car parking occupies most of the site such that the corner and street edges are inadequately addressed insofar as the land is not used effectively. Therefore, the plan proposes to build a car parking building to deal with the parking issue and install some larger scale retails in the eastern part of the site. Meanwhile, the western part will be developed as a mixed commercial area integrating ground floor retail stores and residential apartments above, with provision for a series of public open spaces, lanes and parks (Waitakere City Council, 2008).
4.2 Transforming the original plan.

In the introduction to the New Lynn urban plan, there is mention of a large piece of land being planned for improving the public realm. However, the document still does not show the scale of the new green space that will be built in the town center to improve the environment. The figure 4.3 shows the part of the development plan about the future mixed commercial on the western side of the Lynn Mall area, and there are only a few green spaces and limited roadside trees are planned. Therefore, to achieve the goal of re-building the urban ecosystem and improving the urban environment, my design involves renovating and designing based on the original Lynn Mall plan to design green buildings which have much more green space including green roofs and living walls to improve the urban centre environment. The green roofs and living walls may be have both the intensive type and the extensive type, which could benefit the urban environment and public realm.

Figure 4.3 The concept masterplan of future Lynn Mall and surrounding blocks Source: Waitakere City Council
The major aim of my first design is increasing the green space to improve the urban ecosystem. Thus, I re-designed the layout of the building footprint and applied green roofs and living walls to the buildings. The first design draft include:

1. Two large scale buildings which could be the future Lynn Mall in the eastern part of site and which have a courtyard between them to potentially improve the public realm.

2. The parking building changed into underground car parking and entrances were set between the two large buildings.

3. On the western side of the site there were six multi-use commercial buildings which which could be used as retail stores, workshops, restaurants and some offices.

All those buildings will install green roofs and living walls to promote the local environment (maybe more than 55,000 sq. meters).
The Auckland government’s Geo map calculates that the site area is about 78,700 sq. meters, and the buildings area occupies approximately 55,100 sq. meters (70% of the site). In my first design draft there was an intersection across the whole area connecting the surrounding main avenues from the north to the south and east to west, which could be convenient for the local citizens to access.

Figure 4.4 The first design draft transfer from government plan. Photo by author, Hao Long
4.3 An improvement via the second design plan

The first design makes the route more flexible, but the connection between each building was too weak. In fact, it was too focused on the green space and thus neglected the public realm. To fix the problem, I upgraded my design, which modifies the buildings in the east part of the site and creates some bridges and tunnels for connecting each building to the other. Another issue is the car parking needed to be reorganized, because the underground parking entrance is in the courtyard of the shopping mall in the previous version, the

Figure 4.5 The second design draft model top view. Photo by author, Hao Long
passing vehicles would be a threat to the safety of pedestrians. There were also some surrounding routes that could be improve as well. A retail store area between the Lynn Mall and the residential area blocks neighbouring residents from entering the Lynn Mall area directly. And southern side road is not used efficiently so could be better promoted.

Thus, in the second design plain, the following improvements were made:

1. On the eastern side, the two large scale buildings were re-designed to become two new shape buildings, and the western side mixed commercial buildings were also re-organized. The entire buildings area occupied about 47,300 sq. meters (60.14%).
2. Some tunnels and bridges were added to connect each building, which, in turn, created an upper-level open space for improving the public realm.
3. Access to the roof was considered, some of them would be staircases and others would be ramps. Most of this access would be built outside of the building to allow the public to enter the upper open space at any time.
4. The underground car parking entrances were re-designed close to the main routes so as to be convenient for automobiles and provide a safe internal path within the site for the pedestrian.
Chapter Five: Refined Design Process.
5.1 Overall Concept of New Lynn Town Centre.

By considering the first two drafts, it can be discovered that if using green roofs and living walls as a solution to solving the problem of biodiversity, different plant configurations need to be used and different types of roof gardens and green walls need to be designed to ensure a variety of ecological habitats. Therefore, in the third edition of the design, the function of the roof level is expanded, and there are different using areas are divided on top of the two large buildings (which are the future shopping malls). Small trees and shrubs are used to provide the food resource and nesting opportunities for wildlife to create the habitat patch. Also, to improve the town center public activity areas, the practical grassland and plank roads are applied on the roof. Moreover, some rooms are built on the roof to house the ancillary building facilities (e.g. air conditioning, water tank, ventilation system). The integrated commercial building is modified so as to reduce the footprint area of the building, expand the streets on the ground floor and plazas and street trees are designed to increase the landscape on the ground level.

Meanwhile, all mixed buildings are converted into multi-floor buildings; the first floor is the podium that can be used as a restaurant, large store, workshop or other land use. The high-rise buildings on the podium can be used as offices or apartments. All these roofs have different types of green roofs. The roof of the podium uses shrubs and grasses as the major plants, and will be accessible for the public as leisure places. The extensive roof that uses ornamental vegetation, yet provides ecological value, is installed on those high-rise levels. On the façade of all the buildings, the use of cliff plants and vine plants to build a green wall makes the whole design a vertical multi-level ecological habitat, providing a source of food and habitat for wildlife while beautifying the central urban
environment. Moreover, the bridge and glass tunnels connecting the buildings make all the roof gardens a large activity area loop.
5.2 Detailed Plans

To address the research question, which is about improving urban biodiversity, the configuration of plants is essential when building roof gardens and green walls because they produce different kinds of habitats. In my design, there are mainly seven different types of plants, and they will provide these different wildlife habitats. These are as follows:

1. Ornamental ecologically valuable plants, which are mainly distributed on those high-rise roofs of commercial buildings. They use shallower soils, which have lower requirements for architectural structure but still can bring ecological value to wildlife.

2. A low forest ecological area, which is mainly distributed on the roof garden of large buildings and ground floor green spaces. It is mainly composed of pioneer trees and coastal trees. The height of these trees is lower than 10 meters, and they will have a certain bearing capacity requirement for the building structure, which requires deeper soil as their basis. However, they will be the main nesting place for birds and a source of food.

3. Shrublands, which are mainly distributed in the roof gardens of the large-scale buildings, podium building roof gardens and grounds on podiums, using coastal shrubs, subalpine shrubs or wetland shrubs to establish lighter shrub habitats for small birds and Insects provide habitat.

4. Grassland habitats, which are distributed in almost all areas, using sedge, alpine grass, and wetland species to create green areas that can be valuable for insects and be used for people for leisure.

5. The stone land habitat, mainly distributed in the ground landscape, composed of scree, cliff, and dune, providing habitat for reptiles and insects.

6. Cliff vegetation, which is mainly distributed on the façade of the low-rise buildings. It can provide food sources and nesting space for birds. It can also help buildings store rainwater and reduce the pressure of the urban drainage system during heavy rain.

7. Vine-type habitats, which are mainly distributed on the facades of tall buildings. They climb onto the surface of the building
and can greatly change the facade of the city buildings and change the traditional impression of the city.

Figure 5.2 The aerial view of final design. Photo by author, Hao Long
In the eastern part of the future Lynn Mall district, there will be two large-scale buildings which will become the future shopping malls. The large building on the north side is an intensive green roof, which mainly provides public activity space for citizens. Most of the vegetation is shrublands and grasslands. It is divided into different areas by the plank road. The central area is the main human activity area, where people can rest and entertain. There are also several rooftop sunrooms in the central area of the garden, some of which are used for the placement management of building annexes. Others can be used as landscape nodes for the public.

In the southern Mall building, there is a large intensive roof garden made up of low forestland and shrublands. Its main function is to provide a habitat patch for wildlife. The center of the roof garden and the southeast corner cover a large area of low trees that provide food sources and habitats for birds, reptiles, and insects. At the same time, there is a circular plank road and several water features on the roof garden surrounding the central habitat area, giving people a chance to get close to nature.
Figure 5.3 The top view of the new Shopping building. Photo by author, Hao Long
Between the two shopping mall buildings there is a plaza to provide for the active outdoor space for the public, and between these two buildings, there is a bridge connecting each roof, which could improve people’s active space. In addition, using landscape ramps and staircases can encourage people to access the roof level to enjoy high-level views.

On the top of the northern shopping building, there is an active public center in the middle of the roof garden, which could be used for events, a playground, or range of education functions.

![Figure 5.4 The plaza between two shopping buildings](image)

![Figure 5.5 The public active centre on the Northern shopping buildings.](image)
Figure 5.6 The top view of seven multi-using commercial building.
On the western side, there are seven multi-use commercial buildings, all of them have a podium. Above them there are some high-level buildings which could be used, for example, as offices or apartments. There are also some high level green spaces outside those potential offices and apartments which could be used as their balcony gardens, measuring 8,200 sq. Meters (10.47%).
All the green roofs on the podium are publicly open green roofs, mainly covered by shrubs and grassy vegetation. They provide ecological value and can also be used for outdoor activities in people's daily life. The podium roof gardens can form a high-quality, high-level event space, while the two south buildings are connected to the new platform in the south to further expand the public space.

The high-rise floors of the building above the podium are mainly used for offices and apartments. Thus, the green roof of this area uses mainly decorative grass. They can only be accessed by users on this floor (due to safety and privacy issues). On these high-rise facades, green walls made up of cliff plants and vines provide more habitat patches without taking up the interior space of the building.
There are many different entrances to encourage people access the top roof level, such as the entrance buildings on the western side. The comprise two sun rooms, top roofs of which can be used by people to access the high-level green roofs. Moreover, green walls are applied to the façades of those buildings; these green walls can provide a habitat function for wildlife, change the urban landscape view, and also improve the performance of the buildings themselves in terms of energy saving to reduce water waste.
On the southern side, a part of the original Totara Avenue is blocked, and a ground floor car parking installed to replace it; above this car parking, a new platform is built to function as a new open public space for the citizens. It has several entrances and also connects to the shopping mall and podiums, which become another connection link for the public to enter the roof garden. This
platform measures about 7,300 sq. Meters; it could cover the underground railway. The idea is to have some light holes to illuminate the underground railway with natural light.

Figure 5.9 The ramp and lift of the platform

The platform has different kinds of entrances from ramps to lifts, which encourages all kind of people to access it. Light holes are used to illuminate the ground floor car parking under the platform.

Figure 5.10 The ground floor car parking under the platform.
Each building has a different kind of way to access to the roof; for example, the northern shopping mall uses ramps and staircases to encourage people to get onto the roof level. In addition, there are some trees, grass and fountains to attract people.

Figure 5.1 The detail of ramp and staircases of shopping mall

Figure 5.12 The detail of staircases and steps of shopping mall
5.3 Design Diagrams

The low forest and shrubland are the main habitat area; they could provide the ecological function for the wildlife and also encourage people to access the roof level, which allow the large-scale green roofs becoming a high-level activities space for citizens to use.

Figure 5.13 The detail of bridges and tunnels of between the buildings

To solve the problem of the area flooding during a heavy rain period such as that described in the site analysis, my proposal is to upgrade the existing neighborhood park in the northwest corner, transform it into a rainwater park thus providing essential urban landscapes functions. During a rainstorm, this upgrade and transformation can connect part of the drainage system in the area, collect and store the overloaded rainwater, and relieve the pressure of urban drainage.

Figure 5.14 The detail of northwest raingarden
In the design of the roof garden, because the urban eco-system has been damaged and the consequent need to improve the ecological environment, there are some special conditions for the choice and size of the trees. On the intensive roof, it is necessary to strengthen the structure of the tree pool to ensure that the roots of the tree will not stab the waterproof layer in the future. Meanwhile, the building itself can bear the weight of plants and people, which could provide both ecological functions and improve the public realm.

Figure 5.13 The sections of planting pools
Chapter Six: Conclusion

This thesis aimed to answer the question: How can green roofs and living walls be used as an integrated part of urban development to increase biodiversity and to re-establish the connections between people and nature?

The research is trying to resolve the issues of sustainable urban development, urban design, urban eco-systems, and social interaction and look for the connection with landscape architecture.

Through my research into existing green roofs and living walls around the world, the findings suggested that the installation of green roofs and living walls could be a part of commercial development, which could improve the urban environment from different angles. As a part of landscape architecture, green roofs and living walls can influence the urban environment and create a habitat patch for wildlife in the town centre area. Furthermore, green roofs and living walls could establish a new open space in city centers, which provides a great opportunity for people to connect with natural green space.

My design process shows that it is possible to create a habitat patch in a town center area by using green roofs and living walls. The key to improving the urban biodiversity is created through a liveable ecological environment for wildlife by using different types of vegetation and spaces. Although commercial buildings occupy most of the city center's land, it is possible to make rational use of the roof above the building and the façade which are rarely considered for building ecological habitats. At the same time, in the process of establishing a roof garden, the use of the roof was explored; it could provide a higher level of urban space use in ways that have a significant value for improving people's outdoor activities.
6.1 Design Reflection
The model design is a method which tries to resolve the environmental problem we meet in Auckland urban areas and innovate a new type of building form for the future. The primary aim of the design was to add green roofs and living walls to change the urban, regional environment – in this case, the center of New Lynn. The re-build and creation of a new town centre could be a pilot project to test the function of the green building.

6.1.1 The method of using green roofs and living walls
To transform the appearance of buildings in the city center and the connection between the buildings, green roofs and living walls are used to show how the city could sustainably develop thus improving the landscape, the ecological environment and the public realm in the urban area. The primary purpose of the design is to install green roofs and green walls on those buildings in the central region of the city to explore the feasibility of bio-habitats and improve the quality of public areas.

The project site is in the commercial center of New Lynn in West Auckland. The project is a pilot for the sustainable development of urban planning in the future and designed to improve the quality of the open public space in urban areas. Redesign of the Lynn Mall commercial district was used to test this approach to see if would be possible to design a biologically functional habitat for wildlife in the city center and to create a sustainable eco-system as a part of urban development in a public space area.

6.1.2 The core context of design
The final design results are the product of research, analysis, and early design studies. On-site surveys were conducted, and the local government-related planning documents were reviewed to ensure the practicality and suitability of the design. The design applied green roofs and living walls which have the eco-function aim of improving the ecological landscape environment of the city center. This was followed by using higher level space and connecting each building so as to produce a loop to expand the urban open public space and improve the quality of activities. The results suggest that the most optimal design is to install green roofs and eco-walls in the urban area, and it could be a landmark to attract people to visit it which may be an opportunity to increase social interaction. This plan is also the most cohesive design for the ecological environment and its social effects.
The final design results are the product of research, analysis, and early design studies. On-site surveys were conducted and the local government-related planning documents were reviewed to ensure the practicality and suitability of the design. The design applied green roofs and living walls which have the eco-function aim of improving the ecological landscape environment of the city center. This was followed by using higher level space and connecting each building so as to produce a loop to expand the urban open public space and improve the quality of activities. The results suggest that the most optimal design is to install green roofs and eco-walls in the urban area, and it could be a landmark to attract people to visit it which may be an opportunity to increase social interaction. This plan is also the most cohesive design for the ecological environment and its social effects.

The principles and techniques behind design goals can be applied to other areas where the same urban environmental problems are occurring. As an example, green buildings with roof gardens and living walls could be used within any city in the world for sustainable development by changing the materials and layout based on site conditions, including the size of the building and the surrounding environment.

The core concept behind the design was about providing a new open public space. Providing social space is another important part of designing a roof garden. Through the research and analysis phase, time and effort were spent in determining the use of a roof garden to provide a high-rise roof activity area. However, other questions appear: How can people be encouraged to enter this higher space? What kind of functions can the upper space provide for people? These represent problems encountered in the public area design process and then solved. Eventually, using landscaped ramp and staircases outside of the building as the major entry method came to be seen as the best option because it uses the attraction of the landscape to encourage people which using the attraction of the landscape to encourage people to approach and explore the deeper landscape to let people into the upper space. Those green roofs are been distinguished become various kind of areas to provide different functions from ecological habitats to public activities areas. For example, those parts of the intensive green roofs which have shrubs, trees, tables, chairs, paths, and walkways could be a roof garden for the citizens, while those parts of the roof areas that have densely
planted trees could be used as habitat patches for wildlife. There are also some extensive green roofs that cover the lawns for entertainment use. The environmental and social effects of these roofs significantly affect the lives and work of the citizens in the surrounding areas, giving them a better urban environment and providing habitat for local wildlife.

6.1.3 The main propose of design
The design promotes outdoor public space from the ground level to the buildings’ roof tops, which is one of the most effective ways to use the land resource in the town center. Of course, there are related to safety that need to be considered in the detail of the design process, but the purpose of this design is to increase the possibility that green roofs and living walls are positive through plant configuration and space use. For those who live and work in the town center and around, there is a public outdoor environment that provides a space for leisure activities, which can significantly improve the quality of people’s living and working environments.

Establishing urban habitat patches in cities is another significant part of sustainable development. The establishment of green roofs and living walls in those urban areas lacking green space has a significant influence on the food resource and habitat of wild animals. Because most extant New Zealand wildlife (insectivorous birds, lizards, invertebrates) are either small or fragile, the small habitat patches can perform useful ecological functions - they can provide high-quality habitats (Henle et al. cited in Meurk & Hall, 2006). Green roofs and living walls in urban centers can recover the green area which has been eroded by commercial and residential land use in the urban development process. Although green roofs do not have the abundant resources and food sources as in natural forests, some of the dense green roofs can provide habitat for wildlife and offer a great opportunity for people to be close to nature. From a visual point of view, urban roof gardens and living walls can change the traditional urban appearance from the previously reinforced concrete to new eco-friendly buildings which could provide a beautiful mix of natural and modern society.

6.1.4 The aim of the design
The design aims to recover the landscape of the town center by utilizing green roofs and living walls on the buildings’ surfaces, providing habitat for wildlife, and rationally
planning to use the higher spaces on the buildings’ roofs to create a new open public space. This design is a demonstration of a new urban-centric architectural approach that expresses a city's sustainable development philosophy and encourages and promotes this approach to improve social, economic and environmental sustainability.

During the research and design process I realized that it is difficult to improve the local environment by some sporadic green buildings, because it is a challenge for the single building to change the urban, regional environment, especially since re-building the habitat patch requires 6.25 ha (a 250 x 250 m square) of high quality green space to generate ecological functions (Meurk & Hall, 2006). Therefore, the recommendation is to generalize the building green roofs and living walls; encouraging this sustainable and innovative design will be more socially valuable for sustainable urban development. Although the biggest challenge of this project is that currently there is no standard to measure the specific environmental impact of this innovative building method, and there is no guarantee of how much social benefit this building can offer, but the goal of the design is to promote an urban development method for the future. Using high-level space can improve the urban environment and expand the public activity area for the citizens, thus promoting the sustainability of urban development.

6.2 General Reflection
The initial goal of the research was trying to deal with the environmental problems in city centers. As the research proceeded, the goal evolved; it became about resolving environmental problems and helping to re-build the eco-system in the urban area, followed by improving the urban public realm and creating open space for people. The relationship between nature and human development appears as increasingly strong and close.

6.2.1 Urban environmental issues
The urban development process will continue to generate a range of environmental problems, from air pollution to biodiversity issues. All those issues are relevant to our societal development and influence our daily life. Air pollution, for example, is a threat to both our health and life. A World Health Organization report estimated that more than 1 million premature deaths annually could be attributed to urban air pollution in developing countries (WHO, 2002). In New Zealand, air pollution is mainly caused by
people burning wood and coal for home heating, followed by vehicle emissions. These all produce PM 10 which is easily inhaled and absorbed into the lungs causing significant health problems (Stats NZ, 2008).

Another significant problem relates to biodiversity. Due to the urbanization process, the natural green space has been replaced by commercial areas, residential zones or other land uses, which result in the wildlife losing their habitats and food resources. A research led by Dr. Stanley pointed out that “as native fungi and insects are often host-specific to native plants, and native birds also often preferentially feed on native plants - it is more than just trees we lose” (Wyse, Beggs, Burns, & Stanley, 2015).

6.2.2 Landscape architecture solution
In urban landscape development, the roof levels and the façades of buildings are not the first places to be considered when urban planning for green space. However, because city center land values have increased dramatically, the green spaces in urban areas are eroded and transferred to another land use (such as commercial or residential using) Thus, how to use valuable land resources more efficiently has become a popular topic in landscape architecture.

In recent decades, because of advances in construction technology, green roofs and living walls have become more well-known and so more widely used around the world. They can not only provide technical benefits for the buildings themselves, but also help to resolve some of the urban environmental issues. In fact, green roofs and living walls have significant effects on both the environment and society. In terms of the environmental aspect, the vegetation of green roofs and walls can help to cleanse the air of pollution, store rain water to release the stress on the urban drainage system. They also benefit biodiversity by, for example, providing habitat patches containing food resources for wildlife.

To answer the research question, I plan to use native plants to build the intensive green roofs and walls for improving the urban biodiversity. To achieve the requirement of ecological habitats, the plants in my design need to be the native plants which can provide food resources and/or habitats for wildlife. For instance, the West Coast Kowhai, a plant widely distributed in the western coastal areas of the Auckland region,
provide a rich food resource for birds such as the Tui, wood pigeon and bellbird ("Kowhai," 2018).

Figure 6.1 The Native trees as food resource for the bird

Moreover, the scale of green roofs and living walls is a significant point when proposing to re-build the urban eco-system. Young and Mitchell (1994) and Davies-Colley et al. (2000) calculated that a compact reserve of around 6.25 ha (a 250 x 250 m square) would have an ecological function for wildlife (Meurk & Hall, 2006). Thus, the green roof and living walls on the design’s two shopping malls and the podium building create a large-scale green space which could become a significant habitat patch in West Auckland.

6.2.3 Improving the public realm

Another research question is about the connection between human and nature. The urbanization process is seeing New Zealand’s urban areas expand. At the same time, citizens have more leisure time so open spaces for outdoor recreation became increasingly important (Kerryn, 2010). Because land values in urban areas have increased dramatically, building new public activity space in city areas has become a challenge.

To resolve this issue, the extra function of green roofs is the new upper-level open space and it is this which can be used to realize the integration of human and nature. The green roofs and walls using existing building façades to create new space for
the public would use land more efficiently. There are some entrances to the green roofs that are outside of the building using ramps and staircases and which have some landscape features to attract people and thus encourage them to access the roof garden for discovering the public activity space. Also, the use of bridges and tunnels to connect each building roof forms a loop on the roof to further expand the activity area of the upper level. These intensive green roofs have paths beside the habitat patch area which could allow citizens to feel close to nature but without disturbing the wildlife.

There are many successful examples worldwide to show the benefits of using green roofs and living walls as public open space, such as Roofpark Vierhavenstrip, which is a park on the top of a shopping mall in Rotterdam, Netherlands. The idea of this roof garden is that it not only can provide an outdoor open space for the public, but also be an attractive landscape to encourage citizens to visit it, which could be a potential benefit for the shopping mall (e.g., more consumers, more sales). “Buro Sant’s en Co’s strategy was to involve the residents, the municipal services, and the developers in the intensive planning process” (Land 8, 2015). In this situation, using vertical green space and green infrastructure could contribute to sustainable urban development.
References:

http://lungusa.kintera.org/sota07pdf.


Declaration

Name of candidate:

This Thesis/Dissertation/Research Project entitled: The use of green roofs and living walls to regenerate the urban eco-system and revitalize the public realm is submitted in partial fulfillment for the requirements for the Unitec degree of Master of Landscape and Architecture.

Principal Supervisor: [Signature]

Associate Supervisor/s: [Signature]

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Date: 28/10/2018

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Practice Pathway: Architecture

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