Architecture and Urban Agriculture

Merging architecture and a local food system in Wellington, New Zealand

by Thomas Zahner

Figure 1. Vertical Tomato Growing

Abstract

Urbanisation and agricultural development have for centuries had an interdependent relationship with each other, where the sophistication and systemisation of food production has led to the evolution and advancement of the city (Lim, Food City 5). Current global food systems seem to be exacerbating a disconnection between people and food production while concurrently harming the environment and biodiversity extensively (Kirschenmann 109). Therefore the demand for sufficient food for a growing population carries with it many challenges for environmentally, socially and economically sustainable food production (O’Kane 268). Local food systems are capable of mitigating many of the issues caused by the globalised food system, adapting local food production to suit the health and environmental needs of a community (O’Kane 274). This results in a more active participation in the food system by the community, increased social cohesion, a promotion of satisfying social and cultural interactions around food, a fostering of social responsibility and stewardship of local land, a nurturing of biodiversity, and a strengthening of the community’s economic vitality (O’Kane 271).

This design research investigates the social and environmental benefits of integrating a localised food production system into an urban setting in Wellington, New Zealand, through the cross-programming of urban agriculture with architecture. The research aims to provide social and environmental benefits to a community and place, as well as raise awareness of the importance of a sustainable and accessible food system. This thesis suggests that merging architecture and urban agriculture can positively improve the quality of life of the residents as well as positively benefitting the surrounding environment and biodiversity.

Figure 2. Site (current state)

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Figure 3. Bumblebee

“With the inevitable exponential growth of the urban environment, future cities incorporating mechanisms for food production and social unity must be reassessed along with our visions of utopia.”

- C. J. Lim, Ed Liu, *Smartcities + Ecowarriors*

Figure 4. Tomatoes

1. Introduction

Introduction

This thesis aims to provide a residential project engaged in urban agriculture which improves the quality of life of the residents and the wider community whilst positively impacting the surrounding environment and biodiversity. Urbanisation and agricultural development have for centuries had an interdependent relationship with each other, where the sophistication and systemisation of food production has led to the evolution and advancement of the city (Lim, Food City 5). As of 2014, 53.6% of the world's population live in urban areas, as do 86.3% of New Zealanders, with these numbers only projected to increase (United Nations, Department of Economic and Social Affairs). Concurrent to this rapid increase in population, we are witnessing a global food crisis, where, due to environmental and political influences, we face a global decrease in agricultural production of between 20% and 40% (Lim, Liu, 9). In many parts of the world food production has been shunned, both physically and ideologically, to the hinterlands, however, in order to avoid impending disaster which is equally human and environmental, food production and urbanisation must converge and work in unison (Lim, Food City 5).

Food production within cities is referred to as urban agriculture. "Urban agriculture is defined as the production of crop and livestock goods within cities and towns" (Zezza, Tasciotti 265). Integrating food production into urban areas could increase connections between people and their food supplies, knowledge of food production, food security, biodiversity and stewardship of land (O'Kane 271). This thesis argues that urban agriculture has the ability to positively benefit urban dwellers in a vast number of ways and has the ability to create an alternative way of thinking and living within urban environments, possibly resulting in a more sustainable urban form.

This leads to the research question of:

How can architecture and urban agriculture be combined in an urban environment to provide social and environmental benefits?

Scope of Research

The final outcome of this design research intends to improve the quality of life of the residents of the design, as well as positively impact the surrounding environment and biodiversity. This research investigates social and environmental effects of integrating a localised food production system into an urban setting in Wellington. The design aims to foster positive outcomes as a result of cross-programming urban agriculture with architecture. It hopes to provide social, environmental and economic benefits to a community and place, as well as raise awareness of the importance of a sustainable and accessible food system. This design-led thesis explores architectural design as a mechanism to respond to wider global, social and environmental issues, whilst accepting that architecture is not able to dictate the lives and thoughts of residents but can provide opportunities and spaces for people to live out suggested ideals through their own participation and accord.

It is also acknowledged that local food systems will only reduce, not eliminate, the reliance on current trade systems and it is hoped that this will provide positive and less unsustainable outcomes.

This thesis suggests agricultural methods, possible plant varieties, water systems, building technologies and community structures, however, it acknowledges that further research and development is required by experts across a broad range of fields in order for this project to be feasible. These fields include agricultural polyculture and permaculture, botany, landscape architecture, environmental science, building science, sociology, psychology and economics.

Structure and Methodology

Initially, the thesis problem was outlined. Secondly, current issues and possible solutions were established and analysed through a literature review. A range of sites were considered and a specific site was selected due to its connections to the surrounding urban fabric. Case studies with positive and tangible relationships with food production were examined, showing applications of social, environmental and affordability ideas. Architectural programmes have been developed drawing on the ideas presented in the studied literature and case studies. Agricultural methods and precedents were further examined, resulting in a quantitative goal for on-site food production. The preliminary design applies the theoretical programme into a physical design and is further developed in the developed design chapter to provide a possible solution to the research problem. The conclusion discusses and summarises the final design outcome in order to answer the initial research question.

Figure 5. Tomatoes

2. Literature Review

Current Global Food System

This literature review examines current social and environmental issues with the global food system and proposes a way to reduce the impacts of these by localising food production and empowering communities.

The increasing demand for sufficient food for a growing population carries with it many challenges for environmentally, socially and economically sustainable food production inside urban areas. (O’Kane 268). “Food sustainability’ has become a critical issue in the agricultural and environmental sciences and public health nutrition in the context of population growth, rising obesity levels, climate change and the environmental degradation that occurs as a consequence of the modern food systems” (O’Kane 268).

Beginning in the 1930s, agriculture became more mechanised to achieve high production rates (Matson, et al 504). In most cases, this brought with it a strong dependency on finite fossil fuels to power large machinery, irrigation systems and artificial nitrogen fertiliser production (Matson, et al 504). The change in agricultural methods allowed the change of economic systems, where high production rates and the globalisation of trade resulted in larger farms and fewer farmers. (Lawrence, *Agri-Food Restructuring* 186). Over time this has led to power within the food industry being concentrated in the hands of a few multinational corporations known as “Big Food”, which dominate most of the international trading markets and practically create a monopoly worldwide (Lim, *Food City* 33). The influence of these companies has been said to be the reason for today’s global ‘nutrition transition’ from locally sourced to highly processed foods (Stuckler, et al 1), as the restructuring of food production systems has allowed retailers and food manufacturers

to increasingly specify what farmers grow through the use of contractual agreements (O’Kane 269).

The trading of food on a global market removes any conscious link to local production, reinforcing the thought that food comes from multinational companies rather than farmers which results in a widespread acceptance of an anonymous and homogenous food supply (Kirschenmann 109). The encouragement of these ideas is a contributing factor to the increased consumption of highly processed food (Caraher, Covenay, 593). Energy dense fast foods are one of the most available on the market (Stuckler, et al 1). These contain high amounts of fats, oils, sweeteners and sugars such as high fructose corn-syrup (now representing around 40% of caloric sweeteners in food and beverages in the USA (Bray 537)), which encourage overconsumption by triggering reductions in insulin and leptin release and hormones that inhibit food intake (Bray 537). This seems to be a factor contributing to rising global obesity levels and increasing profit for food corporations.

With ‘Big Food’ dominating the global trade of food and beverages, the corporations are also outspreading their monopolies into other facets of food production (Lim, *Food City* 33). In 2008 the top ten agrichemical corporations controlled 67% of the US \$62billion seed market (Lim, *Food City* 33), and there is no reason to believe this data would be different in other developed countries due to the process of globalisation of expanding into global markets. Modern industrial agricultural methods often disregard existing ecological systems, multi-strata vegetation and complex crop patterns to raise only a narrow range of crops (Horriggan, et al 445). This leads to the loss of biodiversity and division of natural habitats, causing animal

population decline, particularly in invertebrate consumers, predators and pests. (Chappell, LaValle 9). Mono-cropping (raising only one crop per area) further reduces biodiversity due to high dependency on artificial pesticides that kill not only their target organisms, but also wild bees and other harmless species (Horrihan, et al 446). The reliance on and widespread use of uniform, high-yielding crop varieties distributed by food and agricultural companies further increases food insecurity and threatens sustainability as these varieties are often more susceptible to new or adapted parasites (Johnson 133). The use of chemical pesticides also often results in our food containing permanent residues, harming humans and causing other environmental problems such as soil contamination. (Canavari, et al 108).

As modern agricultural methods seem to have been established to primarily provide maximum yield and maximum economic gain, there are many examples which show extensive environmental damage (Kirschenmann 109). Pastoral or intensive agriculture utilises around half of the world's usable land, resulting in a substantial decline in arable land due to over grazing, erosion and soil quality issues, such as increases in soil acidity and salinity, which debilitates plant growth (Food and Agriculture Organisation, *Livestock's long shadow* xxi). Livestock agriculture is a main factor in deforestation due to the continued need for new arable land, causing further reductions in biodiversity as well as soil degradation (Food and Agriculture Organisation, *Livestock's long shadow* xxi). An example of this can be seen in the Amazon where 70% of once forested land is now used for pasture and crop production (Food and Agriculture Organisation, *Livestock's long shadow* xxi).

Modern agricultural systems also negatively influence water resources (Tilman, et al 671). Agriculture uses 70% of global fresh

water supplies and contributes 93% to water depletion (Food and Agriculture Organisation, *Livestock's long shadow* 126). Water is diverted for recreational, industrial and domestic use, and water quality is reduced through pollution by animal waste, high amounts of fertilisers and pesticides and increased sediment and salinity levels in the soil (Tilman et al 672-674). Only between 30% and 50% of nitrogen fertilisers and around 45% of phosphorus fertilisers are absorbed by crops, with the remainder left somewhere in the environment (Tilman et al 673)). Not only do these types of agricultural methods affect their adjacent environments, but they also contribute widely to climate change (Goodland, Anhang 11). A report issued by World Watch in 2009 states that livestock agriculture accounts for 51% of global greenhouse gas emissions (Goodland, Anhang 11).

The current global food system also comes with extensive social costs. Social capital can be described as the quantity and quality of social participation, norms of reciprocity and trust that exist in a community (Putnam 67). These have traditionally been high, however the modern food system, due to its competitive nature, weakens personal relationships between farmers, food processors, food retailers and consumers (Lawrence, *Agricultural production systems and rural restructuring* 105). Many farmers have to renounce longterm practices in order to produce higher yields to remain competitive on global markets, which leads to smaller, less connected and enduring communities (106). It seems that due to the physical and social disconnection of urban dwellers with farmers, social capital and its associated relationships are being diminished, along with the knowledge of how food is produced.

As outlined above, the current global food system is not sustainable whilst dissuading connections with food producers and nature,

and encouraging detrimental effects on our environment, social fabric and health (O’Kane 271). It will be the future generations who will suffer the consequences of our current, ‘efficient’ agricultural system with the most disadvantaged in our communities being the most vulnerable and susceptible to the effects of food insecurity (O’Kane 271). Therefore any solutions must ensure that current inequalities are not inflated and must aim to achieve social and environmental sustainability (O’Kane 271).

Local Food System

Many non-governmental organisations have demonstrated that the most effective way to provide global food security is to establish structures that allow small local farmers and producers to supply their community (Kukathas 1). Food activists have observed that small-scale sustainable farming practices support their communities by bringing people together with food production as a common interest (Kukathas 1). Such a system can be described as a local food system, with the intention of adapting local food production and markets to suit the environmental and health needs of a community (O’Kane 271). Models of local food systems include community-supported agricultural enterprises, farmers’ markets, roadside stands, pick-your-own enterprises and community gardens (King 117-120). These result in a more active participation in the food system by the community which creates increased social cohesion, promotes satisfying social and cultural interactions around food, fosters social responsibility and stewardship of local land, nurtures biodiversity and strengthens the community’s economic vitality (O’Kane 271). The most critical element with creating and sustaining a local food system is the active participation of its community in order to cater to its unique requirements (O’Kane 272).

In 1991, when the Cuban economy collapsed

due to political influences, citizens began looking to local plots of land to begin growing their own food to feed their families (Ellinger 15). As part of national policy goals, 3m² of land was given to each person for farming, resulting in the production of over half of the yearly fresh produce quota recommended by the United Nations Food and Agriculture Organisation (Buchan, et al 8). Trial and error testing by ecologists, agronomists and residents resulted in the widely successful agricultural system known as ‘organoponicos’ that has become commonplace in urban areas of Cuba (Ellinger 15). Coop agriculture, which emphasises inter-crop and companion planting to provide protection against weather disasters and mono-crop diseases, has fostered worker’s expertise and skills and provided employment and food security. (Ellinger 15).

It seems local food systems are capable of mitigating many of the discussed issues involved in the globalised food system (O’Kane 274). This model may be seen to work on many scales within both rural and urban environments, ranging from domestic and neighbourhood gardens to peri-urban farms and regional agriculture (Buchan, et al 6). Specific urban architecture responding to a smaller scale of the local food system, such as domestic and neighbourhood gardens, could facilitate community engagement in the food production process, promote access to nutritious food, foster social and environmental responsibility and support biodiversity.

Personal relationships and neighbourhood relations are directly influenced by our built environment and “if configured in the correct way can improve the perception of density” (Baldea, Dumitrescu 175). Baldea and Dumitrescu explain that conditions that establish a positive perception of dense built environments include “reducing unwanted social interactions, while supporting positive interactions that reinforce a sense

of community” as well as “presenting in the immediate vicinity of residential buildings qualitative outdoor areas appropriate for social interaction and group control that community members can frequently use”. (Baldea, Dumitrescu 175).

The incorporation of green space and nature into our built environment also results in many beneficial impacts on mental health (Mass, et al 587). A study conducted in the Netherlands concluded that “many people experience nature as an environment where they can rest and recover from daily stress. In the hectic society that we live there is a growing need for nature as a source of relaxation and recreation” (Mass, et al 587). This study shows positive correlations between green space and perceived mental health of inhabitants but focusses on green space within a 1-3 kilometre radius (Mass, et al 587). It is likely that the correlation would be increased if these green, natural spaces were closer and more accessible.

The combination or overlaying of urban agriculture, particularly a local food system model, and urban architecture will be explored in this thesis, with the aim of creating an architecture that stimulates a new way of thinking and living in urban environments. The exploration of this relationship requires an appropriate site which has the potential to benefit from the inclusion of a small scale local food system such as personal and neighbourhood gardens.

Figure 6. Nasturtium

3. Site Analysis

Site Analysis

Wellington is situated at the southern tip of New Zealand's North Island. The city relies on key resources such as food and fuel being imported through land and ocean transport routes (WeLG, WREMO 7). Due to its location, these supply lines are incredibly vulnerable to impending natural disasters, particularly earthquakes along the key Ohariu, Wellington or Wairarapa fault lines (7). The Wellington Region Emergency Management Office estimates that a major earthquake will isolate Wellington from normal road access for 120 days due to landslips on the four roads into the area, and four to five days from sea (5). Their report from 2011, 'Restoring Wellington's transport links after a major earthquake', suggests that 90% of food deliveries will have to arrive via sea, and the rest via air delivery or 4WD vehicles, as there are no food sources in the immediate vicinity (6). Hence integrating food systems into urban Wellington could provide post disaster food security and increase disaster resilience, as well as the social and environmental benefits discussed prior.

Figure 7. Location of Wellington in New Zealand (not to scale)

Site Justification

After searching for sizeable vacant sites within central Wellington, a site on the corner of Tasman and Rugby Streets in the suburb of Mount Cook was selected. The 1.14 hectare site has been vacant and undeveloped following the demolition of the YMCA building and the Boy's and Girl's Institute Indoor Swimming Pool in 2008 in preparation for a new supermarket that never eventuated (Jackman). The site is surrounded by industrial, commercial and residential typologies and is connected to the city water reticulation, storm water and waste water systems. These conditions, as well as the size of this site, present opportunities to merge residential living and community engagement with the production of food. The site slopes down towards the north-east dropping over 12m from the highest to lowest point which suggests possibilities for natural gravity led water systems.

Existing community centres, public community gardens and schools were also mapped in Wellington and it was found that both community centres and public community gardens were lacking around the site (see "Community Centres, Community Gardens and Schools in Wellington Region" on page 23). Therefore, adding these amenities could be beneficial to the surrounding community. The site is easily accessible to students from the many surrounding institutions (see "Proximity of Education Institutions to Site - 1:5000" on page 20) and, being adjacent to the Basin Reserve and close to the Pukeahu National War Memorial Park and Museum, could attract attention from the general public. State Highway 1 passes the site to the north-east attracting attention from vehicle passengers. The site's proximity to Adelaide Road provides access to public transport routes which connect

the central city to southern and eastern suburbs such as Newtown, Island Bay, and Lyall Bay. The location of this site could provide possibilities for an architectural statement of sustainability and difference and promote learning about localised food systems because of its accessibility, centrality and visibility.

Figure 8. Wellington Context Location Plan - 1:10,000

■ Kindergarten	■ Wellington Boys	■ Massey University
■ Mt Cook School	■ Wellington Girls	□ Site
■ Wellington High School	■ St Mark's School	

Figure 9. Proximity of Education Institutions to Site - 1:5000

Long Section 1

Long Section 2

Long Section 3

Cross Section A

Cross Section B

Figure 11. Site Sections - 1:1000

Figure 12. Community Centres, Community Gardens and Schools in Wellington Region

Community Centres in Wellington

- 1 Aro Valley Community Centre
- 2 Brooklyn Community Centre
- 3 Brooklyn Resource Centre
- 4 Crossways - Mount Victoria Community Centre
- 5 Hāitaitai Community House
- 6 Island Bay Community Centre
- 7 Karori Community Centre
- 8 Khandallah Town Hall Cornerstone Community Centre
- 9 Kilbirnie - Lyall Bay Community Centre
- 10 Miramar and Maupuia Community Centre
- 11 Newtown Community & Cultural Centre
- 12 Ngaio Town Hall
- 13 Northland Memorial Community Centre
- 14 Strathmore Park Community Centre
- 15 Thistle Hall Community Centre
- 16 Wadestown Community Centre
- 17 Vogelmorn Hall

Community Gardens & Orchards

- 1 Brooklyn Community Orchard
- 2 Common Ground Community Garden
- 3 Houghton Bay Community Gardens
- 4 Innermost Gardens
- 5 Island Bay and Berhampore Community Orchard
- 6 Kai o te Aro
- 7 Karori Community Gardens
- 8 Khandallah Community Garden
- 9 Miramar Heights Community Gardens
- 10 Mokai Kainga
- 11 Newtown Community Garden

Secondary Schools

- 1 Queen Margaret College
- 2 Rongotai College
- 3 Samuel Marsden Collegiate School
- 4 Scots College
- 5 St Catherine's College
- 6 St Mary's College
- 7 St Patrick's College
- 8 TKKM o Nga Mokopuna
- 9 Wellington College
- 10 Wellington East Girls' College
- 11 Wellington Girls' College
- 12 Wellington High School & Com Ed Centre

Primary, Contributing & Intermediate

- 1 Berhampore School
- 2 Brooklyn School
- 3 Cardinal McKeefry School
- 4 Cashmere Avenue School
- 5 Crofton Downs Primary School
- 6 Clifton Terrace Model School
- 7 Clyde Quay School
- 8 Evans Bay Intermediate
- 9 Hāitaitai School
- 10 Houghton Valley School
- 11 Island Bay School
- 12 Karori Normal School
- 13 Kelburn Normal School
- 14 Khandallah School
- 15 Lyall Bay School
- 16 Holy Cross School
- 17 Miramar Central School
- 18 Miramar Christian School
- 19 Miramar North School
- 20 Miramar South School
- 21 Moriah College
- 22 Mt Cook School
- 23 Newtown School
- 24 Ngaio School
- 25 Northland School
- 26 Owairo Bay School
- 27 Ridgway School
- 28 Roseneath School
- 29 Sacred Heart School
- 30 Seatoun School
- 31 South Wellington Intermediate
- 32 St Anne's School (Newtown)
- 33 St Anthony's School (Seatoun)
- 34 St Benedict's School (Khandallah)
- 35 St Bernard's School (Brooklyn)
- 36 St Francis de Sales Schools (Island Bay)
- 37 St Patrick's School (Kilbirnie)
- 38 St Teresa's School (Karori)
- 39 Strathmore Community School
- 40 Te Aro School
- 41 Thorndon School
- 42 Wadestown School
- 43 Otari School
- 44 Worser Bay School

- View from vehicles travelling west on State Highway 1
- View from vehicles travelling north-west on State Highway 1
- View from vehicles travelling north-west on State Highway 1

Figure 14. Views onto Site form Vehicles on State Highway 1 - 1:2000

Figure 15. Site Dimensions - 1:1000

Flood Zone

 N

Figure 16. Flooding Zone Plan - 1:2000

Figure 17. Wellington Corillan Memorial Tower to the North-West

Figure 18. Basin Reserve and SH1 to the North

Figure 19. State Highway 1 and Basin Reserve to the North-East

Figure 20. Residential Houses to the South

Figure 21. Residential Houses and Massey University to the South-West

Figure 22. Site Topography from North-West

Figure 23. Suburb Density Mapping

<i>Newton</i>	8,418 people	256 ha	32.9 people / ha
<i>Mount Victoria</i>	5,010 people	116 ha	43.3 people / ha
Mount Cook	6,582 people	105 ha	62.9 people / ha
<i>Brooklyn</i>	6,507 people	397 ha	16.39 people / ha
<i>Aro Valley</i>	3,621 people	126 ha	28.7 people / ha
<i>Te Aro</i>	9,654 people	124 ha	77.65 people / ha
<i>Wellington Central</i>	2,461 people	59 ha	50.2 people / ha

Climate

Climatic conditions have extensive influences on food production (Kern, Kern). Wellington's climate is temperate with absences in temperature extremes due to the mediating effects of the Pacific Ocean (Wellington Climate & Temperature). The average temperature during the summer is around 17°C, and 9°C in winter (see "Figure 26. Average Wellington Temperatures and Average Range (C)" on page 35). Precipitation levels are usually high during the winter, with a monthly average of around 138 l/m², and much lower in summer, around 76 l/m² (see "Figure 27. Average Wellington Precipitation (litres/m²)" on page 35). Wellington is known for being particularly windy as it is surrounded by ocean and sits at a latitude which is affected by strong winds known as the roaring forties (Wellington Climate & Temperature). These are created by warm air rising at the equator and cooler, polar air replacing it, causing westerly winds over New Zealand (Wellington Climate & Temperature). This westerly wind is funnelled up through the Kaikoura Ranges in the South Island and the Rimutaka Range in the North Island, often leading to this westerly wind being sped up and deflected into northerly winds (Wellington Climate & Temperature). Therefore the predominant winds in Wellington are from the north and the south (see "Figure 28. Wind Direction Distribution (%) per Month" on page 36). Average sunlight hours per year total 2,012, with approximate daily averages of 3.29 hours every day in June, and 7.32 hours in January (see "Figure 24. Sun Shading on Site throughout the Year" on page 34) (Wellington Climate & Temperature).

21 December 9am

21 December 12noon

21 December 4pm

20 March / 22 September 9am

20 March / 22 September 12noon

20 March / 22 September 4pm

21 June 9am

21 June 12noon

21 June 4pm

Figure 24. Sun Shading on Site throughout the Year

Figure 25. Sun Path on Site

— December — June

Figure 26. Average Wellington Temperatures and Average Range (C)

Figure 27. Average Wellington Precipitation (litres/m²)

Figure 28. Wind Direction Distribution (%) per Month

Figure 29. Marigolds, Carrots, Beetroot

4. Case Studies

Case Studies

In order to further understand the relationship between food production and architecture, existing case studies in this field will be analysed. The following examples have been examined due to their physical or programmatic application of social and environmental ideas which align to the literature discussed previously. The majority promote a positive and tangible relationship with food production.

Farming Kindergarten

This kindergarten's aim was to become a prototype for sustainable school design, creating a low cost environment utilising locally accessible materials, in which children can learn to grow their own food (Fearson). The roof gardens provide cultivation space, while three courtyards provide the children with playing space and access onto the roof (Fearson). The building also uses solar hot water heating, natural ventilation and recycles waste-water from a nearby factory to irrigate the plants and flush toilets (Fearson). Providing an environment which allows future generations to learn about food production and sustainable buildings in an urban environment from a young age could perhaps nurture more environmentally conscious city-dwellers. In reference to the chosen site discussed in the previous chapter, food production could be integrated with surrounding schools' education programmes.

Farming Kindergarten
Dong Nai, Vietnam
Vo Trung Nghia Architects
2013

Figure 30. Farming Kindergarten Rooftop Garden

Figure 31. Farming Kindergarten Courtyard

Figure 32. Farming Kindergarten

Unity Garden

The Common Unity Project Aotearoa is a community based urban farm project established in 2012 in Lower Hutt in conjunction with the Epuni Primary School. This project is a positive way of integrating education and sustainability into the daily life of the community (The Common Unity Project Aotearoa). The success that this program is observing is testament to the willingness to create change for future generations (The Common Unity Project Aotearoa). Education is extremely pertinent and essential if different ideas surrounding food quality and sustainability are to become generally accepted and implemented (The Common Unity Project Aotearoa). “The project is based on a system of reciprocity, community-led development and an understanding that when we acknowledge that every individual has something to offer, we empower families and community (The Common Unity Project Aotearoa). By working with our children and families to produce fresh food, coming together to cook for ourselves and others, and producing a wide range of other sustainable activities, we are weaving strength and togetherness into our community.” (The Common Unity Project Aotearoa). This case has been studied due to the value placed on education and inclusion of all members of the community, as well as the farm-to-table approach of food production, to provide a more sustainable future.

Unity Garden
Lower Hutt, New Zealand,
Common Unity Project Aotearoa
2012

Figure 33. Common Unity Project

Figure 34. Common Unity Project

Figure 35. Common Unity Project

Pasona Headquarters

Located in downtown Tokyo, Pasona Group's corporate office headquarters has been renovated to incorporate integrated urban farming facilities (Kono Designs). Over 200 species of plants are grown on site including fruits, vegetables and rice (Andrews). All the produce harvested is prepared and served at the cafeteria within the building, resulting in the largest and most direct farm-to-table operation inside an office building in Japan (Kono Designs). All crops are cared for by Pasona employees, with help from an agricultural specialist (Kono Designs). The aim was to show that it can change how people think about their daily lives (Andrews). The net rentable area for commercial office space was vastly decreased because of the crop space, but Pasona believed that the benefits of an urban farm to their employees and the wider community far outweighed financial gain (Laneri). Crop production and office space are shared creating an environment that promotes worker's productivity, mental health, and social interaction at the same time as displaying the benefits of urban agriculture to the wider community of Tokyo (Laneri). Inclusive community engagement, education and health are valued more highly than economic cost in this project, which is a position adopted in this research.

Pasona Headquarters,
Tokyo, Japan,
Kono Designs,
2010

Figure 36. Pasona Headquarters Interior Food Production

Figure 37. Pasona Headquarters Interior

Figure 38. Pasona Headquarters Meeting Room

Stacking Green

This house is designed specifically for the climate of Vietnam, and architect Vo Trong Nghia states he designed this house for the continuous 'hot summer' of Vietnam (Chalcraft). This precedent is relevant to this research as it provides an example of the integration of natural plant life specific to a particular climate into a domestic environment. The specialised, automatic irrigation system shows how such a system can be low-maintenance and sustainable using collected rainwater rather than ground water. Providing low maintenance and sustainable systems within the domestic environment could encourage the inhabitants to make use of facilities in which to cultivate their own personal food produce, through accessibility and ease of maintenance. Adapting these systems to Wellington's climate could allow food production to become easier for inhabitants.

Stacking Green,
Saigon, Vietnam,
Vo Trong Nghia Architects,
2011

Figure 39. Stacking Green Planterbox

Figure 40. Stacking Green Interior

Figure 41. Stacking Green

Union Street Orchard

The transformation of an empty section at 100 Union Street in SE1 London into a vibrant urban orchard and community garden is an example of urban food production rejuvenating space and providing a place for social and intellectual exchange (Architecture Foundation). The Orchard was host to discussions and workshops focussing on biodiversity and urban food production as well as musical performances, film screenings and local community meetings (Architecture Foundation). Combining activities concerning food production with entertainment and various creative media on the chosen site could attract a wider range of community members that may otherwise be uninterested in food production.

Union Street Orchard,
London, England,
Heather Ring,
2010

Figure 42. Union Street Orchard

Figure 43. Union Street Orchard

Figure 44. Union Street Orchard

17 Tory Street

An open source space, 17 Tory Street is intended to be extremely diverse in its use, facilitating open-source art, learning, workshops, exhibitions, film screenings, talks and more, and relies on community participation where citizens book the space through social media (Bartlett). Concerned Citizens believe that creative projects are able to reframe discussions, improve social relationships and engage people who might be reluctant to participate in socially driven causes (Bartlett). Such a facility situated within a food production site could attract community members and facilitate discussions around food production, possibly prompting active participation with it.

17 Tory Street,
Wellington, New Zealand,
Concerned Citizens Collective
2012

Figure 45. 17 Tory Street Talk

Figure 46. 17 Tory Street

Figure 47. 17 Tory Street

Regen Villages

Regen villages are off-grid communities which respond to issues such as climate change and food security by creating energy positive homes with mixed renewable energy production and storage, providing high yielding organic food production, and water and waste recycling systems, thereby empowering their local communities (Cooke). These houses combine to form a local eco-system where resources are shared amongst the community (Cooke). This case study is relevant as it shows the possibility of combining food production with housing and resource re-use whilst providing a strong community focus.

Regen Villages,
Concept,
EFFEKT,
2016

Figure 48. Regen Village

Figure 49. Regen Village

Figure 50. Regen Village

Summary

Key themes taken from these precedents are as follows:

Connection of food production and people through architecture.

Respective programmes of architecture facilitating time spent around food production.

Importance of community engagement and accessibility.

Hands-on contact with food production and food provides knowledge and confidence.

Local consumption of yields, farm-to-table systems.

Incorporated natural and sustainable systems into architecture support food production.

Figure 51. Table of Key Themes from Case Studies

Figure 52. Bee

5. Programme Development

Architectural Programme

In order for the ideas and applications seen in the literature review and case studies to be applied to this research, they must be adapted to respond to the specific site. This chapter aims to set up an architectural programme that will be developed into an initial design.

Figure 53. Initial Programme Concept Breakdown

Residential

Integrating local food systems into domestic environments may help reconnect residents with food production through increased accessibility and exposure (O’Kane 270). Wellington, as with most cities in developed countries, relies primarily on food being imported into the city (WeLG, WREMO 7), creating a disconnection between urban dwellers and food production (O’Kane, 269). As seen in the case studies of Pasona Headquarters, Farming Kindergarten and Unity Garden, exposure to environments where food is actively being grown allows opportunities for residents to learn about food production processes, particularly when incorporating a farm-to-table system where the food produced on site is consumed by those who have grown it. Therefore, providing housing with immediate, tactile connections to food production could provide education for residents, as well as supplying much needed housing in response to Wellington’s rising house prices (26% since 2015) (REINZ).

Designing residential apartments with small footprints could provide the most space for food growing to maximize food production. By providing shared living and working common spaces, laundry and storage facilities, personal apartment size could be significantly reduced (Cohousing New Zealand). A model of shared living could also provide residents with a balance between the desire for privacy and independence and the social interaction and connectivity with others (Convivenza Co Housing). Shared living, or cohousing, is based on democratic principles, where resident participation is essential and involves mutual respect, trust, honest communication and the commitment of time and labour from everyone (Sargisson 36). This type of living merges private and collective ownership, shared responsibility, frequent communication and collaboration with neighbours, and facilitates social skills and competencies, leading to increased civic participation, education and

a sense of community inclusion and personal competence (Sargisson 44-45). These ideas, possibly using communal food production as the primary driver, align to a positive increase in social capital and more enduring urban communities (O’Kane 270).

Figure 54. Initial Residential Programme Breakdown

Community

It seems essential to also offer wider inclusive community engagement and to provide opportunities for non-residents to benefit from the proposed application of urban food production in order to avoid a sense of exclusiveness and affluence. Examining the analysed precedents, offering such services as community workshops and education (*Pasona Headquarters*), a multi-use publicly curated space (*17 Tory Street*), a place for discussions surrounding urban food production combined with other creative programmes (*Union Street Orchard*) and active contribution through schools (*Unity Garden*) could all facilitate the increase of knowledge and skills of the public and ultimately increase the social capital of the wider community.

The architecture should aim to facilitate education and act as a catalyst for enhancing critical and creative thinking in order for members of the wider community to possibly imitate, adapt and progress the ideas surrounding urban food production discussed in this research, as “knowledge may provide the building blocks for new ideas” (Meusburger 103). Hence visibility, understanding and interaction with on-site systems and processes seem necessary to provide experience and knowledge for both residents and visitors to build upon, possibly leading to further implementation of these ideas throughout the wider community.

Figure 55. Initial Community Programme Breakdown

Urban Agriculture

Consuming foods such as plant-based foods results in minimised carbon, nitrogen, water and land use (Gephart, et al 126). In order to reduce the severe environmental detriment caused by animal agriculture it seems necessary to encourage a plant-based diet by growing produce (vegetables and fruit) on site to be consumed by residents. Sustainable growing methods such as organic inter-cropping/ polyculture and companion planting can also reverse environmental detriment by increasing biodiversity and eliminating the need for artificial herbicides and pesticides, consequently improving soil health (Ellinger 15). Hence the production of produce using organic intercropping and companion planting methods will be suggested in this research. Raising animals for human consumption has serious impacts on almost all aspects of the environment, including air quality, climate change, land, soil, water, biodiversity and natural resources (Food and Agriculture Organisation, *Livestock's long shadow* 3). Livestock production, including meat, dairy and eggs, comprises 40% of gross global agricultural product and uses one third of the world's fresh water (Walsh). It is responsible for 93% of fresh water degradation (Food and Agriculture Organisation, *Livestock's long shadow* 126), contributes to 51% of greenhouse gas emissions (Goodland, Anhang 11), and run off from livestock grazing and factory farms is one of the biggest causes of pollution in rivers and lakes (Food and Agriculture Organisation, *Livestock's long shadow* 140).

Infrastructural systems such as water systems have major influences on plentiful food production (Fraser 114). A common challenge faced in urban environments is that these servicing systems are often designed secondary to the architectural planning of new developments, thereby often not exploring more efficient and integrated systems (Fraser 114). Consciously planning and designing infrastructural systems concurrently with

architecture will create better integration with the surrounding site, consequently increasing efficiency in water, waste and energy management (Fraser 114). It seems that cross-programming urban agriculture and residential housing could provide opportunities to combine the respective necessary infrastructural systems. Produce grown requires irrigation (Kern, Kern), allowing possibilities for rainwater harvesting and greywater re-use, reducing the demand for fresh water. Produce also requires nutrients (Kern, Kern), allowing possibilities for on-site composting using food scraps from residents to replenish the soil.

In the following section, urban agriculture methods have been analysed from a quantitative perspective to produce an indicative figure of necessary productive land space. This will be combined with the above architectural programme to produce an initial design in Chapter 6, Initial Design.

Figure 56. Initial Urban Agriculture Programme Breakdown

Food Production Figures

The most recent data from the United Nations Food and Agriculture Organisation provides figures for the average daily food consumption per person in Australia by weight and calorie. These have been used as New Zealand data is unavailable. (Food and Agriculture Organisation, FoodBalanceSheets_E_All_Data_(Normalized)).

By weight:	2,551g	
Meat	423g	17%
Dairy & Eggs	670g	26%
Produce	661g	26%
Sugar & Fat	208g	8%
Grain	239g	9%
Other	350g	14%
By calorie:	2637cal	
Meat	553cal	17%
Dairy & Eggs	505cal	15%
Produce	264cal	8%
Sugar & Fat	985cal	30%
Grain	78cal	22%
Other	252cal	8%

Figure 57. Average Daily Food Consumption Table

Assuming that diets are similar in New Zealand, and these figures take into account age, culture, gender, body type difference etcetera, they can be used to make an indicative estimate of the current yearly average of produce consumed per person:

Estimates for 50 people (initial design):

661g of produce per person per day.

50 people x 661g = 33.05kg per day.

33.05kg per day x 365 days = **12,063kg per year.**

12 tonnes produced on site per year.

Estimates for 65 people (improved design):

661g of produce per day.

65 people x 661g = 42.96kg per day.

42.96kg per day x 365 days = **15,680kg per year**

15.7 tonnes produced on site per year

Figure 58. Food Production Amount Estimate Table

Due to the need for a dietary shift, as previously discussed, an overall increase in produce and grain and a reduction in meat and dairy consumption is necessary.

New Zealand Non-Organic Monoculture Yields:

Data from the United Nations Food and Agriculture Organisation provide average national figures for yield per hectare per year for the following crop productions, taken from the 2013 data set (Food and Agriculture Organisation, FAOSTAT_data_8-31-2016 crops):

Apples:	49.6 tonnes / ha
Beans:	6.85 tonnes / ha
Cabbages:	59.7 tonnes / ha
Cauliflower & Broccoli:	49.8 tonnes / ha
Garlic:	4.56 tonnes / ha
Grapes:	9.94 tonnes / ha
Kumara:	12.7 tonnes / ha
Leek:	38.2 tonnes / ha
Lettuce:	26.2 tonnes / ha
Onions:	45.9 tonnes / ha
Pears:	45.3 tonnes / ha
Potatoes:	46.7 tonnes / ha
Pumkin & Squash:	20.2 tonnes / ha
Spinach:	5.2 tonnes / ha
Tomatoes:	111.6 tonnes / ha

Figure 59. Average National Figures for yield per hectare in New Zealand table

This data calculates an average of the entire yield per crop per hectare across New Zealand. This means that varying agricultural methods and the productivity and climate of different regions has been averaged to provide an overall indicative figure. Assuming that these figures are applicable to the Wellington region, and an equal amount of land is provided for each crop to provide a variety and choice for individual diets, a total average of **35.5 tonnes per hectare** can be calculated and used as a guide and comparison for possible food production.

Australian Organic Monoculture:

In Tasmania, intensive and organically grown produce can provide a maximum yield of (Ashley et al):

Carrots:	48 tonnes / ha
Onions:	24 tonnes / ha
Broad Bean:	1.8 tonnes / ha
Shallots:	0.68 tonnes / ha

Combines for an average of 18.62 tonnes per hectare.

Figure 60. Australian Organic Monoculture

Californian Organic Monoculture:

In the state of California, USA, the specified amount of the following produce can be grown organically per year (Kern, Kern):

Asparagus:	5.0 tonnes / ha
Beans:	4.9 tonnes / ha
Beet:	12.1 tonnes / ha
Broccoli:	8.2 tonnes / ha
Cabbage:	15.3 tonnes / ha
Carrot:	21.7 tonnes / ha
Cauliflower:	12.1 tonnes / ha
Celery:	35.8 tonnes / ha
Corn:	6.9 tonnes / ha
Cucumber:	9.4 tonnes / ha
Lettuce:	10.1 tonnes / ha
Onion:	22.2 tonnes / ha
Pea:	2.5 tonnes / ha
Potato:	16.6 tonnes / ha
Potato (Sweet):	6.7 tonnes / ha
Radish:	13.6 tonnes / ha
Squash-Summer:	10.9 tonnes / ha
Squash-Winter:	19.0 tonnes / ha
Spinach:	12.3 tonnes / ha
Tomato:	12.4 tonnes / ha
Turnip:	13.3 tonnes / ha

Figure 61. Californian Organic Monoculture

Assuming that all these crops would grow as productively in Wellington (this may require greenhouses to regulate the temperature/humidity) and organic agricultural methods such as intercropping or polyculture without the use of extensive machinery are practiced, an average from the range of crops could be made, with equal distribution, where the total average yield would be **12.9 tonnes per hectare**.

Polyculture, Growing Power, Milwaukee:

Will Allen has produced 36 tonnes of food from three acres in urban Milwaukee, using a highly intensive and integrated food system where approximately 150 crops are grown together in green houses (Kasper). This equates to 12 tonnes of a range of produce per acre, or **39.64 tonnes per hectare**. Allen says that the key to large yields is the soil and the use of compost. Growing Power use soil-based growing methods as well as aquaponics (Kasper).

Polyculture, Green City Acres, Kelowna:

Green City Acres in Kelowna, British Columbia, Canada produced over **56 tonnes of produce in a hectare** of land using 100% natural, organic methods in 2012 (Green City Acres). The key to the productivity of the land is a method of farming called Small Plot Intensive Farming, or SPIN, where unused city land, such as roadsides and vacant plots, is utilised to cultivate produce, prioritising manual labour over the use of fossil fuelled agricultural tools (Green City Acres).

Polyculture, Viviero Alamar, Havana:

On the outskirts of Havana, Viviero Alamar Organoponicos produces 300 tonnes of vegetables, spices and vinegars from 10 hectares of land (Farmcuba). Good horticultural practices such as mixed cropping, crop rotation, integrated pest management, using well-adapted varieties, drip irrigation, regular application of compost and raised beds all contribute to the high yield (Food and Agriculture Organisation, Urban and Peri-Urban Agriculture). Organoponicos can be practised on unutilised space such as roadsides, vacant lots and building sites, offering a model to be replicated (Food and Agriculture Organisation, Urban and Peri-Urban Agriculture).

Combination of Total Yield Figures:

New Zealand Average (combination of crops, non-organic):	35.5 tonnes / ha
California, USA (combination of crops, organic):	12.9 tonnes / ha
Milwaukee, USA (organic polyculture):	39.6 tonnes / ha
Viviero Alamar, Havana, Cuba. (organic polyculture):	30 tonnes / ha
Average:	29.5 tonnes / ha

Figure 62. Total Yield Figures Table

The above averages provide an indicative figure for the productivity of a hectare of land in Wellington, New Zealand, if the crops were raised using intensive organic polyculture. The figures from Tasmania have been disregarded as there was insufficient variety between crops, making that data inapplicable to the programmatic needs of the project. The figures from Kelowna in Canada have also been disregarded as they are substantially higher than the other figures found and may not provide an accurate average for productivity in Wellington. Therefore an average of 29.5 tonnes per hectare could be the maximum amount of produce grown per year, assuming that the climate will remain similar, adequate care will be given to the crops, agricultural methods will follow those similar to intensive organic polyculture such as those used by Vivero Alamar, and crops will receive adequate sunlight and other necessary resources such as water and nutrients.

Site Specific Application:

Total Site Area: **1.14 ha**

If whole site area used for food production:

1.14 ha x 29.5 tonnes / ha = **33.6 tonnes**
 661g x 365 = 241 kg per person per year.
 33.6 tonnes / 0.241 tonnes = 139.4

Hence whole surface area of site could supply 140 people with produce.

Area needed to produce 12 tonnes a year for 50 people:

12 tonnes / 29.5 tonnes/ha = **0.40 ha**

4000m2 of food production space

Area needed to produce 15.7 tonnes a year for 65 people:

15.7 tonnes / 29.5 tonnes/ha = **0.53 ha**

5300m2 of food production space

Figure 63. Site Specific Application Table

Fruit Trees

Climbing Plants

Figure 64. Fruit Trees and Climbing Vegetables suitable for Wellington

Ground Vegetables

Root Vegetables

Figure 65. Ground and Root Vegetables suitable for Wellington

Figure 66. Potential Planting Combinations

Figure 67. Possible Companion Planting Combinations

Revaluation of the programme in context with the site led to the population of inhabitants within the scope of this research being increased from 50 people to 65 people. The surrounding suburb of Mount Cook has an average population density of 62.9 people per hectare which includes areas of uninhabited space such as parks and roads, thus actual population density in habitable areas would be higher (see “Figure 23. Suburb Density Mapping” on page 31). A density of 50 people would provide a greater amount of food produced per person, but with housing demand in Wellington increasing, proposing a lower than average density of people on the site seems illogical and infeasible. Therefore 65 people residing in approximately one hectare of the site and a community centre in the remaining space seems more appropriate.

As stated prior, these findings will be combined with the architectural programme to produce an initial design.

Figure 68. Peas

6. Initial Design

Initial Design Development

To maximise the amount of land for food production, it seems building footprints should prioritise space for food production. Separating residences could provide greater privacy to residents and allow more opportunities for passive design to reduce operational energy of buildings due to greater surface area for windows (Ministry for the Environment 10). To further reduce total energy use in buildings attention should be paid to the choice of building materials and the re-use and re-cycling of them (Thormark 1025).

Timber is a building material that sequesters carbon and releases oxygen through the process of photosynthesis (Joseph, Tretsiakova-McNally 412). It primarily requires solar energy to grow and requires less fossil fuels during processing than other common building materials (Joseph, Tretsiakova-McNally 411). Some timber harvesting methods cause environmental damage such as loss of biological diversity, land clearing and water and soil pollution, however with strategies of sustainable forest management and harvesting, for example selective logging, timber can be considered a sustainable and renewable material (Joseph, Tretsiakova-McNally 411). Particular timber treatments can also negatively affect human health, air quality and soil quality due to the release of volatile organic compounds, such as formaldehyde (Joseph, Tretsiakova-McNally 412) and copper chromated arsenate (CCA) (Read 23-24). Therefore, it seems important to consider timber treatments and their impacts during their life cycle and beyond. Untreated or naturally treated timber is easily re-used or re-cycled, unlike chemically treated wood which is most commonly disposed of in landfills. (Joseph, Tretsiakova-McNally 412).

Timber is also a structurally strong building material (Joseph, Tretsiakova-McNally 411). Analysis of seismic damage in California and Japan from the Structural Board Association show that panel-sheathed wood frame structures performed better than masonry and concrete buildings (Horwitz-Bennet, Sullivan

61), and a report published in the Bulletin of New Zealand Society for Earthquake Engineering in 2011 concludes that engineered timber structures performed remarkably well in the recent Canterbury earthquakes (Buchanan, et al 400). Timber has therefore been chosen as the primary building material due to its renewable and sustainable qualities and seismic resistance.

Consciously designing with industry standard sizes could potentially increase the possibility of materials being re-used and potentially decrease off-cut waste during construction. Plywood and timber panels are commonly used for external cladding, weatherproofing, structural bracing, interior lining, furniture and joinery (Buchanan, et al 400) and are most commonly manufactured to a size of 1200mm wide and 2400mm or 2700mm high (Musgroves). Plywood is often a cheaper option than other timber products (as seen in the appendix “Selected Material Costings”), therefore a square building footprint of 5 x 1.2m plywood panels (6m x 6m, see Figure 70. Form Exploration with Panel Sizes) has been explored in order to achieve a liveable space with the maximum area and smallest footprint (see Figure 69. Form Exploration (Space Efficient Geometry)).

Figure 69. Form Exploration (Space Efficient Geometry)

Figure 70. Form Exploration with Panel Sizes

Producing food indoors primarily requires adequate light (Kasper). Consequently the top floor of each building will be dedicated to all year round vegetable growing to increase productivity. Therefore roof forms have been explored in order to allow for passive daylight, shading and ventilation strategies, and formal aesthetics have been explored through a series of physical models (see Figure 71. Form Exploration Models).

Figure 71. Form Exploration Models

Roof Framing
Direction in Plan

Roof Framing
Direction in Plan

Pitched Roof - Winter N →

Gabled Roof - Winter N →

Pitched Roof - Summer N →

Gabled Roof - Summer N →

Air Movement N →

Air Movement N →

Figure 72. Form Analysis with Natural Light and Natural Ventilation

The following floor plan iterations attempt to provide a comfortable space within 29.16m², while incorporating aspects from the Passive Solar Design Guidance issued by the Ministry for the Environment. Windows on opposite sides of the space aim to distribute daylight more evenly (Ministry for the Environment 10), while north facing windows will provide good access to strong illumination, however may require shading (12). Easily adjustable louvre systems could be incorporated in order to reduce the effect of glare as well as provide possible opportunities for a consistent visual aesthetic (13). Insulation is extremely important in order to achieve thermal comfort (18). Timber is a good insulator, allowing minimal heat transfer (18), and coupling this with another insulating material such as wool with high R-Values (a measure for resistance of heat flow of an insulator) will be adequate in resisting heat movement (18). Natural ventilation is also important and could occur through the 'stack' effect or through wind air movement (22). Providing windows at a high level will allow hot air to escape while drawing fresh air in through the façade (22). As Wellington's predominant winds are from the north and the south, windows on either side could facilitate air movement from the wind.

Food Production

Private Living

Food Production

Storage
Compost

North Elevation
1:200

West Elevation
1:200

Programme

Food Production

Private Living

Food Production

Storage
Compost

North Elevation
1:200

West Elevation
1:200

Programme

Figure 73. Initial Design Floor Plan Iteration 1

Figure 74. Initial Design Floor Plan Iteration 2

The following plans describe an initial design for a 1 bedroom residential unit, with food production on the ground floor and top floor and residential living in between. Connecting the top food production area with the residential below through a void space over a balcony intends to increase the proximity and contact with food production.

Figure 75. Initial Design Ground Floor Plan - 1;100

Figure 76. Initial Design First Floor Plan - 1:100

Figure 78. Section of Initial Design

Figure 79. Section of Initial Design with Programme

Figure 80. Interior View of Living Space and Balcony, Initial Design

Figure 81. Interior View of Food Production Area on Second Floor, Initial Design

Due to the small floor area, space efficiency is key. The apartment could be transformable, allowing residents to change the space into a living space, sleeping space or workspace, or a combination. Figure 82. Separation of Space with Screen and Figure 83. Space Transformation show possibilities for this in the initial design. Precedents on the following page provide examples of transforming furniture which could be considered to save space. “Figure 96. Reconfiguration of Planterboxes (Plan)” on page 91 explores the transformation of food production space on the top floor into living space.

Figure 82. Separation of Space with Screen

Figure 83. Space Transformation

Figure 84. Yo! Home Prototype

Figure 85. Yo! Home Prototype

Figure 86. Orla Reynolds "As if from nowhere"

Figure 87. Orla Reynolds "As if from nowhere"

Figure 88. Rock Paper Robot Table

Figure 89. Rock Paper Robot Table

Figure 90. Zanica Design "Inside Out Chair"

Figure 91. Zanica Design "Inside Out Chair"

Figure 92. Dripta Design "Magic Chair"

Figure 93. Dripta Design "Magic Chair"

Figure 94. Rock Paper Robot Chair

Figure 95. Rock Paper Robot Chair

Figure 98. Materiality Diagram

Figure 99. Water System Diagram

The previous plans show a possible residential scale solution to combining food production and residential housing within a small footprint, however after the site definition, it was necessary to test the design with regard to aspects such as sun shading, food production quantities, water systems, access and circulation, and visibility. The previous ideas of transformation and flexibility will be continued when designing 2 bedroom and 3 bedroom apartments and the common house and community centre.

Masterplan

The following iterations show potential distribution of food production space in response to shading from the surrounding environment (see “Figure 24. Sun Shading on Site throughout the Year” on page 34), initially for 4000m² and later for 5300m². Due to the site being in a flood prone area (see “Figure 16. Flooding Zone Plan - 1:2000” on page 28), storm water drainage is necessary. Existing topography has been examined to determine the placement of a storm water catchment and filtration swale. To optimise growing space, there must be apartments on the ground floor as well as first floor to create the smallest building footprints possible. Shading has been tested with various iterations of building footprint layouts in order to provide food production areas with maximum sun exposure without segregating them from the buildings. View shafts onto site were also explored in order to inform the site layout to allow passers-by easy visual access to food production areas.

Figure 100. Iterations for the Distribution of Food Production Areas totalling 4000m² (50 People)

Figure 101. Iterations for the Distribution of Food Production Areas totalling 5300m² (65 People)

Figure 102. Water System and Building Footprints Development

Figure 103. Physical Site Model

Figure 104. Physical Site Model

21 December 9am

21 December 12noon

21 December 4pm

20 March / 22 September 9am

20 March / 22 September 12noon

20 March / 22 September 4pm

21 June 9am

21 June 12noon

21 June 4pm

Figure 105. Planning Iteration 1 Sun Shading Study

21 December 9am

21 December 12noon

21 December 4pm

20 March / 22 September 9am

20 March / 22 September 12noon

20 March / 22 September 4pm

21 June 9am

21 June 12noon

21 June 4pm

Figure 106. Planning Iteration 2 Sun Shading Study

21 December 9am

21 December 12noon

21 December 4pm

20 March / 22 September 9am

20 March / 22 September 12noon

20 March / 22 September 4pm

21 June 9am

21 June 12noon

21 June 4pm

Figure 107. Planning Iteration 3 Sun Shading Study

Figure 108. Planning Development with View Shafts

Figure 109. Planning Development Circulation

Figure 110. Planning Development Connection of Food Production Areas

Figure 111. Water Filtration and Irrigation System

Figure 112. Compost Distribution

Figure 113. Residential Apartment Layout

Figure 114. Community Centre Connection

This chapter has outlined the conceptual ideas and preliminary planning on which to base a developed design. The ideas explored will be developed further in the next chapter.

Figure 115. Pumpkin

7. Developed Design

Developed Design

This chapter presents a developed design of the preliminary planning discussed in the initial design chapter. The masterplan layout is a result of overlaying multiple stratas of information onto the site, as seen in the working drawings from the previous chapter to provide a possible design. These layers include food production space, building footprints of the architectural programme, sun shading/exposure, water drainage, filtration and irrigation systems, waste systems, view shafts onto site and accessibility. Minor improvements were also made to the initial design after discussions during design reviews, such as a more even distribution of 1, 2 and 3 bedroom apartments.

Figure 116. Developed Design Site Plan - 1:2000

Figure 117. Developed Design Site Section A - 1:1000

Figure 118. Site Render with Wetland Swale

Accessibility and Visibility

As this design research intends to be provocative and prompt discussions surrounding urban food production, it is important to be appealing both physically and visually to the wider community. Therefore the public community centre has been placed on the north-east corner of the site, close to the Basin Reserve and SH1, to attract the most attention from the largest volume of pedestrian and vehicle traffic. Food production is visible from most dominant viewpoints (see Figure 119. Prominent Viewshafts onto Site - 1:2000) to possibly prompt awareness. The common house is placed adjacent to the community centre to allow sharing of resources such as kitchen facilities and storage and to link the top floor food production areas. Residential areas are further from the State Highway due to noise concerns.

Views onto Site

0 12.5m 25m

● Pedestrian Views
■ Vehicle Views

Δ
N

Figure 119. Prominent Viewshafts onto Site - 1:2000

Figure 120. Site Circulation - 1:2000

Materiality

As discussed in the previous chapter, timber has been chosen as the primary building material. Structural elements must adequately resist vertical and lateral loads while responding to design needs of permeability and lightness in order to provide connection with the surrounding productive landscapes. Consequently timber portal frames are used in this design, with bolted connections to increase the ease of re-use at the end of this project's life span.

Following the Christchurch earthquake in 2011, there has been an abundance of used materials available on the market (Musgroves). Reducing the flow of resources is fundamental in sustainable development (Chick, Micklethwaite 252), hence reusing materials for new construction seems necessary, especially when there is an abundant local source. Therefore, the exterior decking and louvres are intended to be constructed from recycled hardwoods such as kwila or cedar which are abundant (Musgroves). Recycled timber windows could also be used for the green house shell to reduce the need for new material.

Double-glazed windows with well-insulated timber frames will be used to reduce thermal bridging of heat and consequently reduce energy use (International Passive House Association). New Zealand wool insulation could be used to reach passive house design standards for insulation within the 300mm wall cavity, as estimated from the Swiss Minergie standards (Minergie).

Residential

The residential typologies have been developed further from the initial design, where the increase in site population has meant including units on the ground floor as well as the first floor. This reduces the quantity of building materials needed by almost half as, unlike the initial design, a separate structure is not needed for each apartment (see “Figure 122. Programme Distribution” on page 126).

Structural portal frames allow for large glazed areas to let natural light into the apartments. Full-height glass doors on the northern façades connect residents visually and physically with food production areas on the balcony, and the close proximity and visibility of green space from the apartments could increase perceived mental health of residents (Mass et al, 587). The balconies, enclosed by opening recycled window panels and adjustable louvres (see “Figure 132. Louvre and Window Panel Opening” on page 136), provide ventilation into the building and private outdoor space sheltered from the prevailing northerly wind and sun glare. As discussed in the previous chapter, flexibility seems important with such a small floor plan, therefore the glass doors providing a permeable façade could allow the balcony to become an extension of the floor plan.

Figure 121. Site View from North on Tasman Street

Figure 122. Programme Distribution

*Residential - Ground Floor Plan
1 Bedroom Apartments*

0 2m 4m

1. Living Space
2. Sleeping / Office Space
3. Private Outdoor Space / Food Production Space
4. Kitchen
5. Bathroom
6. Outdoor Storage / Composting Space

△
N

Figure 124. Residential Ground Floor Plan (Callout Section) - 1:200

*Residential - First Floor Plan
2 Bedroom & 3 Bedroom Apartments*

0 2m 4m

1. Living Space
2. Sleeping / Office Space
3. Private Outdoor Space / Food Production Space
4. Kitchen
5. Bathroom
6. Storage
7. Communal Storage / Office Space

△
N

Figure 125. Residential First Floor Plan (Callout Section) - 1:200

Residential - Second Floor Plan
Interior Food Production

1. Food Production Space / Outdoor Space
2. Circulation

0 2m 4m

Figure 126. Residential Second Floor Plan (Callout Section) - 1:200

Residential
1 Bedroom Apartment

0 1m 2m

1. Living Space
2. Sleeping / Office Space
3. Private Outdoor Space / Food Production Space
4. Kitchen
5. Bathroom
6. Outdoor Storage / Composting Space

△
N

Figure 127. 1 Bedroom Apartment Floor Plan - 1:100 & Floor Plan Flexibility Diagrams - 1:200

Residential
2 Bedroom Apartment

1. Living Space
2. Sleeping / Office Space
3. Private Outdoor Space / Food Production Space
4. Kitchen
5. Bathroom
6. Storage
7. Communal Storage / Office Space
8. Conservatory / Food Production

Figure 128. 2 Bedroom Apartment Floor Plan - 1:100 & Floor Plan Flexibility Diagrams - 1:200

Figure 129. 3 Bedroom Apartment Floor Plan - 1:100 & Floor Plan Flexibility Diagrams - 1:200

Figure 130. Food Production Floor Plan - 1:100 & Floor Plan Flexibility Diagrams - 1:200

Figure 131. Residential Section - A (not to scale)

Figure 132. Louvre and Window Panel Opening

Figure 133. Residential Balcony Interior

Figure 134. Interconncted Residential Food Production Space Second Floor

Figure 136. Residential Water System - 1:150

Figure 135. Residential Natural Ventilation - 1:100

Natural Sunlight Penetration (Winter) N→

Natural Sunlight Penetration (Summer) N→

Figure 137. Residential Natural Light Penetration - 1:100

Common House

Similar to the residential typologies, the common house has been designed to provide views of and access to surrounding food production areas through permeable walls on the ground floor and opening window panels on the first and second floors. Food harvested from these landscapes can be stored and shared from this building. Food storage requires minimum dampness and constant temperature, hence placing this underground achieves both of these requirements naturally (Stojic, Stankovic 141).

Due to the small floor plan of the apartments, this building must accommodate services which can be communal such as shared laundry facilities, larger kitchen equipment, and communal food storage for the on-site produced food. Pooling together as a community to share resources may encourage major household items or electronic goods to be purchased which are more expensive but much more durable, lowering environmental impact by negating planned obsolescence of cheaper, lower quality products (Lawton 75).

Providing flexible, communal living spaces on the first and second floors allows for social interaction and gathering between residents in order to increase the social capital of the community as described in Chapter 5. The flexibility of interior furniture and food production, similar to the residential apartments, could allow the space to be used for meetings, general living, dining, entertainment or office activities, as agreed democratically by the residents.

Figure 138. Common House and Food Production Space

Common House
Underground Floor Plan

0 2m 4m

- 1. Food Storage
- 2. Laundry / Storage / Multi-Use Space
- 3. Circulation

△
N

Figure 139. Common House Underground - 1:200

*Common House
Ground Floor Plan*

0 2m 4m

1. Communal Kitchen Space
2. Outdoor Space
3. Circulation
4. Compost & Tool Area

Δ
N

Figure 140. Common House Ground Floor Plan - 1:200

Figure 141. Common House First Floor Plan - 1:200

Figure 142. Common House Second Floor Plan - 1:200

Figure 143. Common House Section A - 1:100

Entertainment

1. Cinema Set Up
2. Art / Music Space

Dining / Meeting

1. Dining Space
2. Meeting Space

Figure 144. Common House Programme Flexibility Diagrams - First Floor - 1:150

Open Plan Space
Flexible Multi-Use Spaces

Office Space
Secluded Working Spaces

Figure 145. Common House Programme Flexibility Diagrams - Second Floor - 1:150

Figure 146. Common House Ground Floor

Figure 147. Common House First Floor

Community Centre

Similar to residential typologies and the common house, permeable enclosure of the community centre is necessary in order to firstly provide views and access to exterior food production and secondly to invite the public into the building. The atrium space, with openable recycled window panels, aims to visually attract the public into the crush/gathering space through visual and physical connections. An accessible ramp provides entry to the atrium, community hall and adjoining amenities, and food production space on the first floor is accessed via stairs and an elevator. This is to ensure the integration of the entire community. Connection to the common house allows possibilities for the sharing of utilities such as kitchens and storage.

Compost facilities in close proximity to the common house and community centre could present opportunities to utilise the heat energy produced as part of a heating system, as compost decomposes between 50-70 degrees Celsius (Brown, Rosen). This, however, needs further study and development.

Figure 148. Site View from Sussex Street

*Community Centre
First Floor Plan*

0 2m 4m

1. Community Event Space / Food Production Space
2. CirculationCommunity Hall
3. Bathrooms
4. Storage
5. Deck

Figure 149. Community Centre Ground Floor Plan - 1:200

*Community Centre
First Floor Plan*

0 2m 4m

1. Community Event Space / Food Production Space
2. Circulation
3. Elevator
4. Atrium / Exhibition & Performance Space

Figure 150. Community Centre First Floor Plan - 1:200

Figure 151. Community Centre Section A - 1:100

Community Centre
Façade Permeability

0 2m 4m

←---→ Permeability

△
N

Figure 152. Diagram of Façade Permeability - 1:200

*Community Centre
Connection*

■ Kindergarten	■ Wellington Boys
■ Mt Cook School	■ Wellington Girls
■ Wellington High School	■ St Mark's School
□ Site	■ Massey University

△
N

Figure 153. Community Centre Connection - 1:5000

Figure 154. View from SH1 / Basin Reserve

Figure 155. Community Centre Ground Floor

Figure 156. Community Centre First Floor

Food Production

Food production areas could utilise companion planting (planting plants in close proximity which are known to aid and benefit one another (Flowerdue 10)) similar to models of organoponicos in Cuba where plants such as marigolds, basil, onions and garlic are planted around the perimeter of raised beds in order to naturally repel pests (Ellinger,15). Inter-cropping (or polyculture) and crop rotation provides protection against weather disasters and mono-culture disease, as well as fostering workers' expertise and skills (Ellinger 16). This increase in education could potentially lead to the employment of full-time resident gardeners in order to reduce the workloads of the remaining residents, if collectively decided upon.

Figure 157. Food Production Space

Water System

Using untreated greywater for irrigation can result in increased concentrations of metals (Rodda, et al 1051) and harmful pathogens within food crops and soil content which, over time, can lead to human health concerns (World Health Organisation 36,37). Simple treatment techniques such as constructed wetlands may result in World Health Organisation health-based target-meeting pathogen reduction (World Health Organisation 93), however this requires prior solid/liquid separation (World Health Organisation 94). Therefore it is suggested that a grey water filtration system such as an Aqua2Use system (see appendix for specifications) be used to initially treat the water to ensure safe water quality as well as to separate liquids and solids. This will also result in less maintenance for the constructed wetland due to reduced particles of fat and oils throughout (World Health Organisation 94). Black water could be treated initially though a gravity fed system such as a BioRock treatment system (see appendix for specifications), however further research is necessary.

Filtered grey water, black water and storm water will be further filtered through a surface flow constructed wetland within the swale with water levels between 0-0.4m (Tanner, et al 9) and a slope of 0-1%, to achieve the required flow rate (Sundaravadivel, Vigneswaran 373). Sedimentation forebays where greywater is released from residential housing inlets will slow runoff to allow sediment to settle (Auckland Council 3) (see “Figure 159. Water System Section A - 1:500” on page 177 and “Figure 160. Water System Section B - 1:500” on page 178). Key native plants such as jointed twig rush, kuta, kapungawha and raupo should be used (Tanner, et al 9), as well as supplementary species such as kukuraho, toetoe, ti kouka, karaerea and harakeke in shallower water (between 0-0.3m) (Tanner, Champion, Kloosterman 17-18). Filtered storm water will

be stored after filtration to be used for irrigation on site or by neighbouring sites. Excess could feed into mains storm water drainage or the Waitangi stream beneath the ground under the Basin Reserve and Cambridge Terrace (NZ Transport Agency 51).

Wetlands are vastly supportive of biodiversity and are one of the most nationally threatened ecosystem types in New Zealand. They support a disproportionately high number of threatened animal and plant species (Clarkson, et al 196), thus providing important natural habitats as well as water cleansing functions.

Water System

0 12.5m 25m

- ←····· Filtered Greywater and Blackwater Discharge
- ←····· Irrigation Systems
- Wetland Systems
- [---] Water Storage Tank and Pump line to Top Food
- Production Level

Δ
N

Figure 158. Water System Plan - 1:2000

*Constructed Wetland Section
within Swale*

1. Sedimentation Forebays (discharge from residential)
2. Surface Flow Constructed Wetland

Figure 159. Water System Section A - 1:500

*Constructed Wetland Section
within Swale*

1. Sedimentation Forebays (discharge from residential)
2. Surface Flow Constructed Wetland

Figure 160. Water System Section B - 1:500

Water System Figures

With data from the Natural Resources Management and Environment Department of the Food and Agriculture Organisation of the United Nations, an indicative figure has been calculated as a guide to irrigation quantity necessary on site. A required irrigation quantity of 480l per m² per growing season (or per year) has been deduced from data from onions, carrots, beans, cabbage, potatoes and tomatoes (Food and Agriculture Organisation of the United Nations, Natural Resources Management).

Onion:	425mm
Pea:	425mm
Bean:	400mm
Cabbage:	425mm
Potato:	600mm
Tomato:	600mm

$$425 + 425 + 400 + 425 + 600 + 600 = 2875\text{mm}$$
$$2875\text{l} / 6 = 479.2\text{mm}$$

Water needed for garden irrigation:
480l/m² per year.

Stormwater:

Average Wellington rainfall per month:
106.25 litres per square metre (l/m²) (see climate analysis)
106.25l x 12 months = **1,275l/m² per year.**

Greywater: and Blackwater:

Average Wellington water consumption:
250l per person per day. Assuming that these figures do not take in low flow taps etc, laundry water usage is removed and residents may be slightly more conscious about saving water, the average has been assumed to be 200l per day maximum (Greater Wellington Regional Council).

200l of water per day, 60% greywater, 40% blackwater (Greater Wellington Regional Council).

200l x 60% = 120l of greywater produced per person per day (excluding laundry).
120l x 365 days = **43,800l per year.**

200l x 40% = 80l of blackwater produced per person per day.
80l x 365 days = **29,200l per year.**

Residential Apartments:

Residential House Roof Dimensions:
6m x 8m = 48m²

Stormwater collected per roof:
1,275l/m² x 48m² = 61,200l per year.

Irrigation quantity needed by top floor food production per year:
48m² x 480l/m² = 23,040l per year.

Water not used for irrigation of top floor food production to be discharged into swale:
61,200l - 23,040l = 38,160l per year per residential building.

Stormwater discharged into swale for filtration:
20 buildings:
38,160l x 20 buildings = **763,200l per year.**

Greywater (excluding laundry) discharged into swale for filtration:
65 people x 43,800l per year = **2,847,000l per year.**

Blackwater discharged into swale for filtration:
65 people x 29,200l per year = **1,898,000l per year.**

Total water discharged into swale from Residential:
 $763,200\text{l} + 2,847,000\text{l} + 1,898,000\text{l} =$
5,508,200l per year.

Total water discharged into swale from common house and community centre:
 $876,000\text{l} + 202,800\text{l} + 584,000\text{l} =$ **1,662,800l per year.**

Common House and Community Centre:

Whole Site Total:

Common House and Community Centre roof area:
 80m^2 (Common House) + 100m^2 (Community Centre) = 180m^2

Residential:
5,508,200l per year.
 Common House and Community Centre:
1,662,800l per year.

Stormwater collected per year:
 $1,275\text{l}/\text{m}^2 \times 180\text{m}^2 = 229,500\text{l}$ per year.

Total: $5,508,200\text{l} + 1,662,800\text{l} =$
7,171,000l per year.

Irrigation quantity needed by top floor food production per year:
 $180\text{m}^2 \times 480\text{l}/\text{m}^2 = 86,400\text{l}$ per year.

Irrigation Figures:

Stormwater discharged into swale for filtration:
 $229,500\text{l} - 86,400\text{l} =$ **143,100l per year.**

As 600m^2 of food production area is inside and already being watered, only 4700m^2 out of 5300m^2 of food production space need irrigation.

Assuming the equivalent quantity of greywater and blackwater is produced in total in the common house and community centre as 20 people use per day in their homes (Convivenza Cohousing).

Therefore:

$4,700\text{m}^2 \times 480\text{l}/\text{m}^2 =$ **2,256,000l per growing season (annual).**

Greywater (excluding laundry):
 $20 \text{ people} \times 43,800\text{l} =$ **876,000l per year.**

Irrigation needed: **2,256,000l per year**

Greywater (laundry):
 Assuming 65 people do washing once a week, 60l per wash (Miele):
 $65 \times 60\text{l} = 3,900\text{l}$ per week
 $3,900\text{l} \times 52 \text{ weeks} =$ **202,800l per year.**

Wetland water filtration: **7,171,100l per year**

Blackwater:
 $20 \text{ people} \times 29,200\text{l} =$ **584,000l per year.**

The estimated total water cleaned by the wetland water system is much greater than the estimated required irrigation quantity calculated, therefore using this water for irrigation could be seen as feasible, considering that there will also be added rainfall to the exterior food production areas.

Figure 161. Water System Calculation Table

Figure 162. Wetland Swale, Common House & Composting Area

Waste

The average New Zealander produces approximately 64kg of food waste and 51kg of green waste per year (Waste Not Consulting 2). Therefore, assuming that similar amounts of compostable waste would be produced on site, then 7.475 tonnes could be composted on site per year.

$64\text{kg} + 51\text{kg} = 115\text{kg}$ per person per year.
 $115\text{kg} \times 65 \text{ people} = 7,475 \text{ kg}$ per year.

It is suggested a 5cm cover of compost is needed for soil replenishment per year (US Composting Council), therefore a volume of 265 cubic metres could be needed per year.

$$0.05\text{m} \times 5300\text{m}^2 = 265\text{m}^3$$

The proximity to food production on site could alleviate the need for un-recyclable packaging, which would lead to a reduction in general unrecyclable household waste, thus nearing a zero-waste system.

Compost

Compost Distribution
Composting Areas and Tool Storage

Summary

This developed design proposes that by using the suggested agricultural methods and systems, approximately 25% of residents' food could be grown on site while maintaining a similar population density to the surrounding suburb. It is recognised however, that this is dependent on weather conditions and the knowledge of the residents or gardeners. Even if this quantitative amount is not reached, it is believed that this environment would still benefit the residents, the surrounding community, the environment and biodiversity in a multitude of other ways as discussed. Therefore, through this example, this research argues that the combination of urban agriculture and architecture in an urban environment can provide many social, and environmental benefits.

Figure 164. Beans

8. Conclusion

Conclusion

The intention of this design-led research thesis was to re-configure the relationship between urbanism and agriculture in Wellington in order to create a local food system benefitting urban residents, the environment and biodiversity. Cross-programming residential housing and community involvement with a local system of urban agriculture as seen in the developed design could reconnect urban-dwellers with food systems, stimulating an alternative way of thinking and living. It can be seen through the developed design, explained and discussed in the previous chapter, that:

Social benefits include:

- a probable increase of knowledge and skills surrounding food production, establishing that food is not a homogenous supply.
- a likely strengthening of social capital through an enriching of community, created by increased interaction, connectivity, communication, participation, trust and honesty.
- a potential increase in physical health due to access to nutritious food, and increased mental health due to proximity to natural, green space.

Environmental benefits include:

- a potential reduction of the demand for environmentally degrading, industrialised agricultural methods, possibly leading to a reduction in water depletion and pollution, erosion and soil contamination, and a reduction in the decline of arable land and deforestation.
- a possible increase in biodiversity due to the elimination of harmful herbicides and pesticides and an increase in natural animal and plant habitats, if the suggested production methods are used.
- a foreseeable increase in resistance to disease and weather disasters through polycultural systems and plant diversity, resulting in increased sustainability.
- a conceivable fostering of social responsibility and stewardship of local land.

Throughout this research, it became apparent that a local food system could also create unquantifiable economic benefits as outlined below:

Economic benefits include:

- a foreseeable reduction of the dependence on global food and agriculture corporations (Big Food) through decentralisation and localisation of food production systems, resulting in increased food security.
- a likely increased economic vitality of the community through knowledge and skills gained surrounding food production.

It is acknowledged that architecture alone cannot provide these benefits as they are only achievable with willing community engagement and a sense of ownership, resulting in residents and community members being able to witness these benefits themselves. The use of architecture as a tool to allow residents and wider community members alike to interact with food production on a range of scales will perhaps provide them with a more profound relationship and understanding of less unsustainable food production systems and their benefits. Providing food production spaces on private balconies might prompt residents into closer individual relationships with food production, whereas productive landscapes of polyculture and permaculture surrounding their apartments may produce more cooperative and communal relationships. Providing wider community members with visual access to the on-site food production systems and allowing hands-on engagement through the community centre would provide them with different levels of engagement, possibly leading to further understanding and a possibility of personal application of similar food production systems.

The systems proposed will need time to become established and effective. Systems will need to be tested over time, using a similar testing

process to that of organoponicos in Cuba, to find the most productive for this particular site. Therefore resilience and cooperation of the community will again be particularly important in the early stages of this project.

In the initial stages of this thesis it was intended to produce 50% of the residents' food supply on site. Space restrictions of the chosen urban site were discovered to be a limitation causing this to be unachievable due to the lack of adequate growing land area.

It is recognised that for a local food system to be truly effective in reducing the detrimental impact of industrialised food production systems, it must be implemented on a broader scale than that of this project, incorporating not only personal and neighbourhood gardens, but also peri-urban and regional agriculture. Therefore further investigation into a broad local food system in the Wellington region is necessary, exploring architecture's role in both the physical production of food and in increasing the overarching engagement and connection of people, environment and biodiversity in the region.

The local food system must also be discussed and explored in conjunction with urbanisation and continued population density increase. It is necessary to consider that with continual population increase and minimal land area available for future development in Wellington, central suburbs will possibly have to address an increase in population density in the near future. This is necessary in order to support ideas of new urbanism and accessibility, reduction of urban sprawl and provision of affordable housing. The proposed design could be adapted to a smaller urban site and could still provide many of the beneficial aspects, especially the social benefits, however possibly not to the same extent. Perhaps it is not possible to achieve a local food system solely

through a myriad of individual small-scale projects similar to this thesis design project, but instead could be achieved by integrating similar projects with wider holistic schemes derived by governmental and regulatory bodies locally, nationally and globally.

Wellington is not the only city affected by the issues created by global food systems. Applying local food systems similar to ones explained in this thesis could be beneficial to societies, environments and biodiversities of cities nationally and internationally. The methodology discussed in this thesis could be replicated in a similar way, however, it will only be successful in producing a positive design outcome by acknowledging and including the specific needs, considerations, limitations and social fabric of each specific site and framing these within the overlaid information.

It seems imperative for ideas of food production and its effects on society, the environment and biodiversity to be thoroughly considered and integrated alongside the urbanisation of our cities, not only in Wellington but worldwide. The facilitative role of architecture in this is crucial.

Figure 165. Sunflowers

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Appendix

1. Selected Material Costing

	Type	Material Type	Size Available
Exterior Cladding	1 Shiplap RAD H3.2 Pre Primed Weatherboard	Recycled Timber (Mix)	150 x 25mm
	2 Knotty Cedar Weatherboard Cladding - Bunnings	Western Red Cedar	220 x 19mm
	3 BBS Timbers P67: Rusticated Weatherboard	Western Red Cedar	190 x 19mm
	4 Sawmill Direct Weatherboard	NZ Cedar	140 x 90 x <5400mm
	5 Sawmill Direct Weatherboard	Lawson Cypress	140 x 90 x <5400mm
	6 Timberspec P67 Rustic Weatherboard	Radiata Pine	140 x 19mm
	7 Adobo Vulcan+ Cladding	Radiata Pine	140 x 20 x 4800mm
	8 Plytech Pinetech Plywood Cladding - Shiplapped	Radiata Pine (Plywood)	2440 x 1200 x 12mm
Interior Lining	9 GIB Standard Plasterboard	Plasterboard	2400 x 1200 x 10mm
	10 Superfine Particle Board	NZ Timber	2440 x 1220 x 12mm
	11 Non - Structural Untreated Plywood	Radiata Pine (Plywood)	2400 x 1200 x 12mm
	12 Untreated Construction Plywood	Radiata Pine (Plywood)	2400 x 1200 x 12mm
	13 Untreated Plywood	Radiata Pine (Plywood)	2400 x 1200 x 9mm
	14 Poplar Decor - Birch Plywood	Poplar with Birch Veneer	2440 x 1200 x 12mm

Treatment	Finish	Positives	Negatives	Price /lm	Price / m ²
[H3.2	[None	Recycled Material	Regular maintenance	\$8.00 / lm	\$53.33
[None	[1 coat stain	No treatment . FSC Certified	Regular maintenance	\$5.90 / lm	\$16.76
[None	[None	No treatment or coating needed. FSC Certified	Regular maintenance	\$16.76 / lm	\$88.16
[None	[None	Local Material	Regular maintenance	\$7.50 / lm	\$53.57
[None	[None	No treatment or coating needed. FSC Certified	Regular maintenance	\$7.50 / lm	\$53.57
[H3.2 (CCA)	[Paint, Varnish	No treatment or coating needed. FSC Certified	CCA treated, difficult to dispose of safely	\$7.60 / lm	\$54.29
[Thermally Modified	[Oiled	No treatment or coating needed. FSC Certified	Requires maintenance every 12 months	\$12.95 / lm	\$92.50
[H3 LOSP	[Paint, Varnish	Cheap, no arsenate treatment.	LOSP Treated, difficult to dispose of safely	\$142.20 / sheet	\$48.57
[-	[Paint	Cheap		\$25.80 / sheet	\$8.96
[None	[1 coat stain	Utilises offcut timber	Formaldehyde glue used	\$59.49 / sheet	\$20.81
[Untreated	[Vanish, Oil	Super E0 Low Formaldehyde emissions	Must be finished / varnished	\$36.20 / sheet	\$12.57
[Thermally Modified	[Oiled	Structural	Must be finished / varnished	\$49.00 / sheet	\$17.02
[H3 LOSP	[None	Untreated	Must be finished / varnished	\$37.00/ sheet	\$12.85
[H3 LOSP	[Natural Oil	Finished	Expensive	\$115 / sheet	\$34.27

Material	Type	Timber Species	Size Available
Interior Flooring	15 Gerflor Senso Essential Merek Clair Sheet Vinyl	Vinyl	300 x 2000 x 1000mm
	16 Toryls Tier 7 Natural Birch Laminate	Laminated Timber	190 x 7 x 1200mm
	17 Torlys Smart Floor Classic Premier Cork	Cork (Oak)	300 x 10 x 910mm
	18 Quick Step ARC Bamboo Flooring	Bamboo	137 x 14 x 1850mm
	19 White Pine T&G	White Pine	85 x 18mm
	20 Recycled Rimu Flooring T&G	Rimu	85 x 20mm
	21 Recycled NZ Kauri Flooring T&G	Kauri	85 x 20mm
	22 PLYfloor	Radiata Pine (Plywood)	2400 x 1200 x 19mm
Exterior Decking	23 Vitex Decking Timber	Vitex (Solomon Islands)	140 x 19mm
	24 Garapa Decking Timber	Garapa (Peru)	140 x 19mm
	25 Macrocarpa Decking Timber	Macrocarpa	140 x 35mm
	26 Ekologix Composite Decking	Bamboo, Reclaimed Timber, High Density Polyethelene	137 x 23 x 5400mm
	27 Recycled Kwila Decking	Kwila	90 x 20mm
	28 Kwila Decking	Kwila	90 x 19mm
	29 NatureDeck Pine Decking	Radiata Pine	140 x 32mm
	30 Merchant Grade Pine Decking	Radiata Pine	90 x 35mm

Treatment	Finish	Positives	Negatives	Price /lm	Price / m ²
None	None	No treatment or coating needed.	PVC content contributes to high VOC emission	\$29.98 / lm	\$49.96
None	None	No treatment or coating needed. FSC Certified	Not structural, needs underlay (\$18)	\$49 / lm	\$257.89
None	None	Naturally hypo-allergenic and insect resistant	Not structural, needs underlay	\$117 / lm	\$390
None	None	Naturally hypo-allergenic and insect resistant	Floating floor, not with underfloor heating	\$-	\$100
None	None	Naturally hypo-allergenic and insect resistant	Floating floor, not with underfloor heating	\$7.00	\$82.35
H3.2 (CCA)	Paint, Varnish	No treatment or coating needed. FSC Certified	Not structural, needs underlay	\$8 / lm	\$96
Thermally Modified	Oiled	No treatment or coating needed. FSC Certified	Requires maintenance every 12 months	\$10 / lm	\$120
H3.2	-	Handles underfloor heating, is structural	Needs finishing	\$153.93 / sheet	\$53.45

None	None	Hardwood, no treatment needed	Expensive fixings required	\$11.50 / lm	-
None	None	Hardwood, no treatment	Expensive fixings required	\$12.77 / lm	-
None	1 coat stain	No treatment or coating needed	Expensive fixings required	\$8.60 / lm	-
None	None	No treatment needed	Composite material with glue	\$13.50 / lm	-
None	Paint, Varnish	No treatment or coating needed. FSC Certified	CCA treated, difficult to dispose of safely	\$4.00 / lm	-
None	Oiled	No treatment or coating needed. FSC Certified	Requires maintenance every 12 months	\$6.50 / lm	-
ACQ	None	Local	LOSP Treated, difficult to dispose of safely	\$8.50 / lm	-
CCA	None	Local	LOSP Treated, difficult to dispose of safely	\$3.00 / lm	-

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2. Aqua2use Greywater Filtration System

Aqua2use®
"The Answer for Greywater Reuse"

Aqua2use® Greywater Diversion Device

Features and Benefits

- State of art progressive filtration
- High volume of Matala® filter media
Aqua2use®GWDD: 30 litres (8 gallons) or
Aqua2use®UG GWDD: 60 litres (16 gallons)
- Cross-flow depth filtration: Each filter web has a 3-dimensional structure, able to trap a high volume of impurities without clogging.
- Multichamber plug flow concept: If the first filter web gets clogged, the filtration is done by the second and third filter webs. If the second filter web gets clogged, the filtration is done by the third filter web.
- Submersible pump with integrated Electronic Pump Controller (EPC).
- Durability: The pump is protected from dry run, clogging and other damage.
- Built-in overflow safety.
- Easy to clean.
- Flexible installation: Systems can be installed above ground, half-submerged in the ground, or underground.
- WaterMark approved.

http://aqua2use.com/upload_files/pdf/Aqua2use_Greywater_Diversion_Devices.pdf

MATALA® PROGRESSIVE FILTRATION TECHNOLOGY APPLIED IN GREYWATER DIVERter

The pictures attest to the high filtration efficiency achieved with the progressive density Matala® filter pads. The filter can hold a huge volume of hair, lint, sand, soap residue, and other particles.

Unit tested in a caravan park, Australia: Matala® Greywater Diverter checked after filtering 40,000L (10,810 gallons) of incoming greywater. This system was used with the public shower rooms and laundry facilities.

This is how Aqua2use® Greywater Diverter works:

Step 1: When the diverting valve's arrow points away from the Matala® filter, greywater flows directly to the main sewage.

Step 2: When the diverting valve's arrow points towards the Matala® filter, greywater from the house is diverted to the inlet of the filter.

Step 3: The greywater flows through the first Matala® progressive filtration chamber (ch. 1), where major and medium particles (such as hair, lint, paper, detergent, and other impurities) are retained. Matala® black (low density) and Matala® green (medium density) filter pads are used.

Step 4: The greywater flows through the second Matala® progressive filtration chamber (ch. 2), where medium and small particles are retained. Matala® green (medium density) and Matala® blue (high density) filter pads are used.

Step 5: The greywater flows through the third Matala® progressive filtration chamber (ch. 3), where small and minor particles are retained. Matala® blue (high density) and Matala® grey (super high density) filter pads are used.

Step 6: Filtered greywater is pumped to the irrigation system.

Aqua2use® Greywater Diverter

A simple and easy way to keep your garden green all year round.

Aqua2use® GWDD

Dimensions: 59(L) x 37(W) x 51(H) cm
23(L) x 15(W) x 20(H) inches

Aqua2use® UG GWDD

Dimensions: 80(L) x 60(W) x 66(H) cm
32(L) x 24(W) x 26(H) inches

Aqua2use®

"The Answer for Greywater Reuse"

Matala Water Technology Co., Ltd. 121 Tzu Li 2St., Wu Chi Town, Taichung 435, Taiwan

Phone: +886(0)42630 4015 Fax: +886(0)42630 4067 www.aqua2use.com info@agua2use.com

DISTRIBUTED BY

Aqua2use GWDD Dimensions :

				Unless Otherwise Specified Fillet : R2 Parting Angle : 1° Chamfer : C1 Free Burrs Angular : ±0.5°	<div>δ (standard dev.)</div> <div>< 0.5 ~ 6 ±0.10 ±0.30</div> <div>< 6 ~ 30 ±0.20 ±0.50</div> <div>< 30 ~ 120 ±0.30 ±0.70</div> <div>< 120 ~ 315 ±0.50 ±1.20</div> <div>< 315 ~ 1000 ±0.80 ±2.00</div> <div><1000 ~ 2000 ±1.20 ±2.50</div>				UNITS	MM	MATERIAL	ITEM	<div>Aqua2use</div> <div>"The Answer for Greywater Reuse"</div>	
				<div>Matala®</div> <div><small>Matala Water Technology Co., Ltd.</small></div>		APPROV	Marc	SCALE		FINISH				
						CHKD	Mike	DATE	990208	H.R.C		PART. NO.	Aqua2use GWDD	
NO.	DESCRIPTION	APPR	DATE				DRAWN	Kimi	FIRST USED ON			SERIAL NO.	EDITOR	1.0

3. Biorock Blackwater Treatment System

BIOROCK®
Sewage Treatment

- **Non-Electric**
- **Low running costs**
- **Completely silent**
- **Odourless**
- **Small footprint**

BIOROCK
sewage water treatment

http://www.biorock.co.nz/public/_files/file/brochures/en/Brochure%20ECOROCK%20professionals%20EN.pdf

BIOROCK®

Non-Electric Sewage Treatment Plants for domestic waste water

BIOROCK was established in 1988 and is now an internationally acclaimed and experienced company and industry leading in compact wastewater treatment technology. BIOROCK systems have already been installed worldwide in the past 25 years. Our proven performance leads to trust of both the users of our technology and our supplier's network, which is the basis of our success.

Most suitable for sloped sites discharging direct to a watercourse* or drainage field.

The BIOROCK® Non-Electric treatment process

Initially the raw sewage (A) enters a primary tank (PT, B) to provide separation and the breakdown of organic solids (Primary Treatment). The sewage then passes through an effluent filter before discharging into the BIOROCK® unit which incorporates the well proven aerobic digestion process (Secondary Treatment) and filtration process (Tertiary Treatment).

BIOROCK uses a material with huge surface area which allows colonization of the necessary bacteria, a process which is essential for the effective treatment of domestic wastewater.

The BIOROCK media is highly resistant to degradation and remains extremely stable over the long term - our 25 years' experience in the industry being proof of this.

- Very Stable Inorganic material - does not break down over time, unlike "organic" media
- Requires little maintenance – scraping and scarification is not necessary, unlike for organic media
- The Structure and Composition ensures unsurpassed and unique surface treatment with exceptional purification results
- Ecological material, locally produced and recyclable

BIOROCK offers a much more efficient and ecological wastewater treatment technique compared to traditional techniques that are very high in maintenance and energy consumption.

BIOROCK offers 2 discharge options :

1. BIOROCK gravity discharge
2. BIOROCK high-level discharge

Our high level discharge system is equipped with a reliable, high-quality pump kit. This kit is delivered "pre-assembled" for ease and speed of installation.

Most suitable for level sites discharging direct to a watercourse*, drainage field or raised bed.

*subject to local or national regulations.

Installation for all type of ground conditions and applications.

- High ground-water sites.
- Reinforced and durable, the BIOROCK units and Primary tanks are reinforced as standard enabling them to be structurally sound in all ground conditions.
- The BIOROCK System has the ability to handle inter mittent (seasonal) wastewater loadings, even during long absence periods
- Holiday Homes, Campsites, Caravan Parks, etc.
- The system can also handle low utilization levels without compromising the treated effluent quality.

Unique advantages

BIOROCK provides a revolutionary, efficient and reliable compact wastewater treatment solution. Very compact, our systems are free from any blower or air diffusers. They don't need any electricity for the treatment process, leading to minimal maintenance and repair costs, the lowest operational costs and the longest desludge intervals.

These unique advantages lead to significant costs savings for the user compared to conventional wastewater treatment plants, as the reliability of the system is maximized with no possible breakdowns thus no need for expensive spare parts. The superb purification results produced by BIOROCK have placed our systems in a leading position when compared with older & traditional wastewater treatment techniques.

Revolutionary technology

- ✓ Septic tank replacement / upgrade
- ✓ Non-Electric sewage treatment process
- ✓ 24 Hour start-up period
- ✓ Long absence periods acceptable

Unique advantages

- ✓ Completely silent
- ✓ Low operational costs
- ✓ Very light maintenance
- ✓ Long desludge interval

Sustainability

- ✓ Superb effluent quality
- ✓ Low carbon footprint
- ✓ Ecological material, locally produced and recyclable

The BIOROCK® systems are delivered 'complete' and pre-assembled for ease of installation.

FACTS

TRADITIONAL VERSUS BIOROCK	Traditional units	BIOROCK
Non-Electric purification process	NO	YES
Silent & Odourless	NO	YES
Handles Intermittent Loading	NO	YES
Handles absence periods	NO	YES
Handles most household cleaners	NO	YES
Handles power failure	NO	YES
Septic tank conversion unit*	NO	YES
Intensive maintenance	YES	NO
High sludge production	YES	NO
High operational costs	YES	NO

http://www.biorock.co.nz/public/_files/file/brochures/en/Brochure%20ECOROCK%20professionals%20EN.pdf

The BIOROCK® range of sewage treatment plants

ECOROCK-1500

ECOROCK-2000

ECOROCK-3000

ECOROCK-5000

	ECOROCK-1500	ECOROCK-2000	ECOROCK-3000	ECOROCK-5000
Capacity in P.E.	4/6 p.e.*	10 p.e.*	15 p.e.*	30 p.e.*
Capacity in litres/day	600/900	1500	2250	3750
Material	HDPE	HDPE	HDPE	HDPE
Length	1150 mm	1450 mm	2150 mm	3550 mm
Width	1150 mm	1150 mm	1150 mm	1150 mm
Height unit (max.)	2100 mm	2100 mm	2100 mm	2175 mm
Weight (empty)	186 kg	223 kg	297 kg	625 kg
Δ in- & outlet pipe	1098 mm	1098 mm	1098 mm	1213 mm

Purification results BIOROCK®

Tested conform EU Norm EN 12566-3 + A2		
BOD ₅	4 mg/l	99%
COD ₅	26 mg/l	96%
S.S.	3 mg/l	99%

More results are available upon request

*The capacity of the individual ECOROCK-5000 unit can be increased if the required effluent quality is of a lower standard than the results, achieved during the EN-12566-3 Performance test. "

Options BIOROCK

Extension set ø 700 x 1200 mm

Extension set ø 400 mm

Mechanical fan ø 110 mm

Extension set ø 700 mm

Effluent filter for primary tank

Clips for above ground installations

Sampling pipe ø 160 mm

Pumping well ø 400 mm

Our support

- A brand with strong values
- Access to licensed products
- Daily support by our team of professionals
- Excellent hands-on trainings
- Warranty: 25 years on tanks / 10 years on BIOROCK media*

*subject to conditions, contact us for details

To become a trained and approved
BIOROCK certified professional
and be part of our network:
Please contact us today:

BIOROCK
sewage water treatment

BIOROCK S.à.r.l. | Z.A.E. Robert Steichen | 5, rue Bommel
L-4940 Hautcharage | Luxembourg | www.biorock.com

http://www.biorock.co.nz/public/_files/file/brochures/en/Brochure%20ECOROCK%20professionals%20EN.pdf

ECOROCK-5000 Treatment Unit Tank volume 5000 L

1	Water inlet
2	Water outlet
3	Air inlet
4	Air outlet
5	Overflow Alarm

Characteristics	Value	Unit
ECOROCK-5000 Treatment Unit		
Minimum volume pre-treatment*	500	liters/PE
Capacity in population equivalent	22	PE
Daily volume of wastewater **	200	litres/day/PE
Daily hydraulic load	4.4	m ³ /day
Organic load per PE	60	gr.BODs/PE/jour
Organic load raw influent up to	1.32	kg BODs/day
Specification	Value	Unit
Tank volume	5000	Liters
Overall length	3500	mm
Overall width	1150	mm
Total height of the tank	2175	mm
Overall height (+ventilation pipe)	2350	mm
Total weight (without water)	680	Kg
Pipe diameter	110	mm

This treatment unit can be installed in high ground water table.

*minimum 2000 liters of pre-treatment
** Tested to conform to AS/NZS 1547:2012

Service :				 ECOROCK-5000			
ORIGINATOR		NAME				SIGNATURE	DATE
AUTHOR		NAME				SIGNATURE	DATE
APPROV.		NAME				SIGNATURE	DATE
CHANGES				TITLE:			
AUTHOR				Nb. of PLAN			
APPROV.				UT-X5000			
Overall tolerance : 3%				SCALE:1:22			