Community resilience and urban core shelter implementation:

A Wellington case study

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Abstract

As a result of climate change, extreme weather events are becoming more common around the world. Coupled with the ever-present threat of sea level rise that coastal cities face there is a potential for far more severe weather events to occur. This thesis will seek to understand how an existing city can adapt to a more hostile environment, and how in the event of an extreme weather occurrence it maintains its function. There is an urgent need to understand how a city can respond when faced with these situations. Previous extreme weather events, Katrina, the Indian Ocean tsunami, and extreme flooding around the world, highlight the danger of a lack of preparedness and resilience found in most cities.

The purpose of this thesis is to understand how the concept of a core shelter, as a way to address the threats of extreme weather events, can be applied to a well-established urban context, Wellington NZ. A core shelter is a structure that in the event of a large-scale disaster, protects its users, and post-disaster still reaches permanent housing standards without being deemed to be a permanent dwelling. It will also look at whether it is possible to create areas in an existing city that can be considered "safe havens" in the event of an extreme natural incident.

This thesis outlines the need for these shelters by identifying the potential threats of climate change in a Wellington context, and by understanding the vulnerability of Wellington's current building stock. It reaches a conclusion that through the implementation of core shelters in Wellington NZ, resilience will be improved, disaster response efforts will be aided, and destruction arising from extreme weather events will be reduced. In addition, it identifies the areas of Wellington that are deemed to be of higher risk in a disaster or extreme weather event, analyses an existing building's potential to become a community resilience/core shelter, and proposes a custom building that could be built on Leeds St and Ghuznee St.

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Terminology

WCC -- Wellington City Council

CCA -- Climate Change Adaptation

DRR -- Disaster Risk Reduction

IFRC -- International Federation of Red Cross and Red
Crescent Societies

UNISDR -- United Nations International Strategy for
Disaster Reduction

USJF -- United States Justice Foundation

UKCIP -- UK Climate Impacts Programme

UN -- United Nations

INTRODUCTION

There's one issue that will define the contours of this century more dramatically than any other, and that is the urgent and growing threat of a changing climate.

Barack Obama, September 23rd, 2014

This thesis seeks to analyse community resilience in Wellington, the capital city of New Zealand, and propose a series of solutions that will increase the disaster resilience of an urban area. It proposes that disaster resilience can be increased by the construction of purpose-built community shelters that allow displaced sections of society to be housed safely, and to build back better from. There is a strong focus not only on the post-disaster functions of the building but also on architecture's ability to add to a community pre-disaster, increasing community resilience through the active strengthening of community networks. It is naive to understand disaster resilience only after an event has taken place, and as such more research should be undertaken so that policy makers and government officials can plan to strengthen existing urban centres. This thesis proposes a way to address the issues surrounding community resilience but should be only viewed as a starting point.

This thesis has been undertaken for a variety of reasons. As demonstrated in Fischer and Knutti (2015), McBean (2004) and Solomon, et al. (2007) the number of extreme weather events around the world is rapidly increasing as a direct result of anthropogenic climate change. Heatwaves, windstorms and intense precipitations are a direct result of climate change and our effects on the environment. They pose a very real and serious threat to our cities and built environment. In addition, the recent Kaikoura earthquake has driven home the risk that is faced by living in a country that has a high risk of seismic activity. In order to effectively manage this increased risk, climate change adaptation (CCA), and disaster risk reduction (DRR) must happen throughout our environment, covering all aspects of population, assets and resources. With 66% of the world expected to reside within urban areas by 2050 (UN, 2014), addressing the issue of urban disaster management, and climate change adaptation, is of the utmost importance, not just in the future, but also now. It is far cheaper to address issues of resilience and adaptation before an event than after one, not only in respect to human losses but also economic ones. Cities should be the driving focal point for CCA and DRR; with dense complex populations and infrastructure that often is in need of repair, they are typically at higher risk of extreme weather events, and natural disasters. In addition, cities often

Figure I-1: Wellington city at dusk.
https://upload.wikimedia.org/wikipedia/commons/1/11/Wellington_City_at_dusk.jpg

have wider access to funding, organisational networks, infrastructure, and tools that will allow them to reduce vulnerability and increase resilience.

The two main responses to climate change are mitigation and adaptation. Where mitigation looks at slowing or stopping the effects of climate change, adaptation understands that we have passed the point where we could stop global warming, and instead seeks to survive the changing environment. Adaptation should be implemented over time, and is made up of adjustments to our built environment and behaviours that will increase a community's ability to survive an extreme weather event. Indeed, since we cannot stop extreme or anomalous events, set in motion by current levels of CO₂ emissions and global warming, our only option is to find ways to survive them better, to reduce our vulnerability and increase our ability to bounce back and recover. Every city and community is vulnerable in a different way and each system of infrastructure, whether communications, water, power, housing, or transport has the potential to increase the damage or lessen the effects that an extreme weather event has. As such they should be seen as one part of a large urban organism, and each should be looked at to ensure that they do not become the single point of failure that topples a city.

In order to understand the issues of DRR and CCA that are present within Wellington New Zealand, a literature review has been undertaken. A site analysis was then conducted, leading to a network of shelters around Wellington being proposed. Two specific design strategies on top of the sites identified were undertaken. Firstly, an existing building was investigated to discover whether it could currently function as a disaster shelter. Secondly, findings from this first design investigation led to the design of a purpose-built development that will allow increased community resilience both pre- and post-disaster. International standards and requirements for disaster shelters have been referenced, in order to ensure that the proposed design is fit for purpose.

Figure I-2: The National Library, Wellington.

https://upload.wikimedia.org/wikipedia/commons/f/f7/National_Library_of_New_Zealand_Wellington_2015.jpg

The steps that I followed in completing this thesis are listed here:

1. Research on scope and aims of thesis
2. Review of available literature
3. Case study analysis
4. Concept breakdown
5. Site analysis of Wellington
6. Creation of shelter network around Wellington
7. Analysis of The National Library building
8. Continual iteration development, critique, and testing
9. Final design on Leeds St

The thesis is broken down into the following chapters:

1. Introduction. This chapter serves to orient the reader within this research, and gives a broad overview of the steps undertaken for this thesis,
2. Literature review (including case study analysis). This chapter is a comprehensive review of the available research and literature, covering research from governmental agencies, international standards and recommendations, and examples of how DRR and CCA can be applied to an existing urban environment. In addition, in its discussion, it refers to a number of case studies that are applicable to this research.
3. Site analysis. This chapter focuses on site analysis of both Wellington as a whole, and the individual sites selected for a shelter. It also contextualises the analysis with reference to relevant WRC and WCC policies and strategies and makes direct connections to research identified in the literature review as it applies to the Wellington situation. It will finish by proposing a network of sites around the city that may be suitable for disaster resilient developments.
4. Existing building adaptation, design and analysis. This chapter analyses an existing building, the National Library on Molesworth Street, Wellington, in order to ascertain whether it would be suitable in its current form as a disaster recovery hub and shelter.
5. Purpose-built design. This chapter contains the research and design of a purpose-built recovery hub on Leeds Street, Wellington. It proposes a number of different ways of utilising the building, with both pre- and post-disaster functions. In addition, it gives a number of ways to further improve upon the design in future research, and the key findings of the design process.
6. Conclusion. This section briefly summarises the findings, reflects on the value of the research done, and indicates areas in need of further of development.

Chapters 1-4 have been presented in a draft format at the 6th International Conference on Building Resilience in September 2016 Auckland.

LITERATURE REVIEW

02

Figure II-1: Aftermath of hurricane Katrina.

<https://upload.wikimedia.org/wikipedia/commons/b/b3/Katrina-14588.jpg>

This chapter will review the available literature and how it is applicable to the research. It will provide a thorough evaluation of the current state of DRR and CCA literature and work that has been undertaken already and will seek to rationalise the reasons why more has not been completed. It will also look at a number of case studies around the world in order to understand how different cultures and governments are approaching the issue of DRR.

Methodology.

For this literature review, the following method was employed to identify relevant literature.

The search terms used (with newspaper articles and book reviews excluded) in searches on VUWs Te Waharoa database were as follows:

- Disaster management – 108,106 results
- Disaster recovery – 111,483 results
- Emergency preparedness – 75,740 results
- Extreme weather – 80,332 results
- Climate change adaptation – 55,129 results

- Disaster risk reduction – 8692 results
- Urban resilience – 9177 results

In addition, searching was undertaken through Google Scholar, and by expanding the research to include cited sources in other articles. As a result of this search, 104 sources were identified as being of direct relevance to issues of disaster management and the built environment based on their titles, and restricting sources to only peer-reviewed, English language journals. From this pool, 50 were chosen for review based on the relevance of their abstracts.

Effects and responses.

Natural disasters cause a staggering amount of damage each year. In 2005 Katrina caused around 250 billion US dollars in economic damage and 105 billion in repairs (King, 2005), but on a global level natural disasters caused around 350 billion in losses in 2011 alone (Holm & Scism, 2011). This figure will only increase now that the effects of global warming are causing an increase in extreme weather events (Fischer & Knutti, 2015). Climate change adaptation is the leading method for mitigating these effects, with a large number of preliminary studies having been undertaken already. These studies, (e.g. UNISDR (2005) UNISDR (2011) La Trobe & Davis (2005)), assess the existing frameworks for disaster reduction and propose new ways to integrate resilience into the legislature of each country. While these studies are useful in order to gauge the current level of risk reduction efforts around the world, there are limited examples of physical implementation pre-disaster, with only a few areas in the world actively adapting their built environment in anticipation of the unpredictable effects of climate change (UNISDR, Climate Change Adaptation, n.d.). Nonetheless, these examples are interesting in that they all advocate for active preparedness efforts to begin now, and all propose different ways of adapting, seemingly proving that each situation requires a different response. In the Netherlands, complex floating houses have been developed that allow for sea level rise to continue without threatening at risk housing stock (Tielen & Stam, 2013), while in Mexico (Pelling & Manual-Navarrete, 2011) and Canada (Henstra, 2012), a larger scale urban approach is advocated. The overarching idea that unites these studies is systematic diversity, in which there are a variety of ways that a city can be considered resilient, each one building upon the last (Bryant & Allan, 2011). This enhances a city's ability to bounce back from a disaster. However, each one of these examples focuses more upon a large scale urban typology, rather than a localised and specific attempt to adapt a structure, and as such lacks a site-specific approach that is useful in a direct application.

In order to effectively address a specific situation, we must first understand not only the potential threats but also the options we have in adaptation. Roaf, et al. (2009) give a comprehensive guide to adapting buildings, covering not only the threats we face from climate change, but also the effects they will have, and ways to adapt to them. They introduce vernacular and traditional building as a useful way to understand how past societies have dealt with a changing environment. This historical approach is further reinforced by Fouache (2013) who looks at historical middle eastern cities and their ability to deal with hazards, both environmental and human-made, Chafe (2007) who looks at the effects of climate change on population centres around the world, and the increase in danger over time. In addition, Reghezza-Zitt & Laganier (2013) investigate the flood management systems of Paris since the nineteenth century and compare this with current management levels. Stucki, et al. (2015) look at a specific Foehn storm that occurred in 1925 in order to understand its effects and the likely impact on a modern urban centre. Identifying the threats that urban centres face is

something that Chafe (2007) argues should be looked at from all angles. Chafe details the threats of disasters upon urban centres, creating a series of examples that can be applied in order to reduce disaster risk, and notes that CCA and DRR (Disaster Risk Reduction) cannot be understood from solely an individual level, but instead must be approached from a wider typological one as well. When combined with Roggema (2009), who details a number of countries' spatial solutions to climate change, it is possible to understand both the risks that cities face and the potential solutions.

Gagnon-Lebrun & Agrawala (2006) analysed the extent to which developed countries have implemented climate change adaptation strategies and concluded that most countries do not report on the extent to which they implement CCA development and that there is limited attention being paid to this field. While this study is 10 years old, it is still useful to understand the level of implementation over time. This research was undertaken after the Hyogo Framework for Action¹ was signed, and as such provides a snapshot into the adaptability of countries. The study focused primarily on developed countries, noting that there is a gap between developing countries' research into the effects of climate change, and the actual implementation of adaptation options and solutions. By focusing on various national communications (NC) issued by countries, this study was able to accurately assess the level of engagement with CCA initiatives.

It is also necessary to understand how our cities have come to be the way they are in order to not make the same mistakes of the past. Wamsler (2008) details how past designers of the built environment have had an unconscious effect on increasing disaster occurrence over the last 40 years. Stating that because of the erroneous thought that the linkage between disasters and the built environment was a simple cause and effect relationship, Wamsler concludes that whole sections of society are at higher risk because designs and regulations do not take into account the ability of a disaster to inhibit the functions of a city beyond the immediate damage. This finding is common to Bryant & Allan (2011), who research how disruptions to cities' systems around the world can be shown to demonstrate their individual strengths and weaknesses. Increasing a city's strength and resilience is something that can be undertaken at all levels, and Huraera, et al. (2010) investigate how grassroots coping strategies employed in Korail, Dhaka, allowed the inhabitants to survive extreme weather events. Drawing particular notice to the vulnerability of the urban poor, and the need for government-led intervention that will support the community-led efforts for CCA and DRR. Huraera, et al. identify a number of case studies that use several different types of coping strategies, namely;

- Modifications to the built environment that directly affect an existing structure and area so that they can withstand a disaster.
- The building up of food stores in an urban setting to provide an extra level of food security that may otherwise be at risk in the event of a disaster.
- The diversification of income streams in an urban setting to ensure that a family or group is better able to maintain some form of income should one source be cut off.
- The development of social support networks, so people are able to rely on the help of others for food, shelter, aid, and even physical help. There is particular attention drawn to the erosion of traditional social interaction systems in an urban setting, which should be actively worked against to ensure community resilience.

¹ In 2005, governments around the world committed to take action to reduce disaster risk, and adopted a guideline to reduce vulnerabilities to natural hazards, called the Hyogo Framework for Action (HFA). The HFA assisted the efforts of nations and communities to become more resilient to, and cope better with the hazards that threaten their development gains. (Prevention Web, n.d.)

Addressing resilience at all levels is something that is extremely important, and Wisner, et al.. (2004) provided a distinction between preventative and impact-minimising strategies of adaptation. While preventative strategies typically operate at the individual and community level and focus on people making choices to reduce their risk, impact-minimisation strategies are adopted in order to minimise the loss and facilitate the recovery in the event of a disaster. Put simply, impact-minimisation looks at improving access to the basic requirements that a community has so that in the event of a disaster, they are able to cope far better.

Disaster management practices.

Disaster management is typically composed of four distinct steps, of mitigation, preparedness, relief and recovery (Lindsay, 2012). Mitigation is the attempt to limit the loss of life and property by reducing the effects of disasters and extreme weather events and is normally undertaken by resource organisations in order to understand the effects of hazards and community behaviour on insurance. This is taken further by preparedness, in which the effects of disasters are actively anticipated through the increase in disaster response service effectiveness, early warning systems and public consultation and training. Relief and recovery are the responses after an event and consist of life-saving efforts, property protection and reparation. The damage and losses suffered due to an extreme event can be reduced by the effective implementation of adaptation, mitigation and preparedness efforts pre-disaster.

Disaster mitigation and preparedness are studied in a variety of forms, including the social (Messias, Barrington, & Lacy, 2012), political (Gerber, 2007), and legal (USJF Command, 2008). They are then integrated with ways to improve community and individual behaviours for disaster preparedness (Campasano, 2010), increasing the national preparedness (Conroy, 2008), and the measuring of preparedness (Covington & Simpson, 2006). A cost-benefit analysis was undertaken by Jongejan, et al. (2011) so that the worthiness of disaster preparedness could be ascertained, and compared against the "frequency with which response capacity is expected to fall short", drawing a conclusion that the different sizes of urban form have a drastic impact on the likelihood of a response falling short, thus requiring a complex risk modelling technique for each typology of development. Additional cost benefit has been undertaken by Kunreuther, et al. (2001), Grossi & Kunreuther (2001), Chang (2003) & Ganderton (2005), who compare the cost of mitigation for business versus reduction in damage and lost business time.

Implemented strategies.

There are a number of implemented strategies around the world, each one responding to a specific issue in its immediate environment. Meister, et al. (2009) present a comprehensive list of countries and their adaptation strategies and initiatives, which is extremely useful when comparing approaches. They also document each country's individual risks and threats in relation to climate change, demonstrating the need for specific responses to each environment rather than a one size fits all approach to CCA. However, they focus almost solely on government intervention, and as such do not include a body of research that deals with small-scale intervention. It is necessary therefore to look at specific ways that resilience has been improved, and Tielen & Stam (2013) document the direct implementation of a once theoretical framework in the Dutch Room for the River programme as part of the Flood Resilient Cities project (INTERREG IVB NWE, 2016). This programme allows the rivers of the Netherlands to cope with higher peak flows. While Tielen and Stam's research is useful in terms of understanding a specific design response to a problem. It also deals with the wider issue of awareness, noting that due to the relatively slow change in flood risk over time that many people do not take the threat seriously, and remain unconvinced about the necessity of flood and CCA prevention measures. It notes that the public must remain aware of the dangers related to climate change in order to be able to actively engage with the process of DRR.

In traditional developmental discourse, it was understood that an increase in a country's economy typically goes hand in hand with an increase in that country's resilience. However, Cannon & Muller-Mahn (2010) demonstrate the difference between adaptation, resilience and development /economic growth. Stating that economic growth and development do not necessarily increase resilience, they show that sections of society are often forced to degrade their natural environment in order to continue their economic rise. Cannon & Muller Mahn's research also addresses issues surrounding resistance for climate change and CCA/DRR efforts, and also builds upon Wisner, et al's. (2004) work, in identifying the effects of "development" as detrimental to the safety of many of the urban poor. By directly addressing the threat that poor sections of the world face, it is understood that both bottom up and top down approaches should be used to ensure that sections of society are not marginalised, and left out. Cannon & Muller Mahn refer to the unrealistic nature of many of the adaptation frameworks that are in place, and state that it is still unclear how frameworks can be implemented. This research adds to Wamsler (2007), who takes a comprehensive look at the issues surrounding poverty and the increased risk poor areas of the world face. This work resonates with the larger theme of this thesis and reinforces the idea of there being an excess of planning and framework building by governments and legislative bodies, but a lack of practical and real world application.

By creating a multitude of mixed use developments, it is possible to build resilience into a community at the same time as enhancing everyday capacity (Bryant & Allan, 2011). In addition, being able to prove the economic viability of a development in terms other than disaster resilience will encourage greater private sector interest in DRR and CCA (Alam, Alam, & Rahman, 2015). Incorporating as many stakeholders as possible is one way to ensuring that all areas of a city are addressed in terms of resilience. Balsells, et al. (2013) directly compare the resilience of New Orleans pre- and post- Katrina, in order to assess whether the incorporation of resilience-based design into the city's planning process has gone ahead. The research comes to the conclusion that while flood resilience has been improved, there are other components and functions of the city that have not been addressed. The research demonstrates the necessity to consider all aspects of resilience at once and builds into the ideas of Roggema (2011) and the issues with systematic choke points.

Within the context of DRR and CCA lies the idea of a core shelter. A core shelter is a structure that in the event of a large-scale disaster, protects its users, and post-disaster still maintains permanent housing standards without being deemed to be a permanent dwelling (IFRC, 2013, p. 10). This process directly builds resilience into the city, in order to withstand any change to its environment. Diacon (1992) details the Core Shelter Project of the Philippines, (Figure 1), and its ability to directly build resilience into a community. Since 1988, 41059 core shelter units have been completed, each one a simple and cost effective housing solution that has protected its inhabitants against typhoons with none being destroyed. The core shelter project demonstrated the success of this core shelter principle, allowing communities to withstand disasters and maintain a level of security and quality of life. This project is impressive given the extremely low budget in the areas it was implemented in, and demonstrates the effectiveness of community engagement, allowing members to upskill themselves and carry on work on core shelters long after the management had departed. This case study, however, is one that is specific in its execution but not in its goal. While a site-specific response has been developed in the Philippines in order to combat the threat of Typhoons, its principle of creating spaces in a community which serve both as a shelter in the event of a disaster, and in everyday use is one that could be applied to elsewhere. The implementation of core shelters into an existing urban context, could reduce losses on all fronts and build resilience into communities from the ground up.

System failure.

Bryant & Allan (2011) and Roggema (2011) are complementary in their proposition that systems must be tested in order to ensure that they are understood and that there must be diversity within these systems so that they are able to withstand anomalous or extreme events. Bryant & Allen analyse how three different cities responded after three separate events, rating their responses based on resilience attributes from Walker, et al. (2006), and focusing on spatially-oriented ways of adaptation. This research is interesting in how it addresses and discusses the potential adaptability of existing city structures and stresses the importance of urban grit and strength at a variety of scales. Roggema (2011) looks at the problem of urban resilience in a different capacity, applying the idea of swarm adaptability, to existing urban structures. Swarm adaptability is the theory that much like nature, spatial systems can become self-organising and "develop emergent patterns in order to maintain existence or deal with changes in their environments" (Roggema, 2011, p. 4). It is possible to use these self-organising principles in order to redistribute functionality at the urban level. Roggema focuses on the idea that systems can be seen as choke points. Should a system be inadequate, it will restrict the flow of recovery to other areas of the city. In addition, both Roggema and Bryant & Allen advocate for fail safes to be employed so that basic functionality is not lost in a critical event. Bryant & Allen note that Wellington itself is at high risk due to the singular access in and out of the city, and the presence of earthquake faults under this route and major water supply networks. Adaptability, therefore, is not purely about how the built environment can change in response to an event, but also how it can predict the effects of one, and mitigate them beforehand, ensuring that cities are able to redistribute functions easily and effectively.

Cities have a series of functions that can be deemed critical to their survival, something that is highlighted by Dostal (2008), who specifies what the functions of a city are, and in particular the functions of a capital city. By examining Dostal's research, and its implications, it is easy to understand what parts of a city are deemed integral to its functionality, and which ones are most important to recovery in the event of a disaster. Dostal highlights capital city functions as three main categories:

- Transnational linkages create gateways for other cities and encourage activity from outside the state. The internationalising of a capital is important in terms of socio-economic expansion in predominantly western industrialised countries. Ensuring that these linkages are restored in the event of a disaster, and to a standard that is not seen as detrimental to the country's image, is something that should be designed for.
- Capital cities also play a central role in a country's administrative control and representative actions. Finding a way to maintain these roles is crucial to ensure that the city remains both an important centre and one that is given priority in the event of a disaster.
- A capital also plays a key role as a centre of transactional activities, and as such should be seen as central to a country's economic strength.

These categories should be taken as the base of what makes a capital city important, but do not cover any psychological factors that are present. As a capital city, these issues are pertinent to Wellington, and this thesis engages with all three at different levels. By improving resilience at a community level, socio-economic resilience can be improved, and by providing areas for local administration to continue, Wellington can continue to be represented even after a disaster. Ensuring that these functions are restored to function in the event of a disaster is important, and on architectural level provide a form of hierarchy as to what is most important in a city. After the 2011 Christchurch earthquakes, the city experienced a rapid economic downturn and population exodus as businesses closed, and people moved to a less tumultuous part of the country (Bayer, 2013). This had the observable effect of slowing recovery efforts and contributing to the current state of the city.

Governmental and UN involvement.

There exists a wide range of governmental and intergovernmental policies that directly address CCA and DRR, with the UN taking an increasingly active role in preparing guidance for this topic. The United Nations Office for Disaster Reduction (UNISDR), has produced a number of documents that prepare the ground for legislative and governmental bodies. (UNISDR, 2012) provides immediate guidance for local leaders, and (UNISDR, 2011) addresses the need for engagement at all levels of society. However, it is the Hyogo Framework for Action (UNISDR, 2005) that is the most important document prepared by UNISDR. The Hyogo Framework for Action is a landmark set of principles and non-binding agreements between members of the UN and sets out goals and activities for countries to follow between 2005-2015. While this document has now run its course, it played an integral part in the previous decade's increase in DRR and CCA efforts. It is an intentionally broad document so that it can remain applicable to as many countries as possible, and while it is not as useful on a local level, it nonetheless enables the reader to assess their own government's engagement with these issues. Adding to the guidance of the Hyogo Framework, the UNDP (2004) report on reducing disaster risk provides a comprehensive assessment of the risks and vulnerabilities that communities face due to extreme weather events, as well as individual countries responses to it.

In addition to the broad strokes of the UN, UKCIP (2007) and the Greater London Authority (2010) provide specific plans and examples for London and England to follow in the event of a disaster but they do not go far beyond simply understanding the issues and the vulnerabilities of cities. It would have been interesting to see concrete examples of how CCA and DRR could be delivered.

However, UKCIP does produce a set of adaptation options that could potentially be used to increase resilience. They are grouped into four categories:

- "No-regrets" adaptation. These are measures that are deemed to be worthwhile regardless of the extent of future climate change. They include:
 - o Actions that directly affect a building's adaptive capability as part of a larger strategy
 - o Avoiding high-risk areas of development
 - o Reducing water infrastructure leakage
 - o Minimising overheating in property
 - o Reducing the consequences of flooding through water-resistant materials
 - o The use of multi-season recreation materials.
- "Low-regrets". These have relatively low costs with future benefits that outweigh them, including:
 - o Implementing additional climate headroom for future expansion with developments
 - o Restricting development in flood prone areas
 - o Promoting certain types of space, typically green urban areas and agricultural land
 - o Sharing water facilities around developments
- "Win-win" options. These address not only CCA and DRR but also social, environmental or economic issues.
 - o Flood management through the creation of floodplains and habitat conservation
 - o Improving contingency plans
 - o Improving the cooling of buildings through low or zero energy solutions
 - o Green roofing and walls allow for temperature reduction and water filtration
- "Flexible adaptation". These are undertaken over a larger period of time, with incremental changes rather than sudden interventions.
 - o Delaying specific measures while exploring other options within a governmental and regulatory environment.
 - o The introduction of progressive withdrawal from coastal areas
 - o Investing in recreation in ways consistent with projected climate change.

These options are all interesting and good ways to increase resilience, but once again they are applied with a broad stroke to a large area. They lack the focus to be applied to a specific situation beyond a largely shallow engagement with an area's risks.

Wellington Regional Council and Wellington City Council policies relevant to this thesis are addressed in chapter three, Site Analysis.

Conclusion.

In conclusion, there is evidently a large amount of research and literature covering the effects of climate change, and the dire need for CCA and DRR. However, there is still a lack in direct urban responses to this issue. Most bodies identify the threats and give a broad set of goals and activities that in theory will help build resilience, but they lack the specificity that enables the community to quickly address the risks of climate change. The main reason for this is that each city and community has a very specific set of vulnerabilities that should not be legislated from a national level, but a local one. Instead, the goals and principles set out in guidance documents, along with examples of ways to increase resilience at all levels should be used to inform and create a specific set of plans and actions that each city should then undertake. There is not a one size fits all solution to CCA and DRR, each city should address its own individual needs and requirements, and use existing literature to understand exactly how the effects of climate change will impact their specific environment. Understanding each city's individual risk factors is the most important part of building resilience, and should be undertaken as soon as possible in each area. Only by identifying vulnerabilities can specific solutions begin to be created. In addition, vulnerabilities should be looked at and understood in a variety of ways, from economic to infrastructure, to social and human loss scenarios. Each individual system has the potential to have large effects on others, so ensuring that a city has a resilient set of systems is also of high importance (100 Resilient cities, 2016).

SITE ANALYSIS

03

Figure III-1: Ethnic groups of Wellington, New Zealand.
<http://profile.idnz.co.nz/wellington/ethnic-group>

This chapter will cover site analysis of Wellington at a macro scale. It will document the issues and threats currently facing the city, research the most at risk areas, and understand the steps taken so far to reduce the risk faced. In addition, it will propose a series of shelters that could be developed in order to form a network. Each shelter would be located in a different high-risk suburb and would help to reduce disaster risk and increase community resilience.

Wellington has many resilience-based disaster management aspects to consider, including the strength of its sea walls, waterfront properties, seismic strength, and the reliability of infrastructure. The WCC has outlined a number of areas of resilience building that it will focus on over the coming years in the 2013 Climate change action plan (WCC, 2013). This document was updated in 2016, with additional goals added such as researching how sustainable building practices can be incentivised. From 2010-2012 a sea level rise assessment was undertaken alongside resilience building, asset management and greater collaboration with local authorities. From 2013-2015, research on climate change impacts began, with adaptation integrated into resilience planning, greater public engagement, and water sensitive urban design implemented (WCC, 2013). While increasing the resilience of all aspects of Wellington is important, this design thesis suggests core shelters as a measure to accompany other resilience building efforts within the city.

Wellington statistics and demographics.

Wellington is a comparatively small capital city, with a population of around 470,000 in the greater Wellington region and 190,000 in Wellington City, there are roughly 177,000 dwellings including 15,000 unoccupied dwellings (Statistics New Zealand, 2013). The average median income for the city is \$37,900, which is slightly higher than the New Zealand average of \$28,500 (Statistics New Zealand, 2013). The majority of the population identifies as Pākehā, with small subsets of Māori,

Figure III-2: Topographical map of Wellington.

Pacific, and Asian people, (Figure III-1). The Wellington region is typically a temperate climate, typically ranging between 7-21° celsius with the majority of the year spent in either cold or cool temperature bands. There is a 40%-58% chance of precipitation during any day of the year, with moderate rain the most common type (Weather Spark, n.d.). Wellington is a hilly city, (Figure III-2), with a wide range of outdoor activities possible, and has 98.9km of coastline (WCC, n.d.). The city is expected to experience an increase in weather events due to global warming over the next century, as well as increased sea level rise (Ministry for the Environment, 2014).

The Ministry for the Environment reports that Wellington should expect an increase in average temperature of 0.9°C by 2040 and 2.1°C by 2090. Alongside this, will be an increase in storms and high wind events throughout the region, and 0.8m of sea level rise by 2090 (Ministry for the Environment, 2014). However, this data was only reviewed in 2014, and will not take into account recent research which demonstrates that we have underestimated the effects of climate change on our environment, such as Fischer and Knutti, (2015). As such we should expect the effects of climate change upon the Wellington environment to be more pronounced than previously estimated. In addition to the threats from extreme weather and climate change that Wellington faces, the city and its main transport route, also lies over five major fault lines, indeed "[t]he five faults that could potentially cause the most damage are; the Wellington Fault, Ohariu Fault (north & south), Wairarapa Fault, Carterton Fault and the Masterton Fault" (Civil Defense, n.d.)(Figure III-3).

These fault lines are ones that have moved in the past, and while the risk is rated as relatively low, have the potential to produce a major seismic event in the future (Langridge, Leonard, Van Dissen, & Wright, n.d.). Bryant & Allan (2011) note that Wellington itself is at high risk due to the singular access in and out of the city, and the presence of earthquake faults under this route and major water supply networks. Understanding the threat to each of these systems is key in developing resilience. Adaptability, therefore, is not purely about how the built environment can change in response to an

Figure III-3: Fault-line map of the Wellington region.
<http://www.civildefence.govt.nz/assets/Uploads/Shakeout2015/Maps/Wellington.pdf>

Figure III-4: Map of seismically at risk buildings in Wellington city centre.

Suburb	Population	Median age	Median personal income	Number of households	Person per household	Risk factors
Thorndon- Tinakori Road	4,125	32.3	48,200	1,857	2.2	Coastal proximity, high numbers of seismically vulnerable buildings, close to fault line, very high wind loading
Lambton	5,625	25.1	21,300	1,908	2.9	Coastal proximity, high numbers of seismically vulnerable buildings, lower income level, younger population, close to fault line, high wind loading
Willis Street-Cambridge Terrace	7,329	26.8	36,800	3,117	2.3	Coastal proximity, high numbers of seismically vulnerable buildings, medium level of personal income, younger population,
Mt. Victoria West	5,400	30.7	44,000	2,202	2.4	High numbers of seismically vulnerable buildings
Adelaide	1,020	27.2	22,300	300	3.4	Lower level of personal income, high population density, high numbers of seismically vulnerable buildings
Newtown East	4,878	30.4	28,700	1,797	2.7	high numbers of seismically vulnerable buildings, medium income level, higher levels of density
Kilbernie West- HAITAITAI South	3,207	33.9	38,200	1,320	2.4	high numbers of seismically vulnerable buildings, coastal proximity, very high wind loading
HAITAITAI North	4,563	33.4	45,500	1,725	2.6	high numbers of seismically vulnerable buildings, coastal proximity, extremely high wind loading, aging population

Figure III-5: Wellington suburb risk analysis.

event, but also how it can predict the effects of one, and mitigate them beforehand, ensuring that cities are able to redistribute functions easily and effectively.

While Wellington currently enjoys a predominantly moderate and easily inhabitable climate, the potential for climate change to have an extreme effect on the local climate system is a real one. The 2014 breach of the Island Bay sea wall is now estimated to cost over \$1.3 million dollars to repair, for example (Forbes, 2015). Recent research has shown that the degree of sea level rise in Wellington may exceed past estimates, and as such, we should begin to model these unexpected rises in ways other than simply flood and water level risk (Sharma, et al., 2016).

Wellington urban analysis.

Wellington retains a level of urban grit in its building stock and has a wide variety of building typologies that could be adapted in multiple ways. These typologies range from single unit households, detached, semi-detached, high-density units, and medium density developments. In 2013, 59.7% of households were classified as separate, 28.1% as high density, 9.2% as medium density with 5.3% as other dwellings or not stated (Profile ID, n.d.). On a larger scale, Wellington has a number of suburbs and satellite towns that support the region, with 23.5% of dwellings as medium or high density compared with the 35.2% of Wellington City. This shows that the level of density in the main city is markedly higher, and is increasing each year, with 17,715 in 2006 and 20,124 high-density houses in 2013 (Profile ID, n.d.). The level of difference between Wellington City and the Wellington region requires a different response to be developed for each area, but this opens up options that are able to support each other's individual weaknesses as a whole.

On an architectural level, this thesis is interested in how a city can respond and function both

Figure III-6: Map of population density in Wellington.

Figure III-7: Map of ground shaking in Wellington.

during and after an extreme event, using the idea of core shelters as a key method of resilience. One of the easiest ways to measure this is to understand the vulnerability and fragility of our existing building stock. Using data produced by the WCC, Piers Chamberlain (2011)(Figure III-4), mapped the buildings deemed to be at risk in a seismic event in Wellington. This data will form the preliminary analysis of risk undertaken in this thesis. It assumes that these buildings will be uninhabitable in a seismic event, and so sets the baseline of vulnerability in order to build urban resilience. These buildings are at risk of earthquake damage and are typically unreinforced masonry buildings that are vulnerable to lateral loading and in severe windstorms and are clustered around the CBD. This data suggests a need for core shelters that will provide shelter in both seismic and extreme weather events to the inhabitants of these at-risk buildings, with shelters located in the vicinity of at risk clusters. Creating these interventions will require a multi-stakeholder approach, will need to provide a benefit to the area when not in use as a disaster shelter, and must be able to transition from their non-disaster use to their shelter function quickly. By creating a multitude of mixed use developments (Bryant & Allan, 2011), it is possible to build resilience into a community at the same time as enhancing everyday capacity. In addition, being able to prove the economic viability of a development in terms other than disaster resilience will encourage greater private sector interest in DRR and CCA (Alam, Alam, & Rahman, 2015).

In order to respond to this need, we must understand the effectiveness of a core shelter, and whether they are the most appropriate solution for Wellington. Core shelters are effective for a number of reasons; they are focused on strength over aesthetics, they are built with issues of resilience and disaster response in mind, and are seen within the community as places to go in the event of a disaster thus creating a highly visible focal point for recovery. In the Wellington context, a network of these shelters could provide for the people of the city who are made homeless in the event of a disaster and provide certain forms of infrastructure service to the city. The services provided could range from electricity generation to water sanitation, and telecommunication facilities.

Figure III-8: Map of Wellington tsunami zones.

These shelters will directly mitigate the effects of a disaster on both the city's services, but also its population through relief accommodation and shelter. This thesis proposes that there are two main ways of applying core shelters to an existing urban environment; direct physical implementation, and a conceptual one.

Core-shelter implementation.

Physical implementation would see a network of structures located in areas deemed to be at high risk and would provide immediate shelter during an event, and prolonged shelter after one as recovery effects are undertaken. These shelters would not be seen as permanent dwellings for the users, instead offering a secure and safe place to stay whilst other forms of accommodation or shelter are provided. The ability to reduce the strain on aid organisations and facilities through these pre-existing structures is also useful and was mentioned in a recent memorandum from the Kumamoto International Foundation (2016), a public service organisation founded to foster international cooperation and strengthen local communities.

Conceptual implementation would take the underlying principle of a core shelter, that of a centralised core that is protected at all costs, demonstrated for example, in the New Zealand parliament building's National Crisis Management Centre (New Zealand Government, 2006), and apply this to a larger area. This treatment of the system is one that is focused entirely on protecting each suburb's central area and would provide shelter to the outer areas of each suburb through resilient design and upgrading of existing building stock. The population of the outer suburbs would move to their nearest shelter, with shelters located in areas with clusters of high-risk buildings.

For the purpose of this design research, high-risk areas were identified by the following criteria:

Figure III-9: Map showing locations of at-risk suburbs in Wellington.

Figure III-10: Map showing locations potential shelter sites.

1. Their proximity to the coast (therefore vulnerable to tsunami and
2. The wind loading that they experience (dominant wind direction and exposure)
3. The quality of the existing housing stock nearby (quality of maintenance, height of surrounding buildings)
4. The lack of multiple transport routes (proximity to major transport access ways)
5. The density of population (higher density areas have greater risk of population displacement, as one building that is damaged may contain hundreds of people)
6. The age of the population (ageing populations have greater health risks and requirements than those who are younger, while younger populations often have lower material wealth)
7. The economic stability of the population (those with reduced access to emergency funds often find it harder to react to sudden changes in lifestyle)
8. The vulnerability of the areas in a seismic event (e.g. prone to liquefaction, slope failure, ground shaking)

These factors have led to the following areas being identified as of higher vulnerability in a disaster event: Willis Street- Cambridge Terrace, Mt. Victoria West, Adelaide, HAITAITAI North, Kilburnie West- HAITAITAI South, Newtown East, Lambton, and Thorndon- Tinakori Road (Figure III-5)(Figure III-9). In addition, the sites shown in (Figure III-10), are ones chosen based on criteria described in chapters four and five.

These areas are all ones with high concentrations of vulnerable buildings and higher concentrations of dwellings and demonstrate a need for core shelter intervention. Shelters would be sized dependent on the population expected to be displaced in a disaster event and would provide services that each community is likely to have restricted access to post-disaster. Each building will follow a set of design guidelines so that they are able to be adapted to a variety of sites and situations but will differentiate themselves from each other based on each community's needs. A combined approach is the most appropriate for an existing built environment because by building resilience at a large systematic level, and at a small local scale, it is possible to reduce a city's vulnerability overall and provide direct and specific shelters to those who will need it. Research has shown that lower-income communities, (Figure 6), are typically more vulnerable in the event of a disaster, such as Wamsler (2007), the World Bank (2012), and the UNFCCC (2007). Within this resilience building effort also lies a wish to protect sections of communities that are unable to flee in the event of a disaster as easily as those with financial means.

Conclusion.

In conclusion, it is likely that our existing built environment will not be able to support rapid or extreme changes in our climate without intervention. Should this climate change bring along an increase in extreme weather events or disasters we will have to drastically alter how a city withstands and adapts to these new threats. Urban core shelters provide a means to do this, and allow the inhabitants of an area to remain safe during and after an extreme event, and also provide a benefit

to the community beforehand. Wellington is at high risk of a disaster inhibiting the city's ability to function, and as such resilience-building efforts should be undertaken at once, and should also acknowledge that current efforts to strengthen communities and buildings are not progressing at the same rate as climate change and its effects. As such, a series of urban core shelters could be introduced alongside traditional resilience-building efforts so that should part of a city fail in protecting its citizens, there are still areas for them to seek shelter and begin recovery.

LIBRARY ANALYSIS

04

Day 1.	Day 1. + Week 1.	Week 1. + Month 1.
Temporary accommodation set up - Billeting.	Accommodation becomes more structured	Clearly delineated accommodation blocks.
First aid and trauma station operational.	Operable walls rolled out, personal space for inhabitants more defined.	Family and individual units for low income community members for whom other accommodation has not been found.
Immediate safe rest areas provided.	Medical centre reduced in size, focuses on out patient and minor injuries.	Med centre closes / minor first aid station.
Food and catering service begins.	Women/ Children area set up.	Community space / Marketplace opens.
	YA area set up.	Focus shifts to community operations and recovery.
	Temporary shower and washing facilities set up.	
	Morale and recovery area set up.	

Figure IV-1: Stages of shelter operation post-disaster.

This chapter will document the analysis and adaptation of an existing building in Wellington to operate as a core shelter post-disaster. The building chosen is the National Library on Molesworth street, a large-scale public building that houses both office workers and priceless and fragile collections of documents and art. It will provide a series of steps that should be taken in order to successfully adapt the building, pre- and post-disaster, and come to conclusion about whether the building should indeed be used as a shelter post-disaster.

Figure IV-2: Basement and Lower-ground level plan of The National Library post-disaster.

Figure IV-3: Concept 1: Ground level, and level 1 plan of The National Library.

Analysis of 70 Molesworth St.

To understand the issues surrounding the creation and utilisation of disaster shelters in an urban environment, it is first necessary to understand whether the existing building stock can be used or adapted for post-disaster functionality. To this end, an existing building was chosen in Wellington and analysed over a number of weeks. The building chosen was the National Library of New Zealand at 70 Molesworth St. This building was chosen for a number of reasons:

1. Size
2. Recent structural strengthening
3. Position next to main transport networks
4. Availability of open space nearby
5. Existing community engagement levels
6. Elevation from ground level.

The National Library contains a large number of bibliographic collections, as well as digital archives, teaching spaces and exhibition space. It also contains a large amount of open plan office space, catering facilities for the office workers and visitors, and an outdoor courtyard on the top level. It is a largely New Brutalist design (influenced by Kallman McKinnel & Knowles' Boston City Hall, 1962-1968) that alongside the New Zealand Parliament buildings, anchors the corner upon which it resides.

Figure IV-4: Concept 2: Ground level, and level 1 plan of The National Library.

Figure IV-5: Concept 3: Ground level, and level 1 plan of The National Library.

The first step in analysing this building involved identifying the requirements for a core shelter to be effective. Based on research undertaken by the IFRC (2009), they have been identified as the following:

1. Protection from climate and environment
2. Access to sanitary areas
3. Access to private space
4. Adaptable community areas
5. Space for medical facilities
6. Resistance to ill health and disease
7. Security and personal safety
8. Support for family and communal life
9. Communal coping methods

Figure IV-6: Concept 3: Level 2 and Level 3 of The National Library

Focus on creating a community centre before a disaster through increased foot traffic and use from locals.
Expansion of outdoor planter areas for use as community garden area
Monthly cultural festivals
Monthly creative festivals
Community art gallery and space
Skills based workshop and classes
Kids group and childcare
"Gap filler" like community spaces

Figure IV-7: Proposed new programme for the ground floor of The National Library, pre-disaster.

1:200 @ A1

Spatial and programmatic changes.

The plans shown throughout this chapter have been developed so that the library can function well both before and after a disaster event. To that end, new programmes have been added to the building to engage sections of the community that otherwise would not normally interact with the building, as well as more traditional hard-coded design moves. These include operable walls to ensure adaptability, spatial rearrangements post-disaster, zoning changes, and usage evaluation (Figure IV-9). In addition, community-led gardens have been introduced around the edges of the building (Figure IV-7). However, even with the addition of the new programme, and internal modifications, there is still a large caveat for the use of the building post-disaster; that is the requirement for the sanitary facilities to be fully functional. If a disaster scenario has led to the destruction of underground waste facilities and piping, then this building cannot be used as a core shelter, and instead could only viably function as a community recovery hub. In order to combat the risk of damage to the sanitary facilities, a septic tank should be installed with flexible in ground connections so that in a disaster, the sanitary facilities can be quickly switched over to the septic tank. The Thorndon Residents' Association (TRA) has identified the Pipitea Marae as a location for shelter in the event of a disaster, and should the National Library not be functional as a shelter, then the marae should be used as the primary location for shelter (Thorndon Resident's Association, 2015). The TRA also acknowledge the lack of sanitary facilities in the event of a disaster, giving instructions on how to create emergency toilets should the need arise.

Requirements for use as shelter:

- Isolated septic tank
- Seismically restrained services
- Flexible in ground connections
- Dedicated water supply
- Rainwater harvesting system
 - Storage tank
- Dedicated power supply
 - PV panels on rooftop
 - Batteries in basement

Recommendations for building:

To ensure the building is able to operate as a post disaster shelter there are several areas that need to be addressed. The building must have a seismically resistant sewerage system that is independent of the cities. In the event of a large scale disaster, underground pipes and services will likely be destroyed, which will render toilet facilities unuseable. To counter this a dedicated septic tank with flexible in ground connections should be installed so that the buildings toilets still function.

In addition, it is highly likely that power and water will be knocked out, so PV panels and a storage system should be installed alongside a rainwater harvesting system and water tank. 3 days worth of water should be provided assuming maximum shelter occupancy of 200 persons, plus 50 people as admin and support staff.

Figure IV-8: Overall recommendations for The National Library.

Requirements for use as shelter:

- Isolated septic tank
- Seasonally restrained services
- Flexible in ground connections
- Dedicated water supply
- Rainwater harvesting system
- Storage tank
- Dedicated power supply
- PV panels on rooftop
- Batteries in basement

Shelter provided in event of disaster only if above criteria are met, and if all services are functional.

Should services be non-functional, shelter provided at Piglea Marae, as per Thomson crisis management plan.

Food and canteen area not required due to nature of food supply post disaster.

Building shifts to a shelter for community, and a volunteer hub.

Recommendations for building:

To ensure the building is able to operate as a post disaster shelter there are several areas that need to be addressed. The building must have a seismically resistant sewerage system that is independent of the city. In the event of a large scale disaster, underground pipes and services will likely be destroyed, which will render toilet facilities unusable. To counter this a dedicated septic tank with flexible in ground connections should be installed so that the buildings toilets still function.

In addition, it is highly likely that power and water will be knocked out, so PV panels and a storage system should be installed alongside a rainwater harvesting system and water tank. 5 days worth of water should be provided assuming maximum shelter occupancy of 200 persons, plus 50 people as admin and support staff.

Figure IV-9: Proposed new programme for the ground floor of The National Library, post-disaster.

1:200 @ A1

1st Floor shelter:

- 80 persons
- Day 1 volunteers clear floor of stacks and equipment, creating large open space for displaced population.
- Future accommodation expansion through operable walls.

Figure IV-10: Proposed new programme for the first floor of The National Library, post-disaster.

1:200 @ A1

2nd Floor shelter:

40 persons

Day 1 volunteers clear floor of stacks and equipment, creating large open space for displaced population.

Future accommodation expansion through operable walls.

Figure IV-11: Proposed new programme for the second floor of The National Library, post-disaster.

1:200 @ A1

3rd Floor shelter:

80 persons

Day 1 volunteers clear floor of stacks and equipment, creating large open space for displaced population.

Future accommodation expansion through operable walls.

Outdoor courtyard area transitions to temporary shower facilities, cold water showers only.

Figure IV-12: Proposed new programme for the roof of The National Library, post-disaster.

1:200 @ A1

Findings from the adaptation of the National Library.

With proper adaptation, the National Library can succeed at providing immediate shelter to the community, as well as developing into a hub that the community can build back better from. Existing buildings can be adapted providing that each one is thoroughly analysed beforehand so that any issues that may arise in a disaster situation can be dealt with. There should also be a strong focus on pre-disaster functionality so that people in the community that the building is located in, use the building regularly and become accustomed to it. This is key in improving community resilience at a larger level and will ensure that in the event of a disaster, the community is aware of the centre and its role in disaster risk reduction. To successfully adapt buildings, there must be active community engagement at all levels of design, a strong focus on proving the viability of the design pre-disaster, an acknowledgement that any post-disaster design should be as adaptable as possible, the building must be structurally sound to minimise the risk from additional structural damage, and the building should enable as many sections of the community to inhabit it safely and securely.

There are a number of reasons why buildings have not already been adapted into disaster recovery hubs, with the largest being the cost and perceived requirement for them. Historically, disasters have had the largest effect on third world countries, and countries that have a large rural population. However, as more and more people move to the city, and our climate continues to change, the risk of a large-scale disaster to hit an urban city centre only increases. We should not be designing and building for the risks that we are currently exposed to, but rather the risks (including their greater frequency and magnitude) that we will likely face in the future. It is this risk that recovery shelters and hubs should be built for. However, as with any future risk, it is often hard to spur action without a large shock to the system (Spittal, McClure, Siegert, & Walkey, 2008). The Christchurch earthquakes shocked the country and as such a huge amount of focus was put into the structural strengthening of buildings in anticipation of another major quake. However, DRR should be begun as soon as possible, and not only in response to a large-scale system shock. To begin design only after a large-scale disaster is irresponsible, and assumes much about the future of the country. As such, further research into the adaptation of these existing buildings as core shelters should be done both at a national, and local level, with a potentially national body overseeing the countrywide implementation, and local bodies overseeing the specific design and construction. National subsidies could be set aside for the cost, as well as retail facilities propping up the costs of development. Using existing buildings should also cut down on the initial cost of construction.

Conclusion.

In conclusion, the National Library is a good building to adapt provided that certain issues are resolved pre-disaster. The sanitation facilities need to be overhauled and a backup system installed in the event of a city-wide sanitation failure. If this does not happen then shelter should be provided instead at the Pipitea Marae, and the library should transition into a recovery hub only. This chapter has documented a number of steps that have been advocated for and provided plans that show the additions and changes that can be made. There has been a strong focus on both the pre-disaster functionality of the building as well as the transition to its post-disaster purpose.

SPECIFIC DESIGN

05

Figure V-1: Specific design. Above Ghuznee St.

This chapter will cover the design and documentation of a purpose-built design on Leeds St and Ghuznee St, Wellington. It shows the process from initial concept, through development and iteration refinement, and finally ends with presentation images and plans that show the final design. There is a strong focus on proving the development's viability both pre- and post-disaster, and in developing a brief that serves the functions of both scenarios.

A3 format plans are located in the appendices.

Figure V-2: Floor plan level 0 Pre-disaster. A101. 1:100@A1

Figure V-3: Community market area

Figure V-4: Outside park area. Leeds St.

Figure V-5: "Coiffice" space, Leeds St building's ground floor

Design brief.

There are a number of opportunities created by the design of a purpose-built disaster relief hub. By specifically designing a building to function both pre- and post-disaster, it is possible to code functions and programme into the design from conception, instead of attempting to adapt a building successfully. However, in order to design for both pre- and post-disaster, a brief must be decided on that allows for internal and external adaptability. The brief for this purpose-built design is as follows:

Pre-Disaster:

1. Provide flexible, relaxed, and adaptable office space and facilities
2. Provide economic opportunities through retail and hospitality areas
3. Provide community advice areas for all sections of society
4. Provide active areas for recreation and exercise
5. Provide childcare facilities and equipment
6. Provide community market areas
7. Provide appealing and accessible outdoor space for use in both pre- and post-disaster

Figure V-6: Floor plan level 1 Pre-disaster. A102. 1:100@A1

Figure V-7: Market area, Cuba St. accessway.

Figure V-8: Restaurant/cafe. Ghuznee St building.

Figure V-9: Main accessway.

Figure V-10: Cafe/Restaurant.

scenarios

8. Offset on-grid energy demands through the implementation of renewable power sources on-site, and contribute to the broader mitigation of climate change
9. Provide areas for future expansion and adaptation
10. Provide self-sustaining potential within the building
11. Design and build above current building code standards

Post-Disaster:

1. Provide secure short term accommodation for upwards of 150 people
2. Ensure accommodation areas conform to the 3.5m² of emergency shelter space as recommended by the Red Cross
3. Have separate and secure areas for the different sexes, and children
4. Provide a short term medical area for minor injuries
5. Provide sanitary facilities
6. Provide areas for rest

Figure V-11: Floor plan level 2 Pre-disaster. A103, 1:100@A1

Figure V-12: Main centre by night.

Figure V-13: Market area night.

Figure V-14: "Coffee" area. Night.

7. Provide areas that will allow for economic recovery
8. Provide spaces for community notices and information to be posted
9. Provide a distribution area for supplies and relief aid
10. Provide self-sustaining potential within the building

The main aims for this design were to create a space that the community wishes to actively inhabit pre-disaster. This will create a sense of ownership within the community, so that post-disaster the building are seen as a space to retreat to, and that the building is already well known within the area. To aid with this aim, it was necessary to code in programme that appeals and will draw in a wide section of society, to ensure that those with lower economic resilience are catered for.

Site selection.

The site selected is on the corner of Ghuznee Street and Leeds St. It is approximately 65m long, by 45m wide. The site is currently in use primarily as a car park but has a number of buildings that will need to be demolished. The site was chosen based on the following reasons:

1. Availability of open space
2. Position near to main transport networks (e.g. Taranaki St, high levels of foot traffic)
3. Potential community engagement levels

Figure V-15: Floor plan level O Post-disaster, A104, 1:100@A1

Figure V-16: "Coffice" space night. Leeds St. building's ground floor.

Figure V-17: Shared office space. Level 2 Leeds St.

Figure V-18: "Coffee" space, Leeds St building's ground floor

Figure V-19: View of Ghuznee Street building from parkland.

4. Distance from coastline
5. Protection from high winds
6. Proximity to Cuba Street and Courtney Place (high density of both workplace and residential occupation)
7. Proximity to Victoria University of Wellington, Faculty of Architecture and Design campus (availability of student volunteers)

Programme description.

The pre-disaster Ghuznee Street building houses the Citizens Advice Bureau, a restaurant and bar, and a sports and recreation area on the second floor, with basement storage for emergency equipment and supplies. Post-disaster this building will function as a main information centre for the community, with notices, and coordination being controlled from the CAB offices. In addition, there is accommodation for men and young adults on the second floor. The Leeds Street building is the main economic hub of the development, with a flexible open office space, that is perfect for co-location working, as well as a café area, a small bookshop, and it also provides accommodation for women, families and children from the second floor up.

The sections of society that can be expected to be displaced in the event of a disaster are hard to predict, and as such a broad set of people have been designed for. The following is deemed the "average" user of the shelter post-disaster:

Figure V-20: Floor plan level 1 Post-disaster. A105. 1:100@A1

Figure V-21: Restaurant/Cafe, Ghuznee St. building.

Figure V-22: Main accessway by night.

Figure V-23: Meeting room. Level 2 Leeds St. building.

A family of four, with two adults and two children. They are in the lower to middle bracket of socio-economic status and have found accommodation for family pets. Their normal housing has been damaged beyond inhabitation and they are in need of short-term disaster relief and aid. They have limited contacts in the Wellington region and as such cannot look to friends or family for accommodation, and have limited ability to purchase other types of accommodation in the city. As such they require shelter in the development for up to a week, at which time it is assumed the government will have developed other solutions for the housing and shelter of displaced people.

Design description.

Throughout this design process, there has been an overarching theme of testing, and change. Each time an element of the building was changed, it was evaluated to determine whether it was optimal, or sub-optimal, with changes following based on that classification. The resulting design works at a number of scales, protecting against the large buildings that surround it and allowing for personal interaction at the ground plane. There has been a strong focus on adaptability, with operable walls located in several places, and flexible open plan areas allowing for office works and the public to flow between indoor and outdoor space. Post-disaster, while these spaces have been designed for a specific programme at this stage, it is understood and expected that the users will change from one day to the next as the community's requirements shift. To this end, several areas have been shown as largely untouched in the event of a disaster, the café and restaurant for example. Both can be seen as crucial areas for the community, not just in terms of economic resilience and recovery, but also on a psychological level. Having areas that are classified as in "normal operation" allows a semblance of normality to be restored to those who utilise them, giving them a likely much-needed break from the stress of a disaster situation. The building is primarily a timber framed building, with Techlam supporting structure. Techlam moment frames support the building through mortise and

Figure V-24: Shared office space. Leeds St. building 1st floor.

Figure V-25: Floor plan level 2 Post-disaster, A106, 1:100@A1

Figure V-26: Figure 5.18: Main area post-disaster.

Figure V-27: Market area post-disaster.

Figure V-28: Market area post-disaster.

Figure V-29: Meeting room post-disaster. 3rd floor Leeds St. building.

tenon joining at the columns. The basement level is a concrete slab supported by a piling system. The brick sections of the buildings are in fact brick slips over a timber framed wall.

The design of the Leeds St building has evolved in many ways. The coffee space was originally only single height but is now a double height atrium-like space that seeks to draw in as many people as possible. This space was designed in order to function as a "Coffice"² area for the office workers to utilise throughout the day, and for members of the public to be drawn into. The adjoining bookshop provides a niche market to tap into and helps to balance out the financial viability of the area. This "coffice" area primarily serves the open plan shared offices that inhabit the second and third floor of the Leeds St Building. This office space ensures continued operation and use by many sections of the community, from small start-up workers to more established companies who wish to provide flexible office space for their workers.

The third floor is characterised by its slow sweeping roof line, which draws the eye in, and counters the roof line of the Ghuznee St building and market area. The centre of the Leeds St building is an outdoor space that provides child play equipment for the public to use and gives office workers a space nearby for their children. In a post-disaster scenario, the building transitions into a shelter rather than an office. The second and third floors are stripped of their furnishings and the portable disaster beds are set out. In addition, the ground floor has a had medical centre added to it that can treat minor injuries. The Leeds St building would house families, and single women, ensuring that women and children have separate safe areas for security reasons (World Health Organisation, 2005).

The Ghuznee St building has a restaurant and bar on its ground floor to help drive the usage of the

² A "coffice" space is a coffee-shop office, and provide a different environment that many office workers find to be beneficial to their work productivity (Stewart, 2014).

Figure V-30: Basement plan, A107, 1:100@A1

Figure V-31: Main entranceway post-disaster.

building throughout the day, with doors that lead out onto the open grass area in the centre of the development. Doors also lead into a central atrium space that can be used as a place for reflection. It also has a WREMO/CAB office attached to provide advice to the community pre-disaster on a wide variety of issues. It also has the re-located Polaris pole dance studio on the second floor and provides a large open space for speaking above the restaurant. In a post-disaster scenario, the restaurant transitions into a safe space/hangout area for the community to rest in, and the CAB/ WREMO offices turn into a community notice area and coordination hub. The second floor becomes shelter space for single men, with the pole dance studio returning once suitable accommodation has been found for those occupying the space. The market area provides space for local sellers and artisans to sell their wares in a regular location, thus giving the community a hub to gather around. The open sections of the market also have outdoor BBQ areas for the public, and columns for market vendors to create their own stalls upon.

Located throughout the development are concrete benches that can be stacked, arranged and changed in response to the communities need, providing a novel way to interact with the area. The basement of the design houses the plant rooms, water sanitation facilities, water storage, fuel storage and emergency generators. It also has a large space for the storage of emergency supplies, food, and the shelter beds. Post-disaster this area could also be used for additional accommodation if required, as the use of bedding and supplies in other parts of the building will free up space in the basement. Alternatively, it could also be used to house volunteer staff on-site. In keeping with the wish to remain as self-sufficient as possible, solar panels are installed on the roof, with wind turbines placed around the development.

Conclusion.

Figure V-32: Shared office space post-disaste

In conclusion, this chapter has documented the process of designing a custom disaster relief and recovery hub in central Wellington. It has proved a clear brief that has been adhered to over several months and iterations so that each successive design's success can be gauged. By following this process a design has emerged that serves all the functions and requirements that have been identified and allows future expansion and adaptation to be undertaken.

Figure V-33: Roof Plan, A110, 1:100@A1

Figure V-34: Elevations B101, 1:100@A1

Figure V-35: Elevations B102, 1:100@A1

Figure V-36: Elevations B103, 1:100@A1

Figure V-37: Elevations B104, 1:100@A1

Figure V-38: Sections C101, 1:100@A1

Figure V-39: Sections C102. 1:100@A1

Figure V-40: Sections C103, 1:100@A1

① Pre Transverse Office
1:100

Figure V-41: Sections C104, 1:100@A1

Figure V-42: Sections C105. 1:100@A1

Figure V-43: Sections C106. 1:100@A1

Figure V-44: Roof Structure D111, 1:100@A1

① Roof Structure

Figure V-45: Shelter bed isometric E101, 1:100@A1

Figure V-46: Details F101, Scale noted @A1

CONCLUSIONS

The aim of this thesis was to understand and test the potential for urban disaster shelters to reduce the impact of disasters and increase community resilience. It began with a thorough examination of the existing literature on DRR and CCA, as well as case study analysis of implemented DRR strategies around the world. It drew comparisons between how strategies have been implemented in an urban context, the use in a rural context, and the conceptual implications of each scenario. The outcome of this literature review informed both the direction of the thesis, as well as specific design requirements in any shelter development. Through analysis of Wellington, several sites were located around the city which were deemed to be suitable for shelter implementation, each site with the potential to add to the community once developed. After this process was completed, an existing building was chosen for analysis, in order to determine whether adaptation was possible. The National Library was examined closely, with several key findings resulting from it. The building was deemed to be suitable for shelter usage once a series of internal changes were made, and also assuming that the sanitation facilities were functional. It is important in any discussion of DRR and CCA to prove the viability of a design both pre- and post-disaster. To this end, new programme and functions were coded into the National Library in order to engage the community further before any potential disaster. The outcome of this process allowed a specific brief to be developed for a purpose-built design to be developed. The specific design was located on the corner of Leeds and Ghuznee Street' and the final design has attempted to avoid the shortcomings of the National Library adaptation seeking to engage the community on several levels. It also proposes a complete post-disaster plan, that will allow upwards of one-hundred and eighty-two people to inhabit the building safely, providing shelter and recovery spaces throughout.

This research has allowed a design to be developed that acknowledges the issues surrounding DRR and CCA, and the myriad of complex requirements for a disaster recovery shelter. It is site-relevant and seeks to enhance the community that it is within, allowing for resilience to be built pre-disaster, not just post-disaster. It is hoped that this research will spur further interest in the field of DRR and CCA and stresses the importance of preparing for a disaster, rather than reacting to

one. Resilient community design cannot be taken lightly and must be addressed with the issues of the local community at the forefront. It should engage relief agencies, local governmental bodies, community groups and the public as much as possible in order to create a site-specific design that will allow for the best recovery possible. This research could be used by planners, architects and local officials in order to understand the pressing need for DRR and CCA, and should serve as an example of how to go about designing for a community and site in a way that will increase that specific community's resilience, and therefore the city's. This thesis acknowledges that there are gaps in the research and that further development would allow for greater community engagement. With further testing and development, the author believes that it is possible to develop a series of solutions that are applicable in a wide variety of locales, which will streamline the design process greatly. This would allow people to assess their own environments resilience, and design in DRR solutions as soon as possible. Community resilience is not therefore just about creating a structurally sound building, but is about creating a design that brings the community together, strengthens societal ties, and creates an area that the community can rebuild around in the event of a disaster.

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APPENDICES

Figure VII-1: Sketch concept

Figure VII-2: Sketch concept

Figure VII-3: Sketch concept

Figure VII-4: Sketch concept

Figure VII-5: Sketch concept

Figure VII-6: Sketch concept

Figure VII-7: Developed concept 1 3D

Figure VII-8: Developed concept 1 3D

Figure VII-9: Developed concept 1 3D

Figure VII-10: Developed concept 1 3D

Figure VII-11: Developed concept 1 3D

Figure VII-12: Developed concept 1 3D

① Level 1
1 : 200

Figure VII-13: Developed concept 1: floor plan M/1 pre-disaster

Figure VII-14: Developed concept 1: floor plan M/2 pre-disaster

Figure VII-16: Developed concept 1: floor plan w/ 2 post-disaster

Figure VII-22: Developed concept 1: Exterior 3D

Figure VII-23: Developed concept 1: Exterior 3D

Figure VII-24: Developed concept 1: Exterior 3D

Figure VII-25: Developed concept 1: Exterior 3D

Figure VII-26: Developed concept 1: Exterior 3D

Figure VII-27: Developed concept 1: Exterior 3D

Figure VII-28: Developed concept 1: Exterior 3D

Figure VII-29: Developed concept 1: Exterior 3D

Figure VII-30: Developed concept 1: Exterior 3D

1 Level 0 Pre
1 : 200

Community resilience hub

Floor Plan Lvl 0 Pre Disaster

A101

Scale @A1 1 : 200

Community resilience hub

Floor Plan Lvl 1 Pre Disaster

A102

Scale @A1 1 : 200

Figure VII-32: A102 @ A3

① Level 2 Pre
1 : 200

Community resilience hub

Floor Plan Lvl 2 Pre Disaster

A103

Scale @A1 1 : 200

Figure VII-33: A103 @ A3

Community resilience hub

Floor Plan Lvl 0 Post Disaster

A104

Scale @A1 1 : 200

Figure VII-34: A104 @ A3

Community resilience hub

Floor Plan Lvl 1 Post Disaster

A105

Scale @A1 1 : 200

Figure VII-35: A105 @ A3

1 Level 2 Post
1 : 200

Community resilience hub

Floor Plan Lvl 2 Post Disaster

A106

Scale @A1 1 : 200

Figure VII-37: A106 @ A3

1 Basement
1 : 200

Community resilience hub

Basement

A107

Scale @A1 1 : 200

① Roof plan

Community resilience hub

Roof plan

A110

Scale @A1

Figure VII-39: A110 @A3

Community resilience hub

Elevations 1

B101

Scale @A1 1 : 100

① Cafe North Elevation
1 : 100

② Gallery South Elevation
1 : 100

Community resilience hub

Elevations 2

B102

Scale @A1 1 : 100

1 Admin South Elevation
1 : 100

2 Gallery Cafe East Elevation
1 : 100

Community resilience hub

Elevations 3

B103

Scale @A1 1 : 100

1 Longitudinal Leeds st
1 : 100

2 Market North Elevation
1 : 100

Community resilience hub

Elevations 4

B104

Scale @A1 1 : 100

Figure VII-43: B104 @ A3

1 Pre Longitudinal 3
1 : 100

Community resilience hub

Sections 1

C101

Scale @A1 1 : 100

Community resilience hub

Sections 2

C102

Scale @A1 1 : 100

Figure VII-45: C102 @ A3

① Pre Transverse Office
1 : 100

Community resilience hub

Sections 3

C103

Scale @A1 1 : 100

① Pre Transverse Market
Gallery
1 : 100

Community resilience hub

Sections 4

C104

Scale @A1 1 : 100

Figure VII-47: C104 @ A3

1 Pre Longitudinal North
South Reverse
1:100

Community resilience hub

Sections 5

C105

Scale @A1 1 : 100

② Post Longitudinal
1 : 100

① Post Transverse Office
1 : 100

Community resilience hub

Sections 6

C106

Scale @A1 1 : 100

Figure VII-49: C106 @ A3

① Roof Structure

Community resilience hub

Roof structure

D111

Scale @A1

1 Ghuznee building detail 1
1 : 10

2 Leeds building wall detail 1
1 : 10

3 Roof ridge detail
1 : 10

4 Roof valley detail
1 : 10

Community resilience hub

Details 1

F101

Scale @A1 1 : 10