Figure 1. Vanuatu Beach.
I would like to thank my family and friends for their tremendous support throughout the five years of architectural school.

Thank you to all my fellow students/friends for helping me get through these two years of Masters, couldn’t have done it without you guys.

Also thanks to my supervisor, Dushko Bogunovich, for his guidance and the knowledge he has shared with me through this project.

Special thanks to Reya, Pinda and Manpreet for not only supporting me all these years but also proof reading my document and providing amazing feedback. I couldn’t have made it without you guys.
Figure 2. Vanuatu after Cyclone Pam.
Abstract

As the population, infrastructure and economies around the world are growing, some global issues - like climate change and natural disasters are hindering the social and economic growth in some developing countries, like Vanuatu. The focus of this research project is on designing an educational and research facility, which allows the people of Vanuatu to prepare for and overcome a natural disaster by providing training and emergency relief.

The facility will work in two different phases a ‘pre-disaster phase’, and a ‘post-disaster phase’. The first phase will cater to the everyday life of people where the centre will function as an educational and research facility. The locals, government and disaster relief organisations will have a chance to collaborate and share knowledge in this phase. The second phase is after a disaster has occurred when the centre’s primary role is the emergency relief facility for the local people by local and international disaster relief organisations. There is another, very short phase, immediately after a disaster, in which the repairs to the damaged parts of the building can be quickly performed.

The UNU-EHS (United Nations University’s Institute for Environment and Human Security) has ranked Vanuatu “the world’s most disaster prone country” in an annual World Risk Report four years in a row. The reason Vanuatu ranks at the top is not because it’s exposed to natural disasters excessively more but because of its lack of preparedness, overall vulnerability based on susceptibility, lack of coping and adaptive capacities.

In this project, the Disaster Relief Centre is located in Port Villa, the capital of Vanuatu, near the USP campus. It will be the hub of a system of satellite relief station throughout the main settled island of the nation.

The design solution has two scales: a master plan for the entire DRC compound, and the design of the main DRC building, and both of them are presented in three states: pre-, in- and post; disaster phase.

The design is based on a mix of considerations: functional efficiency; cultural sensitivity; resource self-sufficiency (resilience) and efficiency (sustainability).

The setting of this thesis might be for a specific country but I am hoping that it can be taken as an example for other less developed countries which suffer majorly from natural disasters. The idea behind the project is that educating the people to prepare for a natural disaster is more important for resilience than anything else and should be able to be replicated anywhere.

The role of architecture in this project is to create a design which is strong and should be able to withstand any natural event. Therefore, it will use modern construction methods but will also incorporate the cultural aspect in it for the locals to create a familiar environment. The influential factor behind the idea of incorporating the cultural aspect in modern architecture is to help provide ‘a sense of a safe place’ for the locals and also be educational and inspirational for them at the same time.
Table of Contents

1.0 Introduction..................................9
  1.1 Research Question............................10
  1.2 Background of Project..........................10
  1.3 Project Outline................................12
  1.4 Aims/Objectives of the Project...............12
  1.5 Scope and Limitations..........................13
  1.6 Methodology....................................13

2.0 Defining the Problem............15
  2.1 Literature Review..............................16
    2.1.1 A Global Problem..........................16
    2.1.2 Why is Vanuatu most at risk?...............18
    2.1.3 The ability to Bounce Back................19
    2.1.4 Why Prepare?................................20
    2.1.5 Learning from Japan........................22
    2.1.6 Importance of Cultural Heritage............23
    2.1.7 Traditional Architecture...................24
    2.1.8 Disaster Risk Management....................26
  2.2 Precedent Studies............................28
    2.2.1 International Precedents....................28
    2.2.2 Cultural Precedents - International.........32
    2.2.3 Local Precedents............................36

3.0 Context..................................41
  3.1 Context Research.............................42
    3.1.1 Historical Context..........................42
    3.1.2 Geographical Context........................43
    3.1.3 Climatic Data................................44
    3.1.4 Cyclone Season................................44
    3.1.5 Energy Resources............................45
  3.2 Post-Disaster Impact – Cyclone Pam........46
  3.3 Vanuatu’s History of Disasters...............48
  3.4 Lack of Construction Knowledge...............50
  3.5 Benefits of Preparedness.....................52
  3.6 Port Vila.......................................52
  3.7 National Disaster Management Office.......54
Table of Contents

4.0 Site Analysis...............................57  
   4.1 Site Selection....................................62

5.0 Design Process.......................65  
   5.1 Resilient Design....................................66  
   5.2 Building Function.................................67  
   5.3 A Safe Place.......................................68  
   5.4 Spatial Arrangement...............................69

6.0 Design Concept......................71  
   6.1 Form................................................72  
   6.2 Programme.........................................74  
   6.2.1 Educational Centre..............................74  
   6.2.2 Research Centre/Headquarters..................76  
   6.2.3 Emergency Relief................................78  
   6.3 Public Connection...............................82  
   6.4 Structure..........................................83  
   6.5 Material Selection...............................85  

6.6 Sustainability............................86  
   6.6.1 Rain Water Collection..........................86  
   6.6.2 Power..............................................86  
   6.6.3 Waste water.......................................88  
   6.6.4 Ventilation........................................88  

6.7 Implementation of The Concept........90  
   6.7.1 Performance During Disaster....................90  
   6.7.2 Masterplan.........................................92

7.0 Conclusion..................................95

8.0 References...............................99  
   8.1 Bibliography......................................100  
   8.2 List of Figures.................................103
INTRODUCTION
1.1 Research Question

HOW CAN ARCHITECTURE ENHANCE THE COUNTRY’S ABILITY TO WITHSTAND NATURAL DISASTERS, AND PROVIDE POST-DISASTER RELIEF?

1.2 Background of Project

Vanuatu is one of the Pacific Islands and has a population of 272,264 people, who get struck by natural events multiple times in a year. These events range from small harmless storms to large devastating tropical cyclones, which leaves the whole country vulnerable. Every year, the earthquakes pose 90,000 people at risk in Vanuatu which is approximately one-third of its population and storms pose about 30,000 people at risk. This means that about 64% of Vanuatu’s population is exposed to natural disaster events every year. If a cyclone or an earthquake hits a country like United States of America or Japan, it might only affect one part of the country however when a small country like Vanuatu gets hit by a disaster, everyone gets affected.

Cyclone Pam being one of the recent major destructing events occurred on 13 March 2015. This category 5 cyclone was considered as one of the worst natural disasters in the islands’ history, killing 11 people and left thousands homeless. All these natural disaster events make it very difficult for the country to grow. The shelters being temporary and not built using correct construction techniques leads to the destruction of the homes leaving thousands homeless, therefore they have to renovate or re-build their houses. This constant rebuilding cycle hinders their ability of economic growth.

The inspiration of this project arrived from a studio project running in 2015 which I was part of, the aim of that project was to create low-cost housing and community centre for one of the villages in Port Vila which becomes an example for the other villages and also helping them in their construction techniques. During our site visit to Vanuatu, one of the locals Jerry Epsorm spoke about how this particular village that we were working on suffered less in terms of getting food, as they had started their preparation including saving food and harvesting crops which helped them survive better than some of the others who were unprepared. This made me think how important it is to be prepared for any kind of natural event and how much of an impact it can have post-disaster. Therefore, this research project is based on helping them prepare for the disaster during the standard hours and act as a base camp for emergency relief after the disaster.

---

3 Pacific Community, “Tropical Cyclones Pam Lessons Learned Workshop Report” (SPC's Suva Regional Office, June 2015), 11.
Figure 4. Vanuatu.

Figure 5. Vanuatu.

Figure 6. Vanuatu - Laonkarai Village.
1.3 Project Outline

The research project is based on designing a Natural Disaster Relief Centre in Port Vila, Vanuatu which will act as a base camp during such events and will raise awareness among the locals on how to prepare themselves better for future. The centre will include a headquarters for the organisation to conduct their research and collaborate with other disaster relief organisations and also provide on premises accommodation for aid workers who have come to provide emergency relief. The site will be based next to the University of South Pacific located in Port Vila as they have the current NDMO (Natural Disaster Management Office) nearby but does not have enough space to expand.

1.4 Aims/Objectives of the Project

The aim of this research project is to design a facility for the people of Port Vila which is not only a disaster relief centre but also an educational centre which will help raise awareness in the locals about the impacts of a natural disaster. It will also educate them regarding the hazards, which may come across as a threat during disasters. When a country is better prepared for any kind of disaster it helps in making the recovery process much quicker. During such events it can take up to days before the people especially in the remote regions receive any help from the government or any organisations. These first few days are the most concerning, as it’s not always the disaster which causes death but the aftermath due to lack of food and shelter.

According to an article written after Cyclone Pam, one of the locals informed that a girl died from the exposure to the storm at night as their home got destroyed and her parents did not have a blanket to keep her warm. This is one of the reasons that the aim of the project is to prepare people so they can survive the crucial days after a natural disaster on their own until help arrives. If people started helping themselves, the recovery process will become much quicker and potentially lead towards helping the country’s economic growth in the future.

---

5 Ibid.
1.5 Scope and Limitations

The scope of this project is to create a design which will cater to the conditions of Port Vila, Vanuatu. The project will be majorly focused on helping the locals prepare for natural disasters and providing emergency relief after the disaster. It will provide an interaction space for the community and organisations to come together and exchange their knowledge and resources. This concept can then be used to build facilities similar to this, around the island of Efate as well as around the archipelago at a smaller scale. This facility will operate as a base headquarters to which the smaller facilities will be linked to, creating a network in Vanuatu.

Basing a project in a foreign country is presented with many limitations. I am fortunate to have worked on a project previously in Vanuatu, which looked at providing betterment in lifestyle for a local village. As a foreigner, the biggest challenge is understanding the context and culture of the country which is completely different compared to New Zealand. This is essential when the project is evolved around natural disasters, as you’re dealing with a country in a vulnerable state. Having said that, it becomes vital for the facility to act as a shared space between the community, the government and non-government organisations.

Since this project deals with an ongoing problem which the government wants to resolve, it has the potential to be built and creating an example for other pacific countries dealing with the same issue. Therefore, I had to limit the material presented to suit the existing context. The idea is that the research gathered through this process can be used as a prototype in similar climate conditions.

1.6 Methodology

The design process begins with taking existing knowledge about natural disasters in Vanuatu and exploring it further into the reasons they are considered very problematic for the country.

Research on impact of natural disasters in Vanuatu vs other countries who deal with natural disasters at a similar frequency rate. Comparing the disaster risk management system of the countries, to find out what makes them resilient.

Architectural precedents were analysed in terms of their programme, sustainability, materiality, cultural values and how they can be all combined to design a facility which focuses on them all. The role cultural significance plays in times when the country is vulnerable and how it helps in the recovery process.

Explore different site options in the city centre of Port Vila and do a site analysis based on the public access, visual connection, site conditions and amenities.

Diagrams and drawings were conducted to explore design ideas for the form which fit the programme, site conditions and provide cultural significance. Applying the theories of resiliency into the design principles and exploring options for the structure to withstand natural disasters.
Figure 7. Vanuatu after Cyclone Pam.
DEFINING THE PROBLEM
2.1 Literature Review

2.1.1 A Global Problem

Natural Disasters have become a global issue that our world is facing currently and based on the previous year’s statistics the frequency of it is likely to increase over the years. This issue might not impact everyone in this world but it does impact some more than others. Some natural events are not as destructive as others, although the ones which turn into disasters does seem to leave a major impact on our built environment. “The frequency, scale and distribution of disasters in recent years is further evidence, if any is needed, that hazards – of both natural and man-made origins – are a global problem, threatening to disrupt communities in developed, newly industrialised and developing countries”.

The impact of these disasters on developed or undeveloped countries is different however, developing countries suffer more in terms of the economic loss, which affects the country’s growth. “In part, this high risk felt by developing and newly industrialised countries can be attributed to hazard frequency, severity and exposure”. This talks about how hazards which we are surrounded by posing a major life threat during disasters. Undeveloped countries have a higher fatality rate than developed countries. This is due to the fact that developed countries being more resilient and prepared with their resources have the ability to recover faster. Non – developed countries, however, do not have such a strong economy which impacts their resilience and preparedness, and slows down the recovery process. “Recovery is usually known to be slow, expensive and complex in terms of coordination and management”.

“As a consequence, destruction of a community’s built environment during a disaster, regardless of that disaster’s origin will, in all likelihood, significantly hinder the regular functioning of that society”. This talks about how the impact of the disaster on the built environment’s community affects the way individuals function on day to day basis. Even though emergency relief response has been increased over the years, it is the permanent damage which requires more attention. Emergency relief organisations focus on temporary shelters despite the fact that reconstruction of the permanent structures in the community requires more attention. The literature mainly talks about the problems communities have to face after a disaster and how it affects them. Although, it does not talk about how those issues can be resolved which is something I will be looking at in this research project.

Figure 8. Japan Tsunami.

---

8 Amaratunga and Haigh, Post-Disaster Reconstruction of The Built Environment: Rebuilding For Resilience, 1.
9 Ibid., 2.
10 Ibid., 3.
11 Ibid., 6.
12 Ibid., 13.
Figure 9. Nepal Earthquake.

Figure 10. Vanuatu after Cyclone Pam.
2.1.2 Why is Vanuatu most at risk?

Vanuatu is a small developing country which suffers from natural events like earthquakes, cyclones, volcanic eruptions and tsunamis from time to time at various scales. Some of these natural events can easily turn into natural disasters depending on the scale of the event, with the majority being tropical cyclones and occasional earthquakes.

In March 2015, a few weeks before Cyclone Pam arrived, Vanuatu was dealing with a 6.5 magnitude earthquake which was followed by a volcano eruption on the island of Ambrym.\(^\text{13}\) Due to the continuous cycle of disastrous events Vanuatu has been ranked as 'the world’s most disaster-prone country'. "Vanuatu is the world’s most at risk country for natural hazards, according to a UN University World Risk Index. And it’s not just storms, earthquakes, volcanoes or tsunamis that are the problem".\(^\text{14}\) It is the most vulnerable country when it comes to natural disasters, due to its lack of preparedness. There are four stages to what the country goes through from the point the disaster occurs.

---


\(^\text{14}\) Dillon, “Exposed: Why Vanuatu is the World’s Most ‘at-Risk’ Country for Natural Hazards.”

---

Professor John Birkmann who is the director of the University of Stuttgart’s Institute of Spatial and Regional Planning and also the scientific head of the World Risk Index explains how Vanuatu deals with all these four stages.\(^\text{15}\) This provides the insight of the issues that I will be dealing with for the post-disaster part of my research document. Birkmann also explains the reason Vanuatu is most at risk is not because it is exposed to natural disasters more than any of the other countries for example; Japan or the United States of America but due to their lack of preparedness and resilience for any kind of disaster.

---

\(^\text{15}\) Ibid. Figure 11. Post-Disaster stage diagram.
2.1.3 The ability to Bounce Back – Resilience

Resilience – “a word rooted in the Latin verb resilire, resilience, meaning to spring back or rebound”\textsuperscript{16}. The meaning of resilience has been changed over the years since it was first introduced in the early 17th century. The term has evolved from being a discipline used by some to now a concept, of which everyone has their own definition. It has been known as a concept where the object is able to undergo a state involving a lot of tension and be able to return to its original state without much change. “Douglas and Wildavsky (1982) focus on the ability to simply ‘bounce back’ from a ‘distinctive, discontinuous event that creates vulnerability and requires an unusual response’.”\textsuperscript{17}


\textsuperscript{17} Amaratunga and Haigh, Post-Disaster Reconstruction of The Built Environment: Rebuilding For Resilience, 5–6.

In order to achieve resilience in a city or community, it is important to understand some of the key aspects which are, the hazards around you, the interest of the community, geographical conditions, population, diversity and uniqueness in the community. By having the knowledge of your community and surroundings it reflects the extent of which people are able to recover from any unforeseen event on their own.\textsuperscript{18} One of the key elements of achieving resilience is being prepared. “Individuals, communities, organisations and, indeed, nations that are prepared and ready for an abnormal event, tend to be more resilient.”\textsuperscript{19}


\textsuperscript{19} Amaratunga and Haigh, Post-Disaster Reconstruction of The Built Environment: Rebuilding For Resilience, 6.

Figure 12. Resilience Principles Diagram.
“Conversely, greater mobility, improved communications and awareness, and the growth of national and international NGOs that link societies can all strengthen resilience to crises and improve responses when they occur.” One of the main ways by which resilience can be improved is by raising awareness in the locals which is the intent of this project. The pre-disaster phase of the project involves educating the locals by holding workshops. This will provide them with the knowledge of construction techniques, hazards around them as well as the food and water storage, in order to help them adapt better to any conditions. It is one step closer towards helping the country grow. As when people are able to help themselves and each other without having to rely on much help from the government or any other international agencies, it increases the recovery process and could potentially lead towards a less economic loss in the future.

Another major factor related to achieving resilience is being more accepting towards adapting change. The locals, government and organisations need to change their way of thinking on how to deal with disasters. When people become willing to change the way they think and adapt new methods and techniques to deal with an ongoing issue, it is a step closer towards achieving a solution towards that problem. “The ability and willingness to learn is often linked to adaptability and being prepared.”

2.1.4 Why Prepare?

John Birkmann explains why Vanuatu is the most at risk. He takes Japan as an example and says in an interview for one of the articles written after Cyclone Pam “Japan is highly exposed with the number of people exposed to earthquakes, but disaster risk is lower due to a higher level of preparedness with regard to building codes and infrastructure there, the question of whether an extreme impact is a catastrophe heavily depends on the vulnerability.”

Being prepared is one of the most important elements to recover quickly from a disaster. The size of any disaster cannot be predetermined, therefore it is hard to reduce the economic loss as you can only improve the quality of the building to withstand a catastrophe which has previously occurred. Although, being prepared for a disaster and having the knowledge about the hazards which can pose you threat during one, can reduce the number of casualties.

A good example of why preparation is so important and the difference it can make in terms of the number of lives which get lost during such events is tremendous. In 1992, a category 5 Hurricane Andrew struck Florida, it killed 23 people and caused an economic loss of $26.5 billion. In 1991, a tropical typhoon comparable to the hurricane struck Bangladesh which resulted in the death of 100,000 people and displacement of millions due to the widespread of the flooding. The devastation in Florida was manageable due to the strong social resilience from institutions and early warning systems whereas due to the social vulnerability

22 Amaratunga and Haigh, Post-Disaster Reconstruction of The Built Environment: Rebuilding For Resilience, 7.

Figure 13. 1991 Typhoon Flooding Bangladesh.
in affected areas of Bangladesh, the typhoon resulted in becoming a huge disaster. Tropical typhoons and flooding are common in Bangladesh and during the past decade they have been able to reduce mortality caused by these events through careful planning which was focused on the most socially vulnerable sectors.  

2.1.5 Learning from Japan

Japan is one of the countries who also faces natural disasters on a regular basis and it has led to major destruction in some parts of Japan if not all. A country like Japan is well developed and larger in scale compared to Vanuatu, which is one of the reasons it has the ability to recover and rebuild after disasters quicker. However, the resilience and preparedness have improved over time with awareness being raised on pre and post disaster from past experience.

One of the biggest learnings for Japan was their construction methods for rebuilding after a disaster. When a disaster occurs and causes destruction in a country or part of it is a chance to rebuild that place better than what it was in terms of construction techniques and materials. This will assist in preparing the building to resist any damage or destruction caused by future events. However, that is not the case in most countries due to the economic state of the government or an individual after suffering from such events. Japan is a country which is an example who used this technique after repeating their mistakes numerous times.

Another reason Japan is now resilient is because the government and individuals were willing to adapt to change for a better and safer living environment. “Disasters alone do not revolutionize planning.” They started to take control of the planning of their cities without having to rely on disasters to damage them first before they could improve the structure and quality of the buildings. When a disaster occurs in a city and the infrastructure either gets damaged or destroyed, the focus usually moves on restoring the old heritage rather than building for the future. In countries where disasters occur on a regular basis, it is important to bring change then to hold on to the past and wait for it to be demolished by a disaster, before doing something about it.

27 Ibid.
28 Ibid., 230.
2.1.6 Importance of Cultural Heritage

The Sendai Framework of disaster reduction 2015 – 2030 was adopted by the UN world conference in Sendai, Japan, on 18th March 2015. It is developed for nations and communities to help build resilience to disasters. The framework consists of guidelines which help in preparation of disasters and disaster risk management. The focus of the guidelines is to reduce disaster risk, preventing new risk and reducing existing risk, strengthening resilience and setting guiding principles.30

This framework also talks about cultural heritage being an important strategy of disaster risk reduction.

Nakamal – “A traditional community structure used for decision making, governance, teaching and dispute resolution. Also known as gamal, farea and fare, every village had a nakamal, and the Malvatumauri Chief Nakamal in Port Vila is a significant iconic living heritage where the Council of Traditional Chiefs meet to discuss matters related to the Vanuatu community.”31

The Nakamal located in Port Vila suffered some serious damage although the main structured survived Cyclone Pam, due to its lightweight materials and flexible framing. Many of the nakamals were used as refugee centre after the disaster. The PDNA (Post-disaster needs assessment) conducted by VCC of the cultural sector concluded that it will cost USD 1.4 million to rebuilt and restore the cultural sector. The report revealed that the traditional knowledge system has a major contribution in providing resilience and helping people to recover from disasters.32

32 Ibid.
2.1.7 Traditional Architecture

Architecture is known as being traditional when the local cultural knowledge is reflected in the design. Traditional architecture is the outcome of the design when it reflects on the local cultural knowledge. Every culture has their own knowledge of construction and design techniques, some of which have been evolved over the years by using different materials or methods. Like many other Pacific Islands, architecture in Vanuatu has also gone through the process of evolving using different design techniques, construction methods, spatial organisation and materials over the last century. The archipelago had numerous dwellings styles going around the islands, which use to reflect different origins. Although these have now disappeared over the years, some also forgotten as there is now an evenness amongst communities.33

The traditional architecture of Vanuatu consisted of a hut, which is rectangular in shape and has a gable roof overhanging on both ends of the walls. The walls were quite low on the two sides that the overhang would almost be touching the ground. Both the gable ends of the wall will have a vertical opening for a door just as high as a man. One gable end of the house would be facing the central community space like the rest of the houses around it and was the main entrance of the house to be used by men. The other gable end would be for the women to use which will be facing the bushes or the gardens.34

The main framework of the hut is usually made out of local wood. Bamboo gets used as the main material for roof framing, which is covered with thatch made out of sago palm leaves and fibres from vegetables are used to make walls. It was very important to have the orientation of the dwelling based on prevailing winds for cross ventilation. As there were only two entry points – the front and the back, the rest of the house was fully enclosed. Due to the nature of the cooking style in Vanuatu, a lot of smoke use to be inside these houses, allowing the wood to harden and prevent vermin from ruining the thatch, but it also caused health issues if the dwelling was not ventilated correctly.35

As mentioned above each of the islands in the archipelago had its own unique design style based on its origins. Looking at the island of Efate, the construction of the dwelling was similar to hut shape with a slightly curved gable roof touching the ground as the houses were built half dug in the ground. The roof structure was made out of wood and supported by a carved column in the centre, covered with thatch on the exterior. There was another type of dwelling found on the island of Efate called the hurricane which was similar to the central part of a traditional hut, the difference was the gable ends being fully covered with thatch and touching the ground. It also had vertical openings for doors like a traditional hut, but it was not specified if this particular form was better in performance during a cyclone.36

33 Christian Coiffier, Traditional Architecture in Vanuatu (University of the South Pacific, 1988), ix.
34 Ibid., 44.
35 Ibid., xiii.
36 Ibid., 137–38.
2.1.8 Disaster Risk Management

Disaster Risk is defined when a country gets struck by an event like cyclone, earthquake or tsunami, which can turn into a disaster if it causes any kind of damage or destruction to the infrastructure. Those events leave the country in a vulnerable state, therefore the nation needs to be well organised in advance to reduce the disaster risk and that is where disaster risk management plays a role.37

Disaster risk management is divided into two main phases:
- Pre-Disaster Risk Reduction Phase
- Post-Disaster Risk Recovery Phase

Pre – Disaster Risk Reduction Phase – This phase requires the country to get prepared for any kind of natural events which can potentially turn into disasters. The disaster risk reduction process involves research based on previous years’ disaster statistics, risk and vulnerability surveys, disaster preparedness, any information or planning which will help the country get through such events. It helps in determining any potential hazards which pose a risk to the community or infrastructure, reducing the risk and vulnerability factor and possibly eliminating the risk of a natural event turning into a disaster.38

Post-Disaster Risk Recovery Phase - This phase deals with the aftermath of a disaster. The main focus of the recovery process is to provide emergency relief to the people who suffered. The emergency relief process involves distributing food, water, temporary shelter and also medical, hygiene, transport and telecommunications issues. It also deals with the reconstruction process of any infrastructure which has been damaged or destroyed and calculation of the economic loss and casualties. The recovery is focused on helping the country bounce back to its original state as quickly as possible with the help of local or international organisations. 39

The idea of disaster risk management is to prepare the country to the best level possible in terms of eliminating any possible hazards which can cause damage, destruction or casualties. The better the country is equipped for a disaster, the more chances it has to recover faster and retrieve back to its normal life.

38 Amaratunga and Haigh, Post-Disaster Reconstruction of The Built Environment: Rebuilding For Resilience, 36.
39 Ibid.
Disaster Risk Management System Diagram
2.2 Precedent Studies

2.2.1 International Precedents

The Tokyo Rinkai Disaster Prevention Park

The prevention park is located in the city of Tokyo, Japan and acts as a central base of operations in case of a large-scale disaster. The park not only provides an emergency response but it also houses the local disaster management headquarters and also other institutions who provide disaster-related information and also ways for emergency disaster measures. The park has a large open space area which gets used as a base camp for medical care during a disaster. During the standard hours, the park acts as an attraction for the locals and runs training and other activities to prepare the people for any future natural disasters.40


The park includes the following facilities

Disaster Prevention Base – It is one of the facilities in the park, which acts as the headquarters for the organisations to collaborate with the government agencies and other organisations based outside of Tokyo. The prevention base has a storage facility which holds 139 tonnes of water from which 6 tonnes is to be used for drinking purposes and the remaining 133 tonnes for showers, sanitation and other water systems. It also holds 90,000 litre of fuel stock to be used as an emergency power source, so the centre will keep operating even if the other power sources are down due to the disaster.
Experience – learning facility - The learning centre is divided into two sections, the first is a 72-hour tour which allows you to experience the events which can occur during the first 72 hours of a natural disaster, while the rescue cannot get to you. This helps the people to prepare themselves for the possible events which they might have to face during such events. The second part of the learning centre includes an information lounge, disaster prevention gallery, video hall, lecture room and a window which overlooks to this 72-hour tour to encourage others to participate.
**Entrance Space** – The entrance space area is about 1ha, which is to be used as an emergency relief camp space which will provide medical care to the locals.

**Outdoor Plaza** – This area of the park is to be used as to provide temporary accommodation using tents etc. on site for organisations who have arrived to provide emergency relief.

**Heliport** – The heliport is used post-disaster to allow transportation services to bring people in for emergency relief and any materials or food supplies which might be needed for the locals directly at the headquarters.41

The disaster relief centre facility that I am designing will also include a research centre for the headquarters, educational centre, heliport, a place for medical care and a space for emergency relief. Another sector that I would like to include in my design is a learning space focusing on construction techniques which will also be useful for the locals of Port Vila, as the construction techniques currently used for modern materials is unsafe and becomes a hazard during disasters. The prevention park although uses high-tech and modern design, materials and construction techniques. Whereas the centre for Vanuatu will be using local materials where possible but incorporated in modern construction methods using low-tech. As the locals should look up to it as an example for construction. The relief centre designed for this research project will also have a cultural significance to it in terms of the design and materials to provide the notion of ‘a safe place’ for the locals.

---

Figure 30. Tokyo Rinkai Disaster Prevention Park.

Figure 31. Tokyo Rinkai Disaster Prevention Park.
2.2.2 Cultural Precedents - International

Te Uru Taumatua

Te Uru Taumatua is the new centre of governance and meeting place for the Iwi (a Maori community) in Taneatua built in 2014, near Whakatane, New Zealand which was designed by Jasmax on a 2200 m² site. The main requirement of this facility is to provide a space for large Iwi gatherings and festivals. Sustainability was a key factor in the design, it not only is net zero energy and water but zero waste and toxicity as a result instead of doing less harm these buildings give back to the environment. The building operates as Tuhoe’s Civil Defence centre after a natural disaster event.42

Programme

- Reception Area
- Small Café
- Lobby Housing
- Large Gathering Space
- Library
- Commercial Kitchen and Utilities
- Meeting rooms and open plan offices over two levels

This is a small facility which is only to be used by one particular community, it is a good example in terms of sustainable construction which can be used as a defence Centre after a disaster. It is one of the first building in New Zealand to complete a living building challenge and gives back to the environment.43 Although it does not include any of the other facilities to provide emergency relief and just works as a shelter space for the Iwi community to use in a disaster. However, it does provide a good example of the role cultural heritage can play in a time of disaster. A building which is designed not only to be sustainable and resist natural disasters but also provide cultural significance to make the users feel like it’s their own and acts as a safe place for them.

Figure 34. Te Uru Taumatua - Back View.

Figure 35. Te Uru Taumatua - Front Entrance.

This cultural centre was built in the honour of assassinated New Caledonian political leader of 1989 designed by Renzo Piano. It represents the kanak culture and their traditional local building materials. It consists of a cluster of huts, small pavilions and tree-filled spaces. There are 10 huts which vary in 3 sizes, ranging in between 20-28 metres and are interconnected by a footpath. The three different heights represent three different functions that the cultural centre serves, exhibition spaces, conference room and library and studios for music, sculpture, dance and painting. The shape of the huts was derived from the kanak culture and represents their traditional construction but also has a modern touch to it, by replacing the traditional woven vegetable fibre with wooden ribs and slats. The exterior consists of double skin façade and the skin of the façade is made of adjustable louvers, which allows ventilation throughout the building eliminating the need for mechanical ventilation. The louvers are adjusted according to the wind pressure. The wood used is termite repellent and low maintenance.

The government of New Caledonia had decided to build this centre as the result of increasing ethnic tension between the kanak people and other communities. The starting point for the design of the form was taken from the chief house, which was then deconstructed to come up with the final form. This centre is a good example of incorporating traditional architecture in modern construction materials and techniques and be able to represent the local culture is the building form.


Figure 36. Jean-Marie Tjibaou Cultural Centre.

Figure 37. Jean-Marie Tjibaou Cultural Centre.
Figure 38. Jean-Marie Tjibaou Cultural Centre.

Modified and deconstructed version of traditional New-Caledonia ‘kanak’ for cultural significance

Figure 39. Jean-Marie Tjibaou Cultural Centre.

Movable louver blades to allow ventilation and daylight into the Centre

Figure 40. Jean-Marie Tjibaou Cultural Centre.

Screens to help filter the air

Figure 41. Jean-Marie Tjibaou Cultural Centre.

Column supporting the roof structure, similar technique used in traditional Vanuatu architecture
2.2.3 Local Precedents

Vanuatu National Library and Archives Building & Vanuatu Cultural Centre

Vanuatu National Library and Archives Building was completed in August 2013, located in Port Vila and was constructed by Fletchers Organisation Vanuatu Ltd. The project was funded by Australian Government Overseas Aid Programme with the construction costing VUV232.5 million. It was gift to the people of Vanuatu to mark their 30th independence anniversary. The building consists of two levels with the archives gallery located at the ground floor and Library on the second level. It is connected to the existing Vanuatu Cultural Centre through a covered walkway.45

The Cultural Centre was originally established in 1955 as part of the Franco British condominium. The centre originally consisted of an exhibition room and a library and holds yearly meetings with field workers from different communities to discuss on how to protect and promote the culture of Vanuatu.46

The structure of the building is made out of concrete beams and columns with a concrete strip foundation. The external walls are infilled with dead coral stone approximately 1m high and in-situ concrete above that with window openings. The semi-circular entrance consists of thatch roofing with a modern structure allowing it to be more aesthetically appealing.47

This method of construction has been used in various buildings throughout Port Villa, it is inspired by traditional Melanesian style which is used in the Cultural Centre.48 The exterior of the building is traditional to represent the cultural side of the design, whereas the structure uses modern construction techniques. The structure of the building is quite strong and has resisted any kind of damage from Cyclone Pam.48

47  “Vanuatu National Library and Archives Building.”
High pitched roof to resist the strong winds, storms and cyclones

Modern structure with traditional thatch roof to embrace the cultural element while achieving structural stability

The building is made out of modern material but the front semi-circular entrance acts as a traditional element to connect the locals to Vanuatu’s culture while using western construction techniques

Column supporting the roof structure, similar technique used in traditional Vanuatu architecture
Takara School located on North of Efate Island was built in 2012. It was built as a demonstration for fast and inexpensive construction to meet the growing education demand in Vanuatu. The project aim was to increase the use of local materials and skills while meeting the western building standards.49

The primary portal frame structure is made from locally sourced timber. The design of the portal frame was based around local vernacular, using timber posts and scissor truss system, meeting western standards. This formed a strong and durable building structure, allowing the community to customise the wall infills with the available resources. Local materials like woven sago leaf roof, woven bamboo window hatches and dead corn for walls infills were used. It was constructed by the community, to help them learn the skills for any maintenance afterwards. This project cost 70% less compared to other local building types, is easier and cost effective to repair, involved less construction time, has three times more natural ventilation and 20% more lighting. The building size is 21m x 7m and consists of two classrooms, a store room, teacher’s office and entry veranda. The portal frames are bolted to the concrete base using galvanised post shoes found locally. The dead coral stone used for infilling walls was collected from the beach and were backfilled using a wet concrete mix.50

This school is a good example of modernising vernacular architecture using local materials to western standards. While our stay in Vanuatu, we had a chance to visit this school and examine the building condition after Cyclone Pam. From what we saw, the only part which suffered any damage was the thatch roof which was blown off. The structure was able to sustain from the category 5 cyclone which shows how vernacular form can be modernised and built up to the standard which is safe, strong and durable.51

51  Ibid.
Figure 49. Takara School Vanuatu. Modern structure and construction techniques with traditional thatch roofing.

Figure 50. Takara School Vanuatu - After Cyclone Pam. Tarpoline used to cover the roof structure as the thatch was blown off during Cyclone Pam, however the structure was able to survive the strong winds of Cyclone Pam without any severe damage.

Figure 51. Takara School Vanuatu. Fixed louvers made out of local timber for natural ventilation and daylight to pass through the space.

Figure 52. Takara School Vanuatu. Roof structure built using modern construction methods of a truss system instead of the traditional system where the rafters are supported by a column in the centre.
Figure 53. Vanuatu.
■ CONTEXT
3.1 Context Research

3.1.1 Historical Context

Vanuatu is a Pacific Island located in the South Pacific Ocean and was originally inhabited by Melanesian people. A Spanish expedition led by Fernandnades de Queiros, a Portuguese navigator who discovered the archipelago and claimed the islands as part of the colonial Spanish East Indies for Spain which was named after Australia del Espíritu Santo.

In the 1880’s France and Great Britain claimed parts of the archipelago followed by in 1906 a British French Condominium was formed in which both countries agreed to jointly manage the archipelago. The Independence movement was in the 1970’s, although the republic of Vanuatu was founded on 30th July 1980. The archipelago of Vanuatu is made up of 83 habitable islands which are all isolated. The soil conditions in most of the islands are unstable and they all have very limited access to fresh water. Only 9% of the land in Vanuatu has been used for agriculture. 52

52 Wikipedia, “Vanuatu.”
3.1.2 Geographical Context

Vanuatu has a total area of 12,190 km² and Port Vila is the capital of Vanuatu located on the island of Efate. As of July 2015, Vanuatu’s estimated population is 272,264 and the density is 19.7/km². The population grows at an estimated rate of 2.4% annually and the increasing population requires more resources for agriculture, grazing, hunting and fishing.  

53 Ibid.

Figure 56. Population Growth

Figure 57. Vanuatu Map
3.1.3 Climatic Data

The weather of Vanuatu remains warm to hot approximately 9 months in a year and gets cooler in the remaining 3-4 months. Although the climate has been divided into two seasons throughout the year, summer lasting from November to April and winter season from May to October. The temperature remains uniform throughout the year, February being the warmest and August being the coldest month of the year. Port Vila, in particular, being located on the west coast of Efate results in the average temperature is February remains 27°C and August average temperatures drop down to 23°C. Having said that, warmer seasons get more rainfall than cold seasons but there is no set rain pattern as it is determined by the wind flow.54


3.1.4 Cyclone Season

The cyclones occur during the time of November and April which is the hot season also known as the cyclone season. Vanuatu is located in the south-west Pacific, which is the path of occasional cyclones. In each cyclone season, the average number of cyclones which cross Vanuatu in its path is about 2-3, majority of them arrive in the months of January and February. According to the past statistics “On average, Vanuatu and its marginal seas is a common route to some 20 to 30 cyclones per decade, with 3 to 5 causing severe damage”. 55Due to the size of the islands in the archipelago being very small they are affected by every cyclone which crosses its path.

55 Ibid.
3.1.5 Energy Resources

Water and Sanitation

As the population is growing, the demand for water supply is increasing in Vanuatu. Due to the extreme weather conditions and increasing pollution, the supply of clean water to every single person is very limited. Only 83% of Vanuatu’s population has access to improved quality water, from which 79% is in rural areas and 96% in urban areas. The main water sources in the rural areas are groundwater from open wells, bores, surface water or rainwater collection, due to which the quality of water is compromised by possible contamination.56

Sanitation is also an issue in Vanuatu, as it has not been well planned throughout the country and gets ignored most of the time. Research Statistics by WHO/UNICEF shows that only 53% of the total population of Vanuatu have access to proper sanitation out of which, 48% are based in rural areas and 66% in urban areas. Septic tanks are used in majority of the urban areas for flushing and most of the rural areas use pit latrines which do not have a slab on top.57

After a disaster, a lot of the water sources get damaged leaving most of public without any access to clean water or sanitation systems. When there is no longer any clean water supply for drinking and hygiene, it causes the disease to spread leaving the country in an even more vulnerable state. After Cyclone Pam, 68% of the household population that used rainwater harvesting systems, resulted in their water systems were damaged.58

57  Ibid.

Power Supply

The Energy Statistics from 2013 showed that only 27% of the households, 25% health centres and 42% of schools in the whole of Vanuatu had access to electricity.59 Vanuatu has no known fossil fuel of its own, majority of the energy resources like petroleum, diesel, LPG, kerosene, jet fuel and avgas gets imported into Vanuatu. The largest demand being diesel imported at a rate of 33 million litres each year.60

60  Ibid., 23–24.
3.2 Post-Disaster Impact – Cyclone Pam

On March 13th 2015, Vanuatu was hit by a category 5 Cyclone Pam, which was considered as one of the worst cyclones in the islands history of natural disasters. The archipelago was also hit by a 6.5 magnitude earthquake, which was followed by a volcano eruption on the island of Ambrym first time in 100 years just two weeks before Cyclone Pam.61 The cyclone caused a lot of damage, killing 11 people and leaving more than 65,000 people homeless. The devastation caused by the disaster also included the destruction of all the crops which was the main source of food for the people. Although the shops still had canned food, but not all the locals were able to afford it leaving them in desperate need of help. 62

The strongest cyclone recorded in the island’s history before Cyclone Pam was Zoe which struck at a pressure of 890mb in 2002. Although Cyclone Pam was not far behind, striking the island at a pressure of 899mb and becoming one of the most powerful storms to cross its path through Vanuatu.63

Some of the villages which suffered less damage in terms of food were those who harvested their crops as soon as they received the cyclone warning and dug large holes in the ground to store food supplies and prepared themselves for the worst. The island of Ambrym which had just suffered from a 6.5 magnitude earthquake followed by a volcanic eruption. Even though there wasn’t any damage done by the earthquake or volcano, the island of 7000 people wasn’t ready to be hit by another natural event which will turn into a disaster, as they did not have any time to prepare. Their fields were flattened by the storm, which left them with minimal food supplies lasting hardly a week.64

61 Robertson, “Vanuatu Disaster.”
64 Robertson, “Vanuatu Disaster.”
Post-Disaster Issues

Shelter
Urgent shelter assistance is required after any natural disaster. Setting up tents or temporary structures as soon as possible, as more than the disaster it's the exposure which affects people.

Logistics
Having the transport facilities to bring the goods into the country and easily able to distribute them around the country.

Emergency Telecommunications
The organisations should be able to communicate with each other in different areas to keep up to date track of the situation in all the affected areas.

Health & Nutrition
Urgent medical assistance, for those who are affected by the disaster and also those who are suffering any pre medical conditions. Having medical supplies stored and setting up medical camps in the affected areas.

Water, Sanitation and Hygiene
Not having access to clean water, sanitation and hygiene services which can become the cause of spreading disease. Providing clean water in the areas where there is no access to water and filters in the areas accessible to water sources, also providing soaps etc.

Safety and Protection
To ensure the assistance provided doesn't cause tension between the community members.

Food Security
Agricultural lands need food security assistance, as there is risk of pest infestation on affected lands which can reduce the speed to recovery.

Education
Primary and Secondary education gets affected by schools being damaged or destroyed. Setup emergency schooling camps.

Figure 64. Post-Disaster Issues.
3.3 Vanuatu’s History of Disasters

Vanuatu has had a long ongoing history of natural disasters in the archipelago, located in the Southern Pacific Ocean it is in the path of many Tropical Cyclones which occur in the Southern Hemisphere.

A country like Vanuatu poses a risk not only from large-scale natural disasters but also from seasonal storms which can potentially become a hazard for the locals. Vanuatu is not the only country who suffers from natural disasters but because of the lack of preparedness, vulnerability, susceptibility, lack of coping and adaptive capacities that it has been ranked the world’s most disaster-prone country.65

These are the following statistics of Vanuatu’s Natural Disasters from 1990 – 2014: -


---

Figure 65. Combined Economic Losses Chart.

Figure 66. Deaths Caused by Scale Disasters Chart.

Figure 67. Frequency Chart.
Figure 68. Frequency Chart.
Figure 69. Frequency Chart.
The charts above show the number of large-scale natural disasters Vanuatu has suffered from 1985 to 2000 and then from 2001 to 2016, both being a 15-year time period. Comparing both the charts, the number of destructive cyclones which have occurred from 1985-2000, were 15 Tropical cyclones and from 2001 to 2016 the number was also 15. Although, as you can see above the frequency of the cyclones has increased from 1985-2000 compared to 2001 – 2016. In between 1985-2000 there were seven years where the country was not struck by any major cyclone however, between 2001 – 2016, there were only two years without any major disaster. This shows us that in the last 15 years the frequency at which the cyclones occur and cross path through Vanuatu has increased, from which assumptions can be made that the frequency may continue to increase in future. Therefore, the country needs to prepare itself, as it is easier for an unprepared country to deal with perhaps one major disaster in a year and be able to recover from it slowly. If a country gets hit by a small scaled disaster in the earlier stages, it is bound to cause severe damages. To have that followed shortly by another disaster increases the recovery time resulting in major catastrophe.66


3.4 Lack of Construction Knowledge

A country like Vanuatu suffers from a lot of damage due to not having a building code or standard which everyone should follow while constructing any building. As a lot of people build their own houses using any materials they can find modern or traditional. Most of them do not have the correct knowledge to use these modern materials in the right manner, which in a disaster causes the building to collapse. Although, a majority of the people have now moved away from traditional building materials and have started using modern materials like concrete blocks and corrugated metal roofing.

During our visit to Vanuatu, which took place a few months after Cyclone Pam, we spoke with the local’s communities and found that some of the locals died due a concrete block wall falling over them or from the metal roof flying away because of the strong wind gusts. Based on our experience what we found was that a majority of the construction done in the villages was done using concrete blocks. The walls had been built without any reinforcement or mortar and the corrugated roofs were placed over houses by using concrete blocks to apply weight and were not fixed using nails. As a result, people were killed by the buildings which used modern materials, a lot of the locals especially elderly people were scared of using them and blamed the modern construction and materials for those deaths.

Figure 70. Loankarai Village.
Figure 71. Loankarai Village.
Figure 72. Loankarai Village.
3.5 Benefits of Preparedness

The village of Launkarae is located on the north coast of the island of Efate. This village consists of about 30 people, the majority of them being women and children, whom we visited after Cyclone Pam. Although there was some severe damage on their shelters, after talking to them we found out these people were not relying on any outside help. As sometimes it doesn’t arrive to them on time, due to being a small community and also situated at a distance of 45 – 60 minutes’ drive from the capital. The people of this village had already started storing food and water and putting away the hazards which could get blown off by the strong winds and harm someone. Due to their preparedness, they were able to survive the aftermath of the disaster and recover from it quicker than some of the villages which were unprepared. This led to those other villages around the islands being vulnerable and in desperate of disaster relief.

3.6 Port Vila

Port Vila is the largest city in Vanuatu and has a population of 44,040 people, it forms about 18.8% population of Vanuatu and 66.9% of the island of Efate. The Bauerfield International airport and the harbour for country’s main trade are also located in Port Vila. The major industries which benefit the economy of Vanuatu in Port Vila are fishing, agriculture and tourism.67

After Cyclone Pam, a lot of people were affected in Port Vila, out of which more than 50 families in the northern suburb lived in a church. The reconstruction of their houses was months away, so they continued to live inside the church waiting for their houses to be rebuilt. They had no food and were waiting for help to reach them, somewhere they felt forgotten as no helped arrived to them.68

68 Robertson, “Vanuatu Disaster.”
Figure 73. Port Vila Map.
3.7 National Disaster Management Office (NDMO)

The National Disaster Management Office (NDMO) is the current government agency located in Port Vila, who deals with disaster preparedness, response and recovery options. They work alongside NGOs and INGOs, locally and internationally to organise programmes which will help in disaster risk reduction and management, also help reduce the vulnerability in the local communities of Vanuatu.

After any natural disaster, the NDMO in collaboration with other organisations holds a workshop, at the end of which they create a report. The report determines the things which need to improve in the disaster risk reduction and management programme, in order to improve the preparedness, response and recovery system. The report after Cyclone Pam states the need of better evacuation centres and storage spaces, as at the moment schools get used as an Evacuation Centre. This causes an impact on the education system when they are being used for long-term shelter purposes.

---


70 Pacific Community, “Tropical Cyclones Pam Lessons Learned Workshop Report,” 2.
Figure 80. Port Vila.
■ SITE ANALYSIS
KEYS
- Site
- Minor Roads
- Secondary Roads
- Primary Road

Figure 82. Ministry of Education Site Map
Figure 83. National Disaster Management Site Map
SITE THREE - UNIVERSITY OF SOUTH PACIFIC

Figure 84. University of South Pacific Site Map

KEYS
- Site
- Minor Roads
- Secondary Roads
- Primary Road
4.1 Site Selection

Location
The site is located within the town limits of Port Vila between Teouma Road and Linl Highway, and is part of the Emalus campus of the University of South Pacific. The location of the site is based on the site analysis and criteria, as this site was able to meet the requirements of both. It is approximately 6.2km away from the Bauerfield International Airport via Linl Highway and 4.6km from the Port Vila wharf. Currently, the site does have small existing buildings which are part of the University, which will be demolished and in exchange the University will be able to use the educational centre, as there will be a close working relationship between the two. It does have a close relationship with the rest of the city centre facilities as well and is more than 10m above sea level and not too close to the coastal area.

Criteria
The site has been chosen for the following reasons:
- Located in the main city centre of Port Vila, easy accessibility to the airport and the wharf and at least 10m above sea level.
- Close proximity to the parliament and other government organisations, as the programme of the building, will include working with these facilities.
- Due to the nature of the building it should be able to provide temporary accommodation on the site after a disaster for aid workers, therefore requires large site area.
- Within close relationship of other educational facilities in order to collaborate with one another to help deliver a stronger message to the community about preparation for disasters.
- Accessibility from the main ring road of Port Vila which connects goes around the whole island of Efate.
Figure 85. Environmental Diagram - USP
Figure 86. Loankarai Village.
■ DESIGN PROCESS
5.1 Resilient Design

As discussed in the previous chapters a country has to be resilient in order to survive and recover from a disaster and continue to operate in the same manner as before. The three key design principles are as following:

- Redundancy
- Diversity
- Flexibility

**Redundancy** – “Redundancy is the duplication of critical components or functions of a system with the intention of increasing reliability of the system, usually in the form of a backup or fail-safe”.71 It is one of the key principles for designing a resilient building. As a building which needs to withstand any natural disasters and continue to function to provide emergency relief to the people, cannot just rely on one energy system. In this project, I am going to use the concept of redundancy by providing more than one system for power and water sources. Redundancy can, however, decrease the efficiency of the building in terms of adding more construction and running cost but the resiliency increases which is the aim of this project.72

**Diversity** – In this project diversity will be achieved by providing various functions to the building. The centre has three different sectors and each of those have a different purpose which caters for a range of people from the general public to government and disaster prevention organisation officials. Each of those three sectors in the building has a pre and post-disaster phase, the post-disaster phase will be focused on providing emergency relief by all three. This means having three different sectors, firstly it speeds the recovery process and secondly if one of the sectors is down due to any serious damage from the event, the other two will still be operating to provide relief.73

**Flexibility** - Being resilient, is being willing to adapt to change. In order for a building to be resilient, it will need to adapt to the extreme circumstances while still functioning. Therefore, there needs to be flexibility in the design. As having rigid layout and systems does not provide any flexibility to the building or space to operate for some other use than its original purpose. In this project, the flexibility will be achieved in the internal layout of spaces as it will allow a particular space to be adjusted depending on the phase. By having non-structural movable walls, it makes the spaces more versatile allowing multiple uses of each space, for example the movable walls in classrooms will allow the space to be turned into accommodation area for relief staff.74


73 Ibid.

5.2 Building Function

The design function is based on the disaster risk management response discussed earlier in the chapters. It is divided between the two phases which come under disaster risk management, pre-disaster risk reduction and post-disaster risk recovery phase. The facility I am going to design for this research project consists of three sectors, each of which fulfils the roles of disaster risk management. The design facility functions are as following:

- Educational
- Research Centre/ Headquarters
- Emergency Relief

Figure 87. Building Function Diagram
5.3 A Safe Place

As explained in the previous chapter the importance cultural heritage has on disaster risk reduction, therefore having a building which represents the cultural heritage of Vanuatu will be essential. ‘Nakamal’ which is the traditional community house of Vanuatu, is a reasonably large building fully enclosed on all four sides with a gable roof and just an opening for the main door. It is made out of traditional materials like thatch used for roofing and pandanus leaf used for weaving the mats which are used for the outer walls. 75

Since this design facility is for the locals of Vanuatu, it is important that they feel welcomed in the space. The form of the centre is inspired by the traditional nakamal, so when the building is approached by any of the locals it gives them a feeling of ‘a safe place’. It will also include the use of local traditional materials combined with modern materials and technology.

75 Joëlle Bonnemaison et al., eds., Arts of Vanuatu (University of Hawaii Press, 1996), 103.
5.4 Spatial Arrangement

The spatial arrangement of the facility is based on the connection between the three zones, socio-cultural, function and circulation.

Socio-cultural is the outer zone where the public courtyard is located for all the community activities and events which will be taking place. The courtyard will be acting as a communal space for the local community to come together as it is an important part of the culture. While the aesthetics of the building should provide the locals with the facility being their own and part of their community.

Circulation being the middle zone acts as a thoroughfare between the socio-cultural and function zone. In Vanuatu’s traditional architecture, the typical huts are usually divided into three sections, one middle and two sides. The side sections are where the sleeping rooms are located and the middle has the entrance door, acting as the main circulation space. It is the common area of the house where the domestic life takes place. Applying this traditional concept of using the middle section of the dwelling as circulation and the main entry point in the design. This is where the reception area will be located, so it will act as the common shared space inside the facility. Due to this fact, the building form is in a Y-shaped representing three wings which are interconnected through the circulation space.

Function zone is where the facility will be operating the pre and post disaster phase. The three programmes of the building will each be located in a different wing. Each programme will have a direct connection to the ground level, whether it is through transparency or movement depends on the function. The wings will be defined as individual centres even though it is all under one roof. The three centres are educational, research and emergency relief. The education centre is located in the North West wing which is the starting point of the slope on the site, being the most exposed to the public as it facing the main road. Therefore, needs a direct transparency and movement connection with the people and public courtyard. The research centre is in the South West wing, the site becomes slightly higher on that end which allows the centre to only have the transparency element, as this facility will only be used by the staff. The emergency relief centre is the East wing facing the University of South Pacific, where the slope level becomes high. The reason for placing the relief centre at the back is because majority of the services allocated in the centre will only be used in the post-disaster phase. Also, this centre will have parts embedded into the ground as it has to be the strongest part of the building.

---

76 Coiffier, Traditional Architecture in Vanuatu, 137.
Figure 91. Loankarai Village - Vanuatu
DESIGN CONCEPT
6.1 Form

The form of the building is a Y-shaped plan which is derived from numerous factors based on the research. As the building facility will have three different functions and each of those functions requires a different level of privacy and access, therefore it was essential to have different spaces for them. Although they all had to be integrated together, due to them collaborating with each other at one point or the other during normal days and post-disaster all the three functions will be focused on one common function which is providing emergency relief.

Also keeping in mind the key principles of resilience, how the design needs to be diverse in order to increase the resiliency aspect. Therefore, by having a Y-shaped building which has three wings, each dedicated to one function and if one gets damaged in a major disaster which Vanuatu has never experienced before, the facility can still operate with the others.

The site itself plays an important role in the plan, as it is located between two roads which means it will be approached from two different directions. Therefore, the idea of the three wings and two of them having a direct visual connection from the roads it gives an opportunity to have the ‘nakamal’ form visible on both sides to maintain the cultural connection with the people. Therefore, the idea of having three wings gives it the opportunity to have the ‘nakamal’ form visible on all sides. This allows the facility to maintain the cultural connection with people.

There are also a few environmental factors involved in the form. Vanuatu is a country which does not have many resources of its own, it imports diesel and other resources from outside. Of the total population of Vanuatu 75% people do not have access to electricity. Therefore, it is essential to adapt the idea of sustainability in the design.

The facility should be able to operate off the grid, by using a passive system for natural ventilation and lighting. The two wings facing the road will have the educational and the research centre and the emergency relief centre will be facing the university and will be partially underground as it needs to be more secure. Majority of the winds in Port Vila arrive from the easterly side, so it is beneficial to have a building which has long narrow wings to allow natural ventilation.

Figure 93. Form and Exterior Sketches
6.2 Programme

As discussed in the previous chapters and based on the precedent study analysis, this project needs to focus on providing the locals of Vanuatu with three main functions and each of which will have its own programme based on the phase. These three functions are going to be under one building and will share a common entrance for public use where the reception area/Information centre will be placed. The following three functions of the facility include:

- Educational Centre
- Research Centre/Headquarters
- Emergency Relief

6.2.1 Educational Centre

- Library
- Disaster Prevention Gallery
- Classrooms
- Workshops

Pre – Disaster Phase

The main aim of this centre is to help the locals in getting prepared for any future disasters. This can be achieved by holding regular activity classes and workshops including watching educational short films. There will also be workshops running on construction methods and techniques using modern materials in a correct manner to increase their knowledge. The disaster prevention gallery will showcase the key things they need to have prepared before any natural event and also showcasing possible hazards which they are surrounded by and can cause them harm during a disaster.

The University of South Pacific will also have full access to this programme so that the knowledge can be shared. Also having an educational centre involved in a project like this will be beneficial as it will encourage the students to learn more about disasters and how to be prepared for a better future. This will result in the students encouraging the locals, who do not have the resources to get an education to learn something which may help save their life one day.

Post- Disaster Phase

After the disaster, the classrooms and workshops will be used as sleeping spaces for the organisation members local or international, who have come to provide emergency relief. One of the main functions of the building is to provide accommodation for the people who have come to help so that they can all be under one roof which will make the relief process quicker.
Figure 95. Educational Centre Concept Plans
6.2.2 Research Centre/Headquarters

- Conference Room
- Offices
- Auditorium
- Operations Room
- Staff Room

Pre – Disaster Phase

This research centre part of the building will only be accessible to staff members who work there and any local or international disaster prevention organisations. The University of South Pacific will be able to collaborate with the research team to give their input towards and research or surveys which are required. It will also be used to hold conferences related to disaster prevention.

Post – Disaster Phase

When a disaster has occurred the research centre will be the base headquarters for providing emergency relief in Vanuatu. The facility will be connected to local and international, government and non-government organisations through land and telecommunication services. The research centre will have more than one power source, allowing it to run with no interruption even if local power source has been damaged.
Figure 96. Research Centre Concept Plans
6.2.3 Emergency Relief

- Large Storage Space
- Recreation Spaces (Sleeping Rooms, Showers, Toilets, Lockers)
- Commercial Kitchen
- Medical Centre

Pre – Disaster Phase

During normal hours the emergency relief sector of the facility will be used for storage supplies kept in case of a disaster. It will also include recreational spaces to be used by the organisation members who have come for research purposes. There will be a medical centre included in this building which can be used by public or staff members when needed.

Post – Disaster Phase

The post-disaster phase of this sector will be focused on providing emergency relief to locals. Any public member can come to the centre if they need food, water, hygiene or medical supplies and all these will also be distributed to the people in need. The recreations spaces will be used to reside any organisation members while they are there to help. One of the reasons for picking a large enough site was so that the accommodation provided on the site can be expanded out onto the site by placing tents if needed, depending on the scale of the disaster. There will be a helipad on the site located near this section of the building to bring supplies and people in the country. The medical centre will be temporarily placed outside on the site to provide any aid to the locals after the devastation.
Emergency Relief Centre Concept Floor Plans

Ground Floor

First Floor

Figure 97. Emergency Relief Centre Concept Plans
Design Concept

GROUND FLOOR

FIRST FLOOR

LEGENDS
- EDUCATION
- RESEARCH
- EMERGENCY RELIEF

Figure 98. Design Concept
6.3 Public Connection

As the facility is being designed to bring awareness to the locals about how to prepare themselves for natural events, it is essential to have a public socialising space. The public courtyard was defined by the negative space between the research and educational centre, as that is the main road frontage and anyone driving or walking by would have a visual connection to the space.

The idea behind creating a visual connection between the courtyard and the context around is to make the space inviting to a diverse group of people. The locals will be able to see the public activities going in the courtyard and it will encourage them to join others and learn more about the facility and what it has to offer.

Figure 100. Design Concept
6.4 Structure

The structural systems for the building will support the original driving force of resilience. Durability plays an important part in the structural process as it will establish to which degree can the structure sustain damage and be able to be reconstructed.

In a cyclone-prone region, the structural emphasis should be less on the material and more on the construction method. The focus is required to be on resisting high wind forces being applied to the structure. Foundation is the primary element of the building, as it transfers the building load to the ground. The stability of the building during a cyclone depends severely on the foundation. A building constructed using light material i.e. timber requires larger or heavier foundation to be able to perform correspondingly in a cyclone as heavy material construction i.e. concrete. 78

During earthquakes the structure should have the ability to resist seismic forces, therefore ductility of material becomes important. Ductile materials have the ability to stretch when a tensile force is applied.79Connections and proportions of ductile materials in a structure defines how well it can perform. If not used in the correct manner, the nature of ductile material cannot be exploited to its full potential.80

As I began exploring ideas for the structure, I was inspired by the local precedents. The use of traditional form and local materials with modern construction techniques in the Takara School and Vanuatu Cultural Centre. Both these buildings were able to resist many severe damages caused by Cyclone Pam. Since the idea behind designing this facility is to also provide cultural significance, I am taking inspiration from both these precedents.

The building form is derived from vernacular architecture. It will incorporate the use of locally found and imported materials. The main structure will be formed out of pre-stressed laminated timber beam and columns. These create a moment frame by using high strength post-tensioning tendons or steel bars. Moment resistance is provided at each beam-column joint by tendons running inside beam ducts, passing through column holes through the whole structure. During an earthquake, the joints become rocking with the help of elastic tendons. This allows the joints to open and close between individual members, pulling it back to the original state once shaking decreases. Ductile steel braces are used to provide additional strengthening at the top and bottom of the beam, increasing the moment resistance of the beam-column connection. 81

Pre-stressed laminated timber is pre-fabricated and will be imported to Vanuatu from New Zealand. The construction of this facility will require funding and help from neighbour countries. The New Zealand government can contribute by supplying the structural material. By doing so, it will also promote New Zealand’s technology, as the product is made and developed in New Zealand. Although if the material is not supplied by NZ due to funding or political issues, it can be substituted with steel framing and will fit equally well in the design concept with a similar outcome.

80 Ibid., 24.
The roof structure material is glue-laminated timber, beneficial for achieving longer span and will use a collar roof system. This system prevents the rafters from dispersing when under load. It is placed approximately at one-third of the distance from the ridge to the wall plate line, also providing extra ceiling height.\textsuperscript{82}

6.5 Material Selection

In a country where an individual’s survival and infrastructure are at risk on a yearly basis, the ability for a building to sustain itself becomes very important for everyone’s safety. Therefore, the material selection should reflect the strength and the ability to sustain itself for the worst. The use of materials like pre-stressed laminated timber for the main structure of the building will provide the traditional aesthetics of Melanesian architecture as well as structure strength, to withstand any natural disasters.

By constructing the structure out of pres-lam it creates a sense of structural integrity of the building. This means that if the structure is strong to resist any disaster, the cladding can be made out of soft materials like timber which is found locally and if the cladding gets destroyed it can be easily replaced. Also, as long as the structure remains intact with the building it will be able to operate and provide emergency relief.

The use of a soft material like timber for the exterior cladding not only provides the advantage of being locally available but also is less of a hazard compared to a hard material. Timber is also one of the main material used in a traditional Vanuatu dwelling. This gives it an advantage in terms of providing cultural significance to the locals. The design will also incorporate the use of dead reef found on local beaches for infilling part of the walls.

The roof will be made out of corrugated metal, which is also found locally and is being used a lot in construction throughout Vanuatu. Although due to the lack of construction knowledge, the material ends up being a hazard. In terms of using the roof surface for rainwater harvesting, the amount and quality of rainwater collected will depend on the area and type of roofing material. Corrugated metal roofing material is suitable for pure rainwater collection. Therefore, by using this material in the correct manner it will be providing the locals with an example of how it can be constructed so it eliminates the risk of the roof getting blown off and becoming a hazard.

6.6 Sustainability

6.6.1 Rain Water Collection

Since clean water in Vanuatu is not easily available, the centre will be collecting its own water through rainwater harvesting system throughout the year. Port Vila on average has 2360mm of annual rainfall. This means even if only 1000m2 of the roof area of the building is used for rainwater harvesting, it should be able to collect 2,360,000 litres of water annually.

The facility will have 6 x 30,000 litre water tanks used for rainwater harvesting. Out of which, 3 x 30,000 litre tanks will only be used in case of disaster emergency. The remaining 3 x 30,000 litre tanks will be used to meet the everyday needs of the building. It will also have a connection to the local water supply of Vanuatu but that will be used in case of emergency or if the rainwater system is down due to maintenance, as a backup option.

Majority of the rainwater harvesting systems operate using the roof drainage systems. In this method, the rainwater runs down the roof and into the roof gutters. The gutters are connected to downpipes which runs down the water through a filtration process, removing all the dust particles and leaves, making it drinkable. Once the water has been filtered, it then gets stored in a tank.

6.6.2 Power

The power supply is a real issue in Vanuatu, as it is not available to all the households. The energy sector in Vanuatu is operated by an independent government agency with the help of two private utilities which are, Union Electrique du Vanuatu (UNELCO) and Vanuatu Utilities and Infrastructure (VUI). Therefore, the building will be generating its own power using solar panels mounted on the roof. The solar panels will be placed on the roof facing North, North East and North West. In order to maximise the solar collection output and get optimum sunlight, the panels will be adjusted throughout the year.

Once the panels are installed on the roof, they can convert sun rays into direct current electricity which gets converted into alternating current electricity through an inverter. The alternating current electricity will be supplied directly to the building. If the solar panels produce any more energy than what the facility requires, the excess power will be stored in battery banks. When the batteries are charged, any more excess energy after that will be fed to the public grid. If the solar panels do not produce as much energy due to bad weather, the facility will the grid connection to meet its needs.

84 Wikipedia, “Port Vila.”
This table below shows the average solar insolation figures measured in kWh/m2/day onto a solar panel where the angle is adjusted each month to get optimum sunlight.87 (All this data have been calculated using www.solarelectricityhandbook.com/solar-irradiance.html)

<table>
<thead>
<tr>
<th>Direction</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>6.67</td>
<td>6.08</td>
<td>5.78</td>
<td>5.40</td>
<td>5.02</td>
<td>4.83</td>
<td>4.98</td>
<td>5.39</td>
<td>5.82</td>
<td>6.37</td>
<td>6.53</td>
<td>7.02</td>
</tr>
<tr>
<td>NNW</td>
<td>6.50</td>
<td>5.93</td>
<td>5.64</td>
<td>5.26</td>
<td>4.89</td>
<td>4.71</td>
<td>4.86</td>
<td>5.26</td>
<td>5.67</td>
<td>6.21</td>
<td>6.37</td>
<td>6.84</td>
</tr>
<tr>
<td>NW</td>
<td>6.34</td>
<td>5.78</td>
<td>5.49</td>
<td>5.13</td>
<td>4.77</td>
<td>4.59</td>
<td>4.73</td>
<td>5.12</td>
<td>5.53</td>
<td>6.05</td>
<td>6.20</td>
<td>6.67</td>
</tr>
<tr>
<td>WNW</td>
<td>5.84</td>
<td>5.32</td>
<td>5.06</td>
<td>4.72</td>
<td>4.39</td>
<td>4.23</td>
<td>4.36</td>
<td>4.72</td>
<td>5.09</td>
<td>5.57</td>
<td>5.71</td>
<td>6.14</td>
</tr>
<tr>
<td>West</td>
<td>5.34</td>
<td>4.86</td>
<td>4.62</td>
<td>4.32</td>
<td>4.02</td>
<td>3.86</td>
<td>3.98</td>
<td>4.31</td>
<td>4.66</td>
<td>5.10</td>
<td>5.22</td>
<td>5.62</td>
</tr>
<tr>
<td>NNE</td>
<td>6.50</td>
<td>5.93</td>
<td>5.64</td>
<td>5.26</td>
<td>4.89</td>
<td>4.71</td>
<td>4.86</td>
<td>5.26</td>
<td>5.67</td>
<td>6.21</td>
<td>6.37</td>
<td>6.84</td>
</tr>
<tr>
<td>NE</td>
<td>6.34</td>
<td>5.78</td>
<td>5.49</td>
<td>5.13</td>
<td>4.77</td>
<td>4.59</td>
<td>4.73</td>
<td>5.12</td>
<td>5.53</td>
<td>6.05</td>
<td>6.20</td>
<td>6.67</td>
</tr>
<tr>
<td>ENE</td>
<td>5.84</td>
<td>5.32</td>
<td>5.06</td>
<td>4.72</td>
<td>4.39</td>
<td>4.23</td>
<td>4.36</td>
<td>4.72</td>
<td>5.09</td>
<td>5.57</td>
<td>5.71</td>
<td>6.14</td>
</tr>
<tr>
<td>East</td>
<td>5.34</td>
<td>4.86</td>
<td>4.62</td>
<td>4.32</td>
<td>4.02</td>
<td>3.86</td>
<td>3.98</td>
<td>4.31</td>
<td>4.66</td>
<td>5.10</td>
<td>5.22</td>
<td>5.62</td>
</tr>
</tbody>
</table>

6.6.3 Waste water

The government of Vanuatu has given the contract for Port Vila's first septic waste treatment plant, in order to improve the sanitation system. The project is now under construction and is expected to be completed by the end of 2016. “Basically, it will pick up all septic waste out of septic tanks and goes and discharges there. Previously, it was an unsightly condition that has not been dealt with for a long time.” 89 This encourages the use of septic tanks throughout Port Vila, therefore the facility being designed for this project needs to support this act by using septic tanks in the building.

**Septic tanks Process**

The waste water will be treated on site using large capacity septic systems. The water from the building through pipes goes into the septic tanks which are buried underground. The concrete septic tanks are watertight, it holds the water until the solid particles settle down at the bottom of the tank and the oil and grease float to the top. The liquid remaining in the middle then gets pumped out to the drain field area, where removes the harmful viruses and bacteria by penetrating in the soil. 90

The solids and the scum in the septic tanks needs to be removed at a regular set time frame. Maintenance and inspection of septic tanks are very important in order to eliminate the chance of possible contamination to any drinking ground water sources.

---


6.6.4 Ventilation

In order to reduce the running cost and environmental impact, the building will use natural ventilation as its main source of cooling and mechanical ventilation as a backup source. In terms of the building having a good natural ventilation system, the orientation and location are the key factor in the design.

On an annual average, 40% of winds in port villa arrive from the East direction. 91 Therefore in order to maximise the natural ventilation of the building, it is important to have the walls almost perpendicular to the wind direction. Also keeping in mind the depth of the building, as a building which is too deep is hard to ventilate all parts of it. 92

---


Environmental Analysis

Solar Panels absorb, which is then stored or delivered as electricity; covering the energy demands of the building.

Rainwater is received and directed along the top of the building to a storage tank, from which it can be used as irrigation and domestic water.

Openings in external facades for cross ventilation to provide passive cooling and not relying on mechanical ventilation.
6.7 Implementation of The Concept

6.7.1 Performance During Disaster

Due to the cyclone frequency being tremendously high, it becomes vital for the design to respond well during the disaster phase. The building is designed to have efficient natural ventilation so that it eliminates the need to use mechanical ventilation systems. In order for the air to circulate between the spaces, openings are required in the external facades. These openings need to be adjustable to control the air flow. Louvers will be used on the exterior facades of the building, which will be adjusted according to the wind pressure to allow air movement for normal wind speed but closed off when there is high wind pressure. Having a protective layer on the external façade creates a shield in front of the opening during a cyclone, which will assist in eliminating the chance of any damage. This will be further explored in the building design.
Disaster Phase

Figure 110. During Disaster Phase
6.7.2 Masterplan

This facility is designed to provide disaster-related knowledge and emergency relief to the locals of Port Vila. Another aspect of this project is the masterplan which is the application of this idea across Vanuatu however, at a smaller scale.

As this project will require funding from the government, organisations and other countries, it will need to provide a substantial capability of working towards a better economy and healthier living conditions. Having said that, it will take a few years for the idea to show improvement and development in the country. This will be achieved by comparing the disasters statistics of Vanuatu, before and after the construction of this project. The results from the comparison will then determine if they are in the favour of this project potential for replication.

The replication of the project will involve the facility in Port Vila acting as the main headquarters, underneath which the facilities built around Vanuatu in the future will operate. The master planning will work in phases, the first being the main facility in Port Vila this project caters to which will take 0-2 years. The second phase will be from 3-10 years focused on building facilities similar to the one in Port Vila however at a very small scale, to be built around the island of Efate. The third phase will operate from 11-30 years and focus on taking the second phase further into constructing smaller facilities around the archipelago – the size of which will be determined by the population it serves. These smaller facilities will only incorporate the educational and emergency relief programme, as the research will be taking place at the Port Vila headquarters.

Figure 111. Port Vila Map - Phase 1
■ CONCLUSION
Figure 115. Vanuatu
This project aimed to use architectural design as a tool to improve the resilience for economic growth and development of Vanuatu. The idea was to bring change in a small part of the archipelago in hope that it can help save many lives, reduce disaster risk, strengthens the community, improve social and cultural issues. This would be achieved by designing a facility which works in two phases; a pre-disaster and a post disaster phase.

The pre-disaster phase focuses on educating people to be well prepared for any future natural disasters, increase their construction knowledge, improve their living conditions, maintain a cultural connection and create an example for the government and non-government organisations to promote this typology throughout Vanuatu. This phase is performed in the educational and research centre where public, government and non-government organisation work closely to improve living conditions of the society. If the public is well educated about hazards and construction methods, it will reduce the causality rate, damage and destruction of infrastructure. Having the correct knowledge about a natural event which hasn’t occurred yet can reduce the chances of it turning into a disaster. This leads the country being able to grow, if there will be less causalities and infrastructure destruction, the recovery process will also become faster and the society will not be dependent on external help.

The post disaster phase focuses on the recovery process of the city that is distributing food, water, temporary shelter, medical care, providing communications between disaster relief organisations and on-site shelter for aid workers. The two phases are linked with each other. As if the pre-disaster phase is done right that means the recovery process will be quicker and the country will be in a less vulnerable state. This then comes back to the idea of leading the country towards a better economy. As a faster recovery process means the country can go back to its original state quicker and operate as normal.

Currently the government of Vanuatu is missing the idea of preparedness in their disaster risk management system. In order to improve the resiliency of the country, changes in the system needs to be made and this facility would be considered as the beginning of that change. Port Vila being the capital will need to remain intact in a disaster situation as the whole country looks up to the capital in time of need. This project brings the opportunity for Port Vila to strengthen their disaster risk management system by introducing the idea of preparing the people as well as strengthening their infrastructure. As the locals of Port Vila use the chief’s nakamal as a go to place after a disaster because it belongs to their local culture and makes them feel safe and basing the design on traditional Melanesian architecture will provide the same sense of safety and fit well in the context. The centre will not just benefit the people by education or emergency relief but also provide a place for social interaction which represents their culture.
FINAL DESIGN WORK
SECOND FLOOR PLAN
POST DISASTER
SCALE - 1:100

SECTION-A

SECTION-B

N
Figure 116: Vanuatu
REFERENCES
8.1 Bibliography


8.2 List of Figures

Figure 1. Vanuatu Beach.  

Figure 2. Vanuatu after Cyclone Pam.  

Figure 3. Vanuatu.  
Image by Jessica Hulme

Figure 4. Vanuatu.  
Image by Jessica Hulme

Figure 5. Vanuatu.  
Image by Jessica Hulme

Figure 6. Vanuatu - Laonkarai Village.  
Image by Author

Figure 7. Vanuatu after Cyclone Pam.  
http://www.thesentinel.com/mont/travel

Figure 8. Japan Tsunami.  
https://www.youtube.com/watch?v=j0YOXVlPUu4

Figure 9. Nepal Earthquake.  

Figure 10. Vanuatu after Cyclone Pam.  

Figure 11. Post-Disaster stage diagram.  
Image by Author

Figure 12. Resilience Principles Diagram.  
Image by Author

Figure 13. 1991 Typhoon Flooding Bangladesh.  

Figure 14. 1992 Hurricane Andrew - Florida.  
http://www.thehulltruth.com/dockside-chat/514820-florida-homeowners-windstorm-insurance-2.html#b

Figure 15. Cheif's Nakamal - Port Vila before Cyclone Pam.  

Figure 16. Cheif's Nakamal - Port Vila after Cyclone Pam.  

Figure 17. Traditional Construction Method - Vanuatu.  

Figure 18. Hurricane Dwelling.  
Traditional Architecture in Vanuatu, pg.36

Figure 19. Traditional Architecture Vanuatu.  

Figure 20. Traditional Architecture Vanuatu.  
http://www.sanddollar.co.nz/SanddollarSeaFrontFareExterior.html

Figure 21. Disaster Risk Management System Diagram  
Image by Author

Figure 22. Tokyo Rinkai Disaster Prevention Park.  

Figure 23. Tokyo Rinkai Disaster Prevention Park.  
http://wikimapia.org/20760092/The-Tokyo-Rinkai-Disaster-Prevention-Park

Figure 24. Tokyo Rinkai Centre - 72 hr Tour.  
http://www.tokyorinkai-koen.jp/en/1f/

Figure 25. Tokyo Rinkai Centre - 72 hr Tour.  
http://www.japantimes.co.jp/life/2013/11/19/lifestyle/preparing-your-kids-for-the-big-one/

Figure 26. Tokyo Rinkai Centre - 72 hr Tour.  
http://www.japantimes.co.jp/life/2013/11/19/lifestyle/preparing-your-kids-for-the-big-one/

Figure 27. Tokyo Rinkai Disaster Prevention Park.  

Figure 28. Te Uru Taumatua.  
http://architecturenow.co.nz/articles/te-uru-taumatua-te-wharehou-o-tuhoe/
Figure 63. Cyclone Pam.

Figure 64. Post-Disaster Issues.

Figure 65. Deaths Caused by Scale Disasters Chart.
Image by Author................................................................. 48

Figure 66. Combined Economic Losses Chart.
Image by Author.................................................................. 48

Figure 67. Frequency Chart.
Image by Author................................................................ 48

Figure 68. Frequency Chart.
Image by Author................................................................ 49

Figure 69. Frequency Chart.
Image by Author................................................................ 49

Figure 70. Loankarai Village.
Image by Jessica Hulme.................................................... 50

Figure 71. Loankarai Village Diagram.
Image by Jessica Hulme.................................................... 51

Figure 72. Loankarai Village.
Image by Jessica Hulme.................................................... 51

Figure 73. Port Vila Map.
Image by Author................................................................. 53

Figure 74. Vanuatu.
Image by Jessica Hulme.................................................... 54

Figure 75. Vanuatu.
Image by Jessica Hulme.................................................... 54

Figure 76. Vanuatu.
Image by Jessica Hulme.................................................... 54

Figure 77. Vanuatu.
Image by Jessica Hulme.................................................... 54

Figure 78. Vanuatu.
Image by Jessica Hulme.................................................... 55

Figure 79. Vanuatu.
Image by Jessica Hulme.................................................... 55

Figure 80. Port Vila.

Figure 81. Port Vila Map
Image by Author................................................................. 58

Figure 82. Ministry of Education Site Map
Image by Author................................................................ 59

Figure 83. National Disaster Management Site Map
Image by Author................................................................ 60

Figure 84. University of South Pacific Site Map
Image by Author................................................................ 61

Figure 85. Environmental Diagram - USP
Image by Author................................................................ 63

Figure 86. Loankarai Village.
Image by Author................................................................ 64

Figure 87. Building Function Diagram
Image by Author................................................................ 67

Figure 88. Conceptual Sketches
Image by Author................................................................ 68

Figure 89. Conceptual Sketches
Image by Author................................................................ 68

Figure 90. Spacial Arrangement Diagram
Image by Author................................................................ 69

Figure 91. Loankarai Village - Vanuatu
Image by Author................................................................ 70

Figure 92. Building Form - USP Site
Image by Author................................................................ 72

Figure 93. Form and Exterior Sketches
Image by Author................................................................ 73

Figure 94. Building Function Diagram
Image by Author................................................................ 74

Figure 95. Educational Centre Concept Plans
Image by Author................................................................ 75

Figure 96. Research Centre Concept Plans
Image by Author................................................................ 77

Figure 97. Emergency Relief Centre Concept Plans
Image by Author................................................................ 79

Figure 98. Design Concept
Image by Author................................................................ 80
Declaration

Name of candidate: Harmandeep Kaur

This Thesis/Dissertation/Research Project entitled: Building for Resilience

is submitted in partial fulfillment for the requirements for the Unitec degree of MASTERS OF ARCHITECTURAL STUDIES (PROF)

Principal Supervisor: Dushko Bogunovich

Associate Supervisor/s:

CANDIDATE'S DECLARATION

I confirm that:

• This Thesis/Dissertation/Research Project represents my own work;
• The contribution of supervisors and others to this work was consistent with the Unitec Regulations and Policies.
• Research for this work has been conducted in accordance with the Unitec Research Ethics Committee Policy and Procedures, and has fulfilled any requirements set for this project by the Unitec Research Ethics Committee.

Research Ethics Committee Approval Number: ..............................................................

Candidate Signature: Harmandeep Kaur  Date: 30/09/2016

Student number: 1401028
Full name of author: HARMAN DEEP KAUR

Full title of thesis/dissertation/research project ('the work'):
BUILDING FOR RESILIENCE

Practice Pathway: ARCHITECTURE

Degree: MASTERS OF ARCHITECTURE STUDIES (PROP)

Year of presentation: 2016

Permission to make open access
I agree to a digital copy of my final thesis/work being uploaded to the Unitec institutional repository and being made viewable worldwide.

Copyright Rights:
Unless otherwise stated this work is protected by copyright with all rights reserved.
I provide this copy in the expectation that due acknowledgement of its use is made.

AND

Copyright Compliance:
I confirm that I either used no substantial portions of third party copyright material, including charts, diagrams, graphs, photographs or maps in my thesis/work or I have obtained permission for such material to be made accessible worldwide via the Internet.

______________________________
Signature of author: HARMAN DEEP KAUR

Date: 30/09/16