The World Bank

Global Program for Safer Schools

Vanuatu Mission Report

Issue | 20 December 2015

Job number 238204-00

Arup
Arup Pty Ltd ABN 18 000 966 165

Level 10 201 Kent Street
PO Box 76 Millers Point
Sydney 2000
Australia

ARUP

Document Verification

ARUP

Job title		Global Program for Safer Schools		**Job number** 238204-00	
Document title		Vanuatu Mission Report		**File reference**	
Document ref					
Revision	**Date**	**Filename**	GPSS Vanuatu Report		
Draft 1	15 Jul 2015	**Description**	First draft		
			Prepared by	Checked by	Approved by
		Name			
		Signature			
Issue	11 Sep 2015	**Filename**	GPSS Vanuatu Report		
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
Issue	20 Dec 2015	**Filename**	GPSS Vanuatu Report		
		Description	Issued to WB		
			Prepared by	Checked by	Approved by
		Name			
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			

Issue Document Verification with Document ✓

Contents

Page

1 Introduction 5

2 Context 6

3 Methodology 8

4 Hazards to School Infrastructure 10

4.1 Cyclone 11
4.2 Volcanic 11
4.3 Seismic (Earthquake) 11
4.4 Tsunami 12

5 School Infrastructure Baseline 13

5.1 Existing School Infrastructure 13
5.2 Characteristics of Safer Schools 15
5.3 School Infrastructure Requirements 22

6 Construction Environment 25

6.1 Institutional and Regulatory Environment 25
6.2 Implementation Process 27

7 Financial Environment 34

7.1 Historic, Current and Planned Investment 34

8 Schools as Evacuation Centres 35

9 Recommendations and Opportunities 37

9.1 Roadmap 38
9.2 Package 1 - Reconstruction of Category 1 and 2 Structures and Supporting Infrastructure 39
9.3 Package 2 - Retrofitting of Category 3 and 4 Structures 40
9.4 Additional Opportunities 41

10 Conclusion 42

Appendix A

Document Register

Appendix B

Hazard Assessment

Appendix C

Mission Details

Appendix D

Presentation to MoET

Appendix E

School Surveys

Appendix F

Building Characteristics

Abbreviations

ADB	Asian Development Bank
APTC	Australia-Pacific Technical College
AS	Australian Standard
AUD	Australian dollars
BoQ	Bill of Quantities
CBC	Community Based Contracting
CTB	Central Tenders Board
DFAT	Department of Foreign Affairs and Trade (GoA)
DSPPAC	Department of Strategic Policy, Planning and Aid Coordination
FU	Facilities Unit
GCC	General Conditions of Contract
GCT	General Conditions of Tendering
GoA	Government of Australia
GoJ	Government of Japan
GoNZ	Government of New Zealand
GoV	Government of Vanuatu
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German Gov Aid Program)
GPSS	Global Program for Safer Schools
GGP	Grant Assistance for Grassroots Projects (GoJ)
IBCs	Island Based Contractors
INGO	International Non-Government Organisation
MFAT	Ministry of Foreign Affairs and Trade (GoNZ)
MFEM	Ministry of Finance and Economic Management (GoV)
MIPU	Ministry of Infrastructure and Public Works Utilities (GoV)
MoET	Ministry of Education and Training (GoV)
NBC	National Building Code of Vanuatu
NGO	Non-Government Organisation
NZ	New Zealand
NZS	New Zealand Standard
PEO	Provincial Education Officer
PMO	Prime Minister's Office
PDNA	Post-Disaster Needs Assessment
RTC	Rural Training Centres
SCC	Special Conditions of Contract
SCT	Special Conditions of Tendering
STC	Save the Children
TCP	Tropical Cyclone Pam
TVET	Technical and Vocational Education and Training Sector Strengthening Program
UNICEF	United Nations Children's Fund
USD	United States Dollars
VIRIP	Vanuatu Infrastructure Reconstruction and Improvement Program (World Bank)
VT	Vanuatu Vatu
WATSAN	Water and Sanitation
WB	World Bank

Definitions

School infrastructure	Buildings (classrooms, houses, and ancillary buildings) and the associated water, waste water, stormwater drainage and road infrastructure that collectively form a school

Executive Summary

On Friday, 13 March 2015, category five Tropical Cyclone Pam (TCP) hit the island nation of Vanuatu and caused widespread damage, with the southern provinces of Shefa and Tafea the most severely affected. The education sector was one of the hardest hit with a significant number of schools throughout the country damaged or destroyed. Following a Government of Vanuatu endorsed Post-Disaster Needs Assessment, the World Bank and other partners offered to support a school reconstruction, retrofitting and repair programme. As a result Vanuatu was identified as a country that may benefit from technical support through a Global Program for Safer Schools Technical Assistance project, which will focus on the structural aspects of a Safe School.

A World Bank mission visited Vanuatu during the period 20-28 August 2015. The key objective of the mission was to identify opportunities for the application of safer school measures in Vanuatu. Specific mission objectives included: (i) develop an informed understanding of damage to the school infrastructure as a result of Cyclone Pam; (ii) understand the government priorities for reconstructing damaged schools; (iii) undertake a diagnostic of the school sector to understand the key natural hazards to which school infrastructure is exposed, school construction typologies and the institutional and policy environment for school infrastructure in Vanuatu and (iv) provide outputs to inform a school infrastructure reconstruction and rehabilitation program, which could be supported by WB and other partners. Consultations were held with a range of government, non-government organisation and industry stakeholders to develop an understanding of the way in which education infrastructure is planned, designed, funded, procured, constructed, operated and maintained. In addition, the mission carried out a field visit to Tanna, one of the hardest hit locations, to assess schools damaged by TCP and conduct semi-structured interviews with school representatives.

The field visits confirmed that damage to school infrastructure in Tanna was severe and widespread. All schools visited displayed some degree of damage, with levels ranging from minor through to catastrophic. A clear pattern emerged in the schools that were visited. Buildings that were constructed by experienced trades, with quality materials and a level of supervision generally survived TCP. Conversely, structures that were built without experienced supervision or skilled trades were vulnerable to cyclonic winds. Connections between structural elements were a key failure point in many of the structures surveyed and it is likely that a lack of maintenance also contributed to the damage or destruction of assets.

Stakeholder consultations revealed that a large scale reconstruction program will need careful design, taking into consideration the existing capacity and capability within the engineering and construction sectors and the competing demand for skilled workers throughout the country.

The need which was identified in Tanna led to the formulation of a project encompassing a two package program plan, with the dual goals of building new safe school infrastructure and making existing schools safer through the introduction of the principles of safer schools to the local construction industry. It is recommended that Package 1 of the program focuses on the construction of new safe school infrastructure where buildings were damaged beyond repair or where adequate facilities do not currently exist. Buildings that require major works and can be cost effectively repaired would also be refurbished in Package 1. These works could be delivered by a Managing Contractor in conjunction with the MoET, using a standard form of construction contract. Works should be supplemented with a training program on supervision for site foreman and on the job construction training modules delivered to workers in parallel with on-site works. Existing community involvement in school construction would be strengthened through the establishment of community participation agreements and the provision of in-kind support for construction. It is recommended that Package 2 of the program could focus on retrofitting undamaged or partially damaged buildings, to improve the safety of these structures and increase their lifespan. As there appears to be sufficient capacity locally to carry out construction, these works could be delivered through a purpose-designed 'on the job' training and capability building program. Participants would include local builders or contractors and members of the school community.

Delivery of a school reconstruction program which simultaneously addresses the immediate need for safer school infrastructure, and incorporates training in safer schools construction has the potential to contribute positively to school infrastructure in the long term. Safer, stronger school infrastructure will in turn provide shelter to communities during natural disasters and allow students to return to school as quickly as possible in the aftermath of an event.

1 Introduction

Each year, natural disasters result in school buildings being destroyed or severely damaged leading to loss of life, injury and disruption to education. Global efforts to make schools more resilient have largely focussed on improving awareness and preparedness, so that teachers and children are better placed to take appropriate action in the event of a disaster. Less attention has been paid to the physical performance of school buildings, which is the focus of an initiative by the Global Facility for Disaster Risk Reduction (GFDRR) - the Global Program for Safer Schools (GPSS). This is being designed as a technical assistance (TA) program targeting countries where there is on-going or proposed investment in school infrastructure.

On Friday, 13 March 2015, category five Tropical Cyclone Pam (TCP) hit the island nation of Vanuatu. A state of emergency for Shefa Province was declared on 15 March by the Council of Ministers and was expanded to other provinces following surveillance flights. The education sector was one of the hardest hit with a number of schools throughout the country damaged or destroyed. According to UNICEF, the closure of schools and lack of access to education will affect at least 70,000 school-aged children (early childhood to secondary) who will be at risk of discontinuing their schooling.

A Post-Disaster Needs Assessment (PDNA) was undertaken and endorsed by the Government of Vanuatu (GoV) and provided an initial indication of the public sector financing needs. The GoV declared the emergency response phase over on 31 July 2015 and the commencement of a two year recovery phase beginning 1 August 2015. The reconstruction, repair and retrofitting of school infrastructure was identified as a possible World Bank (WB) project and discussions commenced with the GoV at the beginning of the recovery phase to determine a potential scope. Through a combination of grants and credits, the Vanuatu Infrastructure Reconstruction and Improvement Project (VIRIP) proposes to support the GoV with up to US$50m of WB funding for post cyclone reconstruction, with US$17.25m allocated to school infrastructure. To complement this investment, the WB has identified an opportunity to provide additional support through a GPSS Technical Assistance (TA) project. This TA would be funded with a combination of VIRIP and GPSS resources and focus on improving the safety of school infrastructure.

In August 2015 a WB mission visited Vanuatu to scope out a potential program and identify opportunities for the application of safer school measures. Specific mission objectives, which were outlined prior to and refined during the mission included:

i.) Develop an informed understanding of the damage to school infrastructure as a result of TCP;

ii.) Understand the government priorities for the reconstruction of damaged schools;

iii.) To undertake a country diagnostic of the school sector to:

   a. Understand the drivers of risk and range of natural hazards and climate change impacts that may compromise the reconstruction, repair, retrofitting and operation of existing school infrastructure;

   b. Understand the range of school construction typologies;

   c. Assess the institutional and policy environment and regulatory framework within which schools infrastructure is prioritised, designed, funded, procured, constructed, operated and maintained.

   d. Understand the capacity and capability of the local engineering and construction industry.

iv.) Understand the plans of other donors and partners working to assist in the reconstruction of school infrastructure.

v.) Develop a roadmap for a school infrastructure reconstruction and rehabilitation program, which could be supported by WB and other partners, and inform consultations with the GoV on an infrastructure reconstruction program post-TCP.

This report highlights a range of opportunities to increase the safety of school infrastructure in Vanuatu. The report focuses primarily on TA opportunities that could be addressed through the VIRIP and GPSS, in a post TCP school reconstruction project as detailed in the program roadmap in Section 9.1. Other opportunities that may be supported outside of this project have also been included for completeness.

2 Context

Vanuatu is an archipelago island chain consisting of over 80 islands in the Pacific Ocean, approximately 2,000km east of Australia. Vanuatu has a population of around 272,000[1] divided into six provinces across 65 islands as shown in Figure 1.

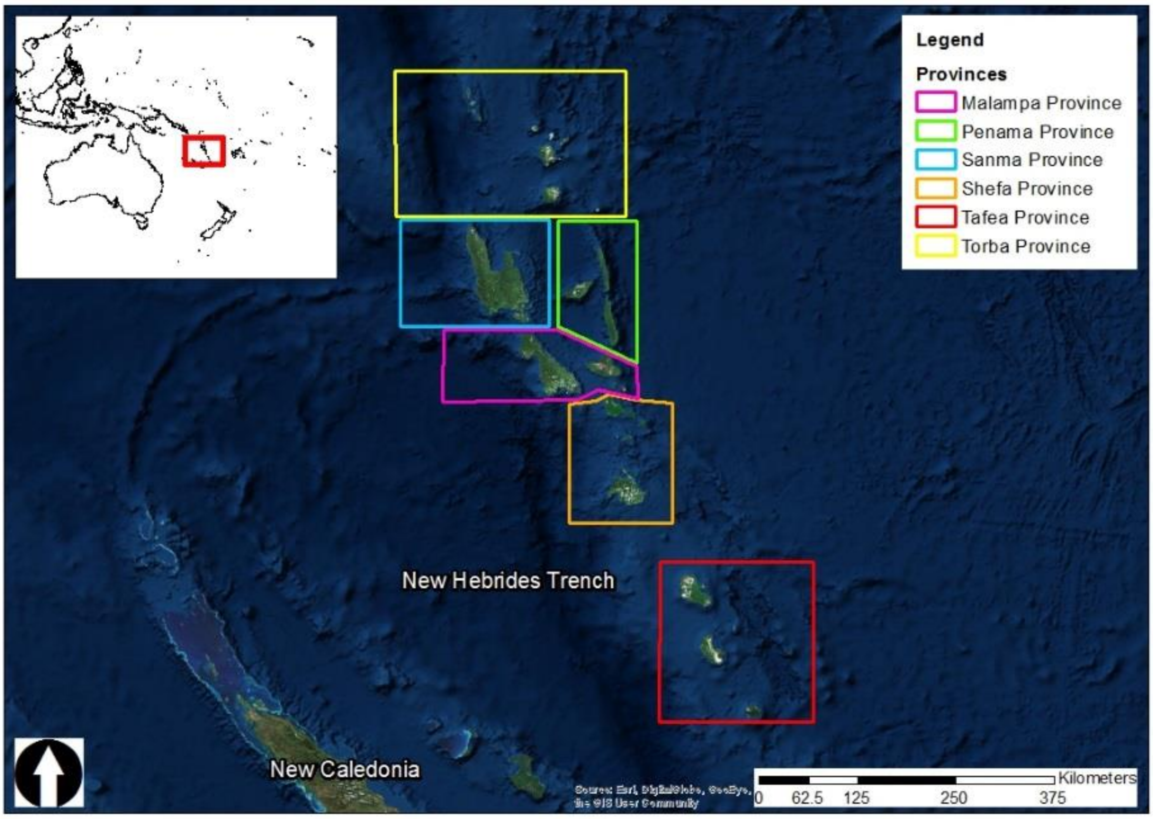


Figure 1: Location and provinces of Vanuatu

Land in Vanuatu is predominantly used for agricultural purposes, namely livestock, copra (coconut oil) and fishing. The majority of settlements are rural, with the major cities being the capital, Port Vila, on Efate (population approximately 45,000) and Luganville on Espiritu Santo (population approximately 15,000). Tourism is becoming an increasingly important part of the economy.

Vanuatu is located in an area that is vulnerable to natural hazards such as tropical cyclones, flooding, storm surge, droughts, volcanic eruptions, earthquakes and tsunamis. The frequency and severity of climate related hazards is anticipated to increase as a result of climate change. Disasters resulting from these hazards can affect the economic, social, and physical environment and have a lasting effect on the long-term development agenda of the nation. Research conducted through the Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) concluded that 'Vanuatu is expected to incur, on average, 48 million USD per year in losses due to earthquakes and tropical cyclones. In the next 50

[1] Vanuatu National Statistics Office, 2015

years, Vanuatu has a 50% chance of experiencing a loss exceeding 330 million USD and casualties larger than 725 people, and a 10% chance of experiencing a loss exceeding 540 million USD and casualties larger than 2,150 people.' (PCRAFI, 2011).

Vanuatu has had a nine Prime Ministers since 1991, with some ministers serving multiple times during this period, including a change in leadership post-TCP. The potential for future change may impact the delivery of a large scale school infrastructure project.

3 Methodology

The observations made in this report are the result of an eight week study carried out by Arup which included: a desk study; field mission, analysis and documentation of findings.

Desk Study

Arup carried out a review of available documentation (Appendix A), and undertook a Hazard Assessment (Appendix B) to identify the range and intensity of hazards facing schools in Vanuatu.

Field Mission

A nine day field mission was carried out by Arup Consultants from 20-28 August 2015.

Key stakeholder consultations included:

i.) Representatives from government (including technical and provincial staff) from the Ministries of Education and Training (MoET), Finance and Economic Management (MFEM) and Infrastructure and Public Utilities (MIPU), and the National Disaster Management Office (NDMO);

ii.) Representatives of the Department of Foreign Affairs and Trade (DFAT- Government of Australia);

iii.) Representatives of Save the Children, UNICEF and the International Organisation for Migration (IOM);

iv.) A representative of the consulting engineering sector (Kramer Ausenco)

v.) Principals, Chairs of School Councils, Teachers and/or school land owners,

A full list of key stakeholder meetings is set out in the Mission Schedule in Appendix C1. The areas of influence for each of the stakeholders in the education sector is set out in in Figure 2 below.

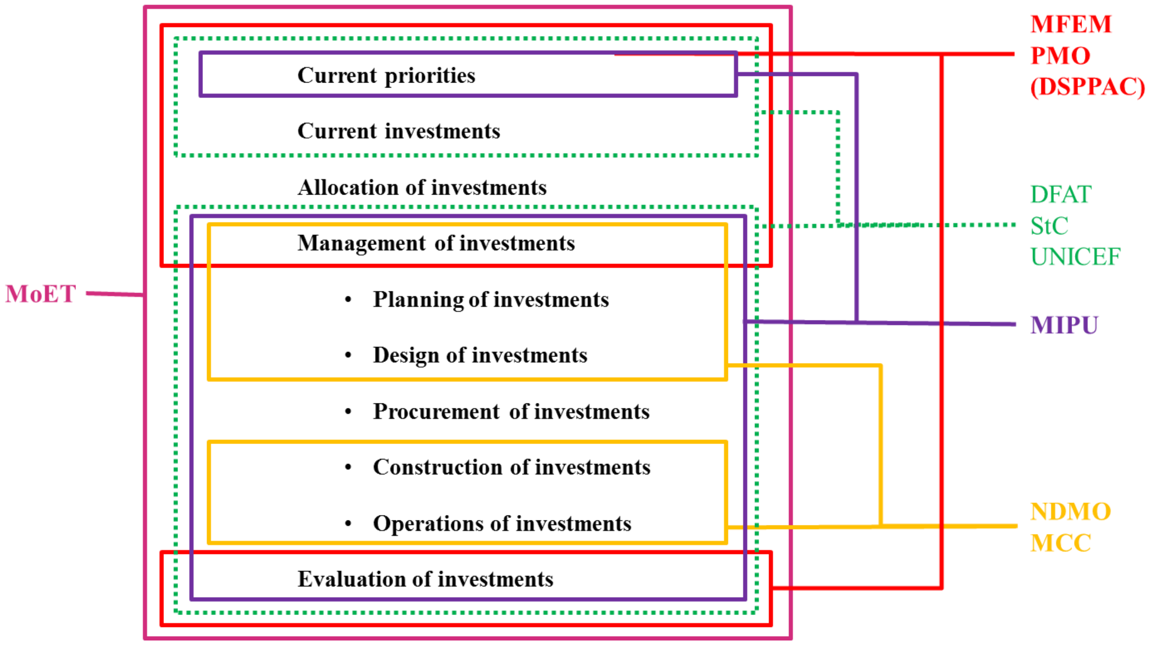


Figure 2: Stakeholder mapping for the education infrastructure sector in Vanuatu

During the mission, a total of 23 schools on the island of Tanna were visited in order to gain an understanding of the different construction typologies and key structural vulnerabilities of school buildings. The locations of each of the schools is shown in Figure 3. These schools were recommended by the MoET and included English and French, primary, junior secondary and secondary schools. Approximately 29% of the total number of schools in Tanna were visited. The sample demonstrated a range of school exposure to hazards, size, physical planning, construction typology and building condition. In addition, all schools represented the range of damage resulting from TCP.

Using the hazard desk study and based on a range of other school assessment surveys that were undertaken by Arup through the GPSS, a country specific survey form was developed. At each school a Rapid Visual Assessment (RVA) was carried out on the main buildings in order to get an understanding of the exposure and key structural vulnerabilities. Data was collected in a web-based data collection app 'Fulcrum[2]', and a report was generated for each school. The survey comprised three main sections:

- User Interview (with Principals and/or Teachers and/or members of the School Council)
- Site Exposure Assessment
- Building Vulnerability Assessment

Initial observations and recommendations were shared with the WB Team Leader and incorporated into a final presentation which was delivered to the MoET prior to departure (Appendix D1). Full details of the data collected for each school are given in to Appendix E.

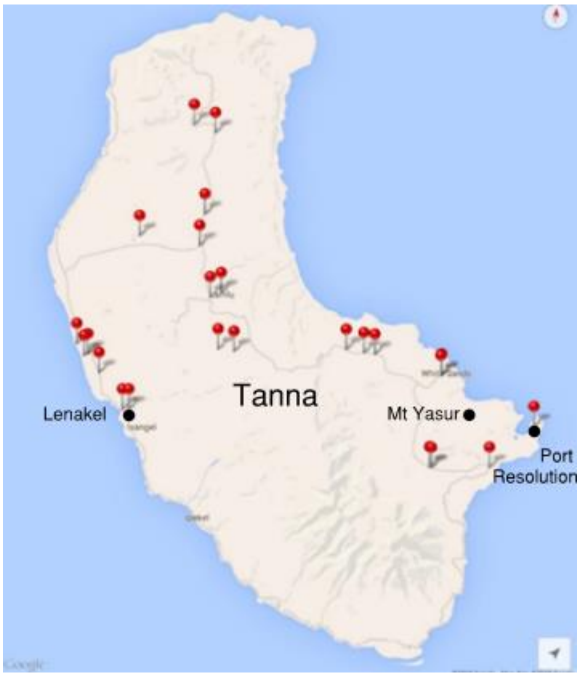


Figure 3: Location of schools visited on Tanna

Analysis

An analysis of the key findings, including a review of further documentation obtained, was carried out following the field mission, and summarised in this report.

The limitations and assumptions from the mission are detailed in Appendix C2.

[2] https://fulcrumapp.com/

4 Hazards to School Infrastructure

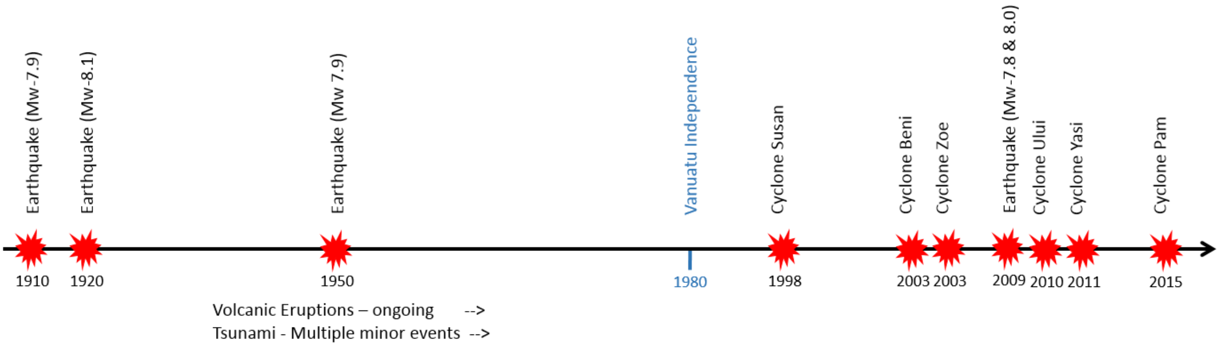


Figure 1: Timeline of major natural hazard events in Vanuatu

School infrastructure in Vanuatu is exposed to several critical hazards which can be divided into two groups: regional and local hazards as shown in Table 1. Regional hazards pose a threat to all school infrastructure across Vanuatu and are largely independent of site location. Local hazards depend on topography and soil type and are more specific to site location. A full copy of the Hazard Assessment and details of strategies which can be employed to mitigate the risks from hazards is detailed in Appendix B.

Damage from cyclones and corrosive emissions from the volcano, Mt Yasur, are the most critical hazards to which school infrastructure in Tanna is exposed. The seismic hazard also poses a significant risk, however, due to the small size and of typical school buildings, seismic damage was not observed to be wide spread. Whilst they still pose a risk to school infrastructure, damage from hazards such as landslides, flooding and tsunamis was not observed during the site visits.

During the site user interviews, awareness of the prevalent natural hazards which effect school infrastructure was evident and the hazards identified by respondents were specific to the locations of each school. Cyclones, volcanic activity, and tsunami were generally cited as the main hazards, with the effects of earthquake, flooding and landslide not generally considered as significant. This level of understanding was in line with the observed predominant hazards affecting school infrastructure as seen during the site visits. The effects of each of the main hazards to school infrastructure is explained below.

Hazard Type	Hazard
Regional	Seismic (Earthquake)
	Cyclone
Local	Landslide and Slope Failure
	Tsunami
	Flooding
	Volcanic
	Coastal Erosion

Table 1: Hazards to school infrastructure observed for schools in Tanna

It is understood that the National Disaster Management Office (NDMO) and Vanuatu Meteorology and Geohazards Department (VMGD) are currently developing hazards maps for the country. These maps are intended to inform disaster risk reduction planning for evacuation centres and will also be a useful tool for those planning or locating school infrastructure, enabling them to avoid areas at most risk from hazards.

4.1 Cyclone

Cyclones are the predominant hazard that threaten school infrastructure in Vanuatu and can cause extensive damage through a combination of strong winds and heavy rainfall. Between one and three severe Tropical Cyclones develop in the Pacific region each year, with extreme events in Vanuatu experienced approximately every five years. During TCP, sustained winds speeds reached 250km/hr (69m/s) with gusts peaking at 320km/hr (88m/s). This intensity exceeds the basic design wind speed of 70m/s nominated in the Vanuatu National Building Code (NBC). Flooding due to heavy rains is also a hazard to that may occur as a result of severe storms, however, due to the predominantly free draining soils across the majority of Tanna, flooding was not observed to have impacted school infrastructure.

The extent and severity of damage to school infrastructure in Vanuatu in the wake of TCP was severe and widespread. All schools visited displayed some degree of damage, with levels ranging from minor through to catastrophic, with most damage caused by high winds. Supplementary damage to furnishings and ceilings resulted from water damage after roofs (or sections of roof sheeting) were lost.

Due to the regularity of the events and the large potential for damage from high winds, cyclones are a significant hazard to school infrastructure.

4.2 Volcanic

Vanuatu is in close proximity to a subduction zone and there are seven active terrestrial volcanoes and three submarine volcanoes located across five of the six provinces. All of these volcanos have had at least one eruption in the past 10 years.

There are two volcanic hazards that pose a risk to school infrastructure: a direct threat from explosive eruptions and the indirect threat from corrosive gas emissions. Explosive eruptions present a great risk to the schools adjacent to the volcano immediately through lahar, pyroclastic flow and lava flow impact. The indirect threat of corrosive emissions occurs over a longer period of time, with effects spread further afield from the immediate area. Corrosive rain forms when sulphur dioxide and hydrochloric acid emissions combine with water in the atmosphere to fall as acid rain (Cronin and Sharp, 2002).

Corrosion of metallic elements in buildings was observed to be a significant contributing factor to the degradation of school infrastructure, with many elements experiencing a significant reduction in lifespan. In areas downwind from the volcano, roof sheeting was observed to degrade at a rate two to three times faster than would be expected in non-corrosive environments. Connecting elements such as galvanised steel strapping, gang nails in trusses and steel U-bolts tying down roof structures were seen to degrade rapidly, even when located out of the direct weathering area.

Corrosive degradation of materials compounds a structures vulnerability to cyclonic winds and is thus a significant hazard to school infrastructure.

4.3 Seismic (Earthquake)

Vanuatu is located within close proximity to an active plate boundary and as a result has experienced a large number of significant earthquakes (Magnitude > 6). Hazards associated with earthquakes are seismic induced ground motions, liquefaction and lateral spreading, earthquake induced landslide, fault surface rupture and tsunamis.

Despite the regular occurrence and magnitude of earthquakes across the archipelago, the level of earthquake damage observed in school infrastructure on Tanna was minor. Most school buildings were small, rectangular structures, almost exclusively single storey, which reduces their vulnerability to damage from earthquakes.

Due to the potential danger to building occupants, particularly for heavy masonry structures, earthquakes are a significant hazard to school infrastructure.

4.4 Tsunami

Due to the high seismic hazard in the region and the concentration of settlements in coastal areas, tsunami can pose a hazard to school infrastructure. Tsunamis may be generated locally from earthquakes or submarine landslides, or travel thousands of kilometres across the ocean. Many of the coastal schools that were surveyed reported an understanding of the risk that tsunamis posed to their schools, understood the correlation between earthquake and tsunami, and had a plan to seek higher ground when earthquakes occurred.

As a result of the need to provide school infrastructure close to population centres, many schools are constructed in low lying coastal areas that are prone to tsunami. Due to the significant hazard, it is critical that the risks from tsunamis are considered in the planning and design of new school infrastructure.

Opportunity 1: It is understood that a natural hazard mapping process is already underway as part of the identification of schools to be used as Evacuation Centres by the NDMO and VMGD. The rationalisation of primary schools – a current initiative of the MoET – presents an opportunity for exposure to local hazards – specifically tsunami and volcanic risk – to be included in a decision-making about school rationalisation.

For schools that currently lie in tsunami prone areas, early warning systems could be developed to assist with timely evacuation. Such early warning systems and any associated training for students, teachers and school communities, should be designed to complement the work of the NDMO, local Community Disaster Committees and donors (such as Save the Children).

Other strategies that can be employed for the mitigation of hazards are detailed in Appendix B.

5 School Infrastructure Baseline

5.1 Existing School Infrastructure

The education system in Vanuatu is divided into four stages: kindergarten; primary school; secondary school and tertiary education. Kindergartens and primary schools are typically constructed in each village, with students attending from the immediate area. Secondary schools are located further apart and many students come from villages further afield and board in dormitories on school grounds. A limited number of tertiary courses are offered in Port Vila, with many students travelling abroad to Fiji, Australia or New Zealand for university education. In 2012, according to the Vanuatu Education Sector Public Expenditure Review (GoV, 2012), there were '543 early childhood centres, 432 primary schools and 82 secondary schools delivering education services to some 72,000 children/students'.

Prior to Vanuatu's independence in 1980, school infrastructure was built by the English and French colonial administrations, who provided resources for the management and operation of schools. Following independence, the school sector was decentralised through a system of 'school based management', leaving the responsibility for school infrastructure with communities directly. Since this time, unless funding from international donors has been available, school communities have been responsible for the funding of all new school infrastructure (DFAT, 2012). Notwithstanding ongoing investment by school communities, the supply of new classrooms has not kept up with demand (DFAT, 2012). In 2012, estimates from the MoET 'indicated an immediate need for an additional 158 new classrooms' and forecast the need for an additional 37 classrooms per year. In addition, it was estimated that only 44% of classrooms were in 'good' condition and more than 12% were 'temporary structures constructed entirely from temporary materials' (DFAT, 2012, p13).

Improving the supply and quality of school infrastructure was identified as a priority of the Vanuatu Education Sector Strategy 2007-2016 (VESS) and the Vanuatu Education Road Map (VERM). VESS acknowledged the challenges faced by the GoV to improve the supply and quality of school infrastructure. Particular challenges included: facilities that did not meet minimum standards; the absence of adequate water supply and power; the expense of maintenance and upgrading; the empowerment of school communities, Councils, committees, associations, and staff; and the size and location of schools (VESS, 2006, pgs17-18). At the time the Road Map was prepared, the MoET's intention was to develop a 'demand-driven plan' for the construction of new and upgrading of facilities that were 'sub-standard', as well as for the provision of clean water and sanitation (VERM, 2006, pg. 15). To this end, VERM set out a goal of 62 new or renovated classrooms over a three year period (2010-2012).

Prior to TCP, the MoET had begun planning a program of investment in school infrastructure that expected to deliver some 42 classrooms in 18 locations on Tanna. This program aimed to utilize Island Based Contractors (IBCs) to deliver the works under the supervision of a local engineering consultancy. A community engagement program was planned in parallel to maximize the involvement of communities in the delivery of enabling works at each school. (Note: At the time of the mission, this program was on hold pending confirmation of additional funding from donors for recovery efforts on Tanna.)

Also prior to TCP, the MoET Facilities Unit (FU) had commenced a country-wide survey to develop an asset register of all school facilities, to be used as a prioritisation tool for the scheduling of any repair, retrofit and reconstruction works. This survey assessed the key characteristics and condition of the school facilities, addressing criteria including, but not limited to, building number and typology, sanitation facilities, power and water supply and disability access. The survey addressed some structural issues, but does not include detail on key structural vulnerabilities (such as the condition and type of all roof tie downs and bracing as would be required for a detailed structural assessment) nor does the survey include details of exposure to local hazards. Approximately 200 of 430 surveys were completed before TCP, with the remainder to be completed in the coming year.

Following TCP, the MoET carried out a rapid damage and needs assessment of schools located in areas affected by the cyclone. This assessment estimated the level of damage at each school and the magnitude, cost and types of repair works that were likely to be required. A detailed survey of all schools in the affected areas will be needed prior to the commencement of a reconstruction and retrofitting program to validate the outcomes of this initial needs assessment and identify any repair work that may have already taken place.

Due to number of small schools (with enrolments < 200) located in close proximity across the country, a rationalisation process is being considered by MoET. It is understood that the rationalisation process will be undertaken by the MoET with the assistance of a school planner (provided by DFAT from the Australian Civilian Corps) over a 12 month period. The rationalisation process will take into consideration the outcomes of work underway by the NDMO and post TCP shelter cluster working group to identify schools suitable for use as Evacuation Centres.

Opportunity 2: Assistance, specifically on safer schools, could be provided as an input into the school rationalisation process.

The GPSS Rapid Visual Assessment (RVA) methodology developed by Arup for the WB mission could be tailored to augment the MoET's existing school infrastructure condition survey, to enable its use by staff in the Facilities Unit. Technical assistance could be provided to train staff from the Facilities Unit in the identification and assessment process of key structural vulnerabilities.

It is recommended that the school infrastructure data gathered with this tool could be combined with hazard information from the NDMO and VMGD and input into a geo-spatial database. This database would provide the MoET with a tool for the management, planning and prioritisation of school infrastructure in the future.

5.2 Characteristics of Safer Schools

Through Arup's work on the Global Program for Safer Schools, the 10 characteristics of a 'safe' school have been documented as shown in Table 1 (Arup, 2013). These characteristics were identified based on a review of best practice literature and Arup's experiences designing, delivering and evaluating schools.

1. A **hazard assessment** has been undertaken to identify the types of hazard that the school may experience (e.g. tsunamis, volcanoes and earthquakes).
2. A **site assessment** has been undertaken to identify key features that may impact exposure to specific hazards including topography, soil conditions, proximity to water bodies/fault lines, vegetation.
3. Appropriate mitigation measures have been taken in the **physical planning** of the site to adequately mitigate against the risks identified as a result of the hazard and site assessments.
4. An appropriate **structural typology** has been used for the buildings which takes account of the most prevalent hazards.
5. The **building configuration** is reasonably symmetric, allows safe egress, avoids irregular features
6. Significant **building modifications** (e.g. openings, canopies, additional storeys) have not been constructed unless allowed for specifically in the building design.
7. The **structural capacity** of key elements of the building (e.g. foundations, beams, columns, walls, roof, connections) have been assessed for their ability to transfer vertical and lateral loads.
8. The selection of **non-structural elements** of buildings (e.g. façades, internal walls, storage of hazardous materials, equipment, and signage) has taken account of the prevalent hazards and are adequately fixed to the main structure.
9. There are systems in place to assure the quality of **materials and workmanship** during construction and / or there are no signs of structural deterioration (e.g. settlement, cracking, corrosion) in key elements of the building (e.g. foundations, beams, columns, walls, roof, connections) that might impair the structural performance.
10. There is adequate funding and local skills available to carry out regular **maintenance and repairs** of the school buildings and site infrastructure (e.g. drainage channels, access and evacuation routes).

Table 2: The 10 key characteristics of a Safe School.

The following section reviews the observations made during the school surveys using this framework, to evaluate the safety of school infrastructure in Vanuatu. The key vulnerabilities observed in school infrastructure and recommendations for remedial actions and mitigation strategies are detailed in Appendix F3.

5.2.1 Exposure of School Infrastructure

Characteristic 1 & 2: Hazard and Site Assessment

The extent to which exposure to local hazards has influenced decision-making about the siting of schools is unclear. School siting has traditionally been undertaken by the community, typically based on the availability of land and the extent of involvement of the MoET or the colonial administrations (pre independence in 1980) in the siting of schools is unknown.

The siting of schools was not observed to be a major risk for schools that were located away from coastal areas or Mt Yasur. Whilst the relocation of schools away from tsunami and volcanic zones would reduce the exposure of schools to localised hazards, it presents a challenge when schools are required to be located adjacent to population centres.

Opportunity 3: Develop a guidance document for site selection and assessment, which could assist the MoET and school communities in the identification of the best sites for school construction to avoid natural hazards. This document should be utilised in conjunction with the hazard maps being developed by the NDMO and VMGD.

Characteristic 3: Physical Planning

Most of the schools that were visited on Tanna were relatively small (<5-10 buildings), and were located on flat areas, not constrained by close boundaries. This typically allowed for a free arrangement of buildings across the school grounds. Local flooding, drainage or landslides were not observed to be significant issues at any of the schools that were visited. While the arrangement of buildings around sites was at times ad-hoc, there were no cases observed where physical planning encumbered the safe operation of the schools.

Opportunity 4: As part of a reconstruction program, a review of site specific hazards should be undertaken at all school sites and schools sites should be planned to avoid or mitigate the effects of local hazards. A pictorial based guidance document and checklist could be developed to assist the MoET and communities with good physical planning of schools sites.

5.2.2 Vulnerabilities of School Infrastructure

Characteristic 4: Structural Typology

The school buildings inspected in Vanuatu can be divided into five main structural typologies: i) unreinforced masonry, ii) reinforced masonry, iii) reinforced concrete frame with masonry infill, iv) timber frame and v) mixed masonry and timber construction. Images of these typologies and a description of the advantages and disadvantages of each typology are detailed in Appendix F.

The structural typology and construction methodology of school buildings in Tanna was seen to have a significant impact on their performance during TCP. Two broad categories of school buildings were observed as shown in Table 3 below. Type 1 buildings were those funded and built for the school by the community, without external assistance and Type 2 were funded and built by external parties. A distinct difference was seen in build quality between the two. MoET and school representatives typically referred to these types as ‘semi-permanent’ and ‘permanent’ buildings.

School Building ‘Type’	Typical Construction
<u>Type 1</u> **Community built** school buildings were typically ‘semi-permanent’, built with timber wall frames, often incorporating low level ‘skirt’ walls made of concrete block. These typically showed limited understanding of good construction practice which is likely to indicate that they were built without experienced trades or qualified supervisors.	 
<u>Type 2</u> **Donor built or colonial era** school buildings were typically ‘permanent’, built of reinforced concrete frame with infill concrete block masonry and generally followed a generic rectangular two classroom design. They typically showed a better understanding of good construction practice which is likely to indicate that they were built with experienced trades and/or with qualified supervision. The extent of involvement of the local school community in building Type 2 structures was not known at all schools, but it is likely that they contributed during the construction process.	 

Table 3: Comparison of the two main school construction methodologies observed in Tanna

During the survey, Type 1 buildings were found to be significantly more vulnerable to cyclonic winds, and many were damaged beyond repair during TCP. Where failure of Type 2 structures was observed, it was predominantly due to a lack of building maintenance. Several interviewees reported a ‘fatigue’ within the school community, frustrated at the repetitive reconstruction which is required for semi-permanent structures. A detailed comparison of the key differences in the structural elements of the two construction types is tabled in Appendix F1.

Characteristic 5- Building Configuration

Building configuration was not observed to be a significant characteristic that encumbered the safe performance of the school buildings visited on Tanna. All of the buildings inspected were rectilinear, symmetrical structures, with simple layouts which is desirable when constructing in an area of high winds and seismic activity. Typically teaching spaces were arranged as a double classrooms with a central office/ storage space between. Many buildings inspected had two exit points on opposite sides of the structure, which allowed for safe egress for building occupants. A small number of classroom structures were observed to have a length greater than four times the building width, which can reduce the performance of structures under earthquake loads.

Maintaining a regular building shape is an important characteristic that should be considered in the design of future school infrastructure.

Characteristic 6- Building Modifications

Few buildings showed modifications to existing structure that reduced the structural performance of the buildings. The majority of the ‘permanent’ school structures surveyed did not appear to have any modifications of concern.

A number of ‘permanent’ structures were observed to have retrofitted connections at the truss/wall interface which was carried out as part of a GoV retrofitting program in the 1990s. It appeared that the provision of thick metal strapping tie downs (~25x5mm) at these locations ensured that the majority of the roofs on these structures remained intact through TCP. In these cases, low cost interventions were carried out on sound structures, which in turn protected them from broad scale damage. The use of thick steel tie downs demonstrates the importance of solid connections and highlights the benefits of a retrofitting program in making existing structures safer and extending their life.

Characteristic 7- Structural Capacity

In the absence of design documentation for the schools that were visited, it is not known whether buildings in Vanuatu have been engineered, or whether buildings have been constructed based on the knowledge of those contractors, builders, donors and the workers that built them. The survey found that many buildings had inadequate structural capacity to resist damage or destruction during TCP. School buildings commonly failed at the connections between structural elements at three main locations: from roof sheet and battens to primary roof structure; from primary roof structure to walls and from walls to foundations as shown in Figure 2.

Figure 2: Loss of roof sheet from the use of roofing nails (not screws) and a large purlin spacing (L). Loss of roof from corroded rafter to wall connections (M). Complete loss of building as the wall bottom plate is anchored to the foundation, but the walls are not anchored to the bottom plate (R)

Typically the effectiveness of connections was limited by poor detailing practices, degradation of the connections due to corrosion and the limited availability of materials or insufficient finances to purchase materials, suitable for creating strong, durable connections. In the absence of design documentation, it is unclear whether the poor quality of connections was due to inadequate design, an absence of design or a failure of builders to follow the design.

Many Type 1 buildings that were inspected did not have a clear lateral stability system making them vulnerable to collapse under cyclone and earthquake loads. It is likely that the lack of a robust lateral stability system led to the destruction of many of these buildings during TCP.

The combination of corrosion of structural connections and a lack of engineered buildings was found to be a major vulnerability of school infrastructure and must be addressed as part of a reconstruction or retrofitting program. There were a large number of buildings inspected during the survey that survived TCP, but with further degradation will be unlikely to withstand a significant storm or earthquake in the future. There is potential to retrofit these structures to extend their useful life.

Opportunity 5: Technical assistance could be provided to develop a building retrofitting assessment tool and retrofitting guidelines. The assessment tool could be structured around a decision/ logic tree, which would assist workers to determine the appropriate retrofitting solutions. The guidelines would contain a tool kit of typical details which address the key structural vulnerabilities and should be presented using clear 3D documentation, to convey details in a way that is relevant to the level of education and training of the construction workforce. All details provided would be designed by a qualified structural engineer.

Characteristic 8- Non-Structural Elements

Most buildings surveyed were simple in scale, design and had minimal contents or non-structural elements. Cyclone shutters made of plywood or flat tin were typically fixed to the window openings of all ‘permanent’ structures, and were in varying states of repair. Few windows showed functional locking mechanisms, which may limit their effectiveness in a cyclone. Some ceilings were also damaged in schools where roof sheeting was lost or roofs leaked.

Opportunity 6: Repair of window shutters and locking mechanisms could be considered as part of a repair program to ensure the safety of building occupants, particularly if these structures are to be used to shelter from cyclones.

Characteristic 9- Materials and Quality Control

Buildings at the schools visited were constructed from a range of local and imported materials which effected the performance of some buildings as shown in Figure 3.

Local timber was used to construct a number of roofs and the material quality varied from good through to poor. Some timbers were observed to be durable and resistant to rot, fungal and insect attack, while others were severely degraded. Whilst the use of local timbers may be suitable, the determination of their structural capacity is challenging due to material testing requirements and local knowledge of the species is required to understand their durability. Where imported timbers were used, these were often treated pine from New Zealand or Fiji and demonstrated a good level of durability.

Beach sand and crushed coral was the predominant material used for the production of concrete, which in some cases was observed to be causing corrosion of the reinforcement in concrete elements. Without adequate washing with fresh water, the salt content in beach sand leads to the rusting of steel, causing the concrete to spall, further exposing the steel to the external environment and decreasing its structural capacity. At a number of schools interviewees were asked about washing beach sand and there did not appear to be an understanding of the need to wash it before use. Washing sand can be a challenge due to the reliance on limited amounts of rainwater or the need to pre-plan works by storing sand in the weather for around six months for the salt to be washed out.

Figure 3: Insect attack to untreated timber (L). Incomplete core filling of concrete blocks (M). Wall reinforcement corrosion likely resulting from concrete made with unwashed sea sand (R)

Many schools in Tanna faced challenges in sourcing quality, durable building materials and typically had to order them directly from suppliers in Port Vila. Transporting these materials to remote islands further increased their costs, making them less affordable for the construction of school buildings. When ordering materials directly, School Councils had an increased level of control over the quality of products that were purchased and some schools showed a good level of knowledge about quality products. When materials were ordered by builders on behalf of the schools, there did not appear to be oversight or quality assurance by the schools, leaving the material choice and thus quality to the discretion of the builder.

A lack of quality control during construction appeared to be widespread, increasing the vulnerability of many buildings to natural hazards. Construction quality was seen to vary from good through to very poor. Many interviewees on Tanna reported that school infrastructure was constructed by workers with limited or no formal training and it is unclear what supervision (if any) was carried out by experienced trades.

Opportunity 7: For a potential reconstruction and retrofitting program, the quality control of the materials needs to be addressed. There is an opportunity for TA to develop a detailed, clear material specification which would be part of the School Construction Manual (refer to Opportunity 13). Quality control of materials during construction could be managed by the Managing Contractor through and a centralised procurement process, which would eliminate variability in the materials used by different contractors. Tendering works based on labour supply only would also assist smaller local contractors to carry out the works, who may not have the capital available to purchase materials in advance.

Quality control of workmanship during construction is further discussed in Opportunity 17.

Characteristic 10- Maintenance and Repair

Providing regular maintenance to buildings is a challenge for most schools that were visited and whilst some carried out maintenance to their buildings, many were observed to be prematurely degraded due to insufficient maintenance. A number of interviewees demonstrated an understanding of the need to maintain buildings, but said that it was difficult due to financial constraints and competing priorities for funds within the school. Maintenance and repair works that were understood to be carried out on buildings included painting, and replacing roof sheets and guttering. Most buildings inspected showed signs of corrosion of steel components, which were believed to be the result of the emissions from the nearby active volcano, Mt Yasur, and the proximity of some structures to the coast. Timber elements that were subject to the weather were also seen to be degrading from exposure. Without regular maintenance, the degradation of materials decreases their strength and increases a buildings vulnerability to cyclonic winds.

Opportunity 8: Materials selected for use in a set of standard school designs should take into account ongoing maintenance requirements and wherever possible be selected to minimise maintenance.

5.3 School Infrastructure Requirements

To return a school to normal operation after a disaster requires a range of infrastructure to be functional such as classrooms, administration buildings, sanitation facilities, water supplies and staff housing. Whilst the RVA survey largely focussed on the examination of classroom buildings, a WB school infrastructure program should consider schools as a ‘package’ which includes all the basic infrastructure to allow a school to function.

5.3.1 Classrooms

Rapid visual assessments carried out at 23 schools examined each classroom for structural vulnerabilities and categorised each building based on its condition. Classrooms were assigned to one of the five categories shown in Table 4 below. The remedial action that is required for each category is also shown based on the buildings potential to be retrofitted or repaired. Figure 4 shows the percentage of buildings from the whole sample which fall into each category.

From this it can be seen that there are only a minor number (5%) of Category 5 classrooms that do not require any remedial action to return them to serviceable condition. It is also clear that here are a significant number (45%/ 25% respectively) of Category 4 and 3 buildings that require minor works, such as the retrofitting of connections and replacing of roof sheeting. 10% of buildings were classed as Category 2, where the rebuilding of roof structure is required and 18% of buildings were identified as requiring complete reconstruction (Category 1). Structures that were classed as having retrofit potential were typically in a state that survived TCP, but over time may not survive another severe cyclone or earthquake as they are in poor condition.

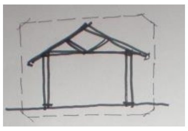
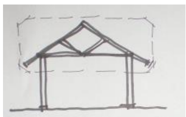
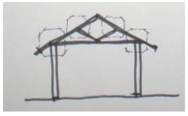
Building Category	**Building Condition**	**Proposed Remedial Action**	**% of Sample and Number of Classrooms in Building Category**		
1	Building damaged beyond repair	Complete Rebuild	18%	22	
2	Roof damaged beyond repair; walls intact	Rebuild Roof Structure	10%	12	
3	Building intact; roof sheet and connections in poor condition	Retrofit Connections + New roof sheet	25%	31	
4	Building and roof sheet intact; connections in poor condition	Retrofit Connections	45%	51	
5	Minor Damage Only	No Action Required	5%	6	-
Total			100%	116	-

Table 4: Categorisation of building condition and remedial actions for classrooms surveyed on Tanna

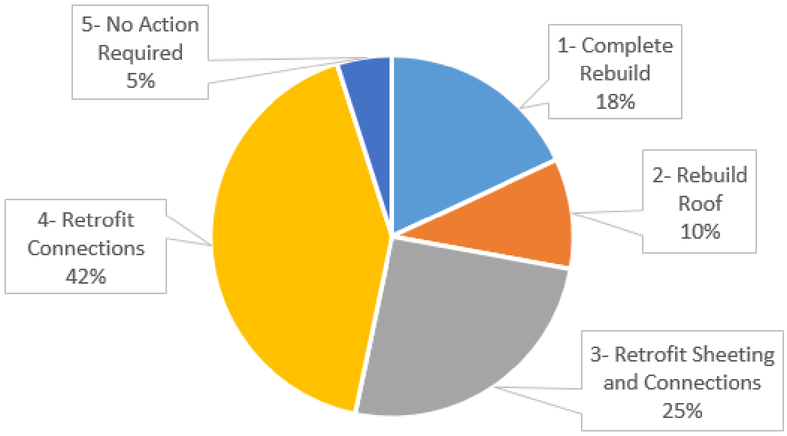


Figure 4: Remedial action required by building category for buildings surveyed

Taking a survey sample size of 29% and extrapolating to the full sample of schools on the island, an indicative number of classrooms to be reconstructed or retrofitted on Tanna can be determined as shown in Figure 5 below[3].

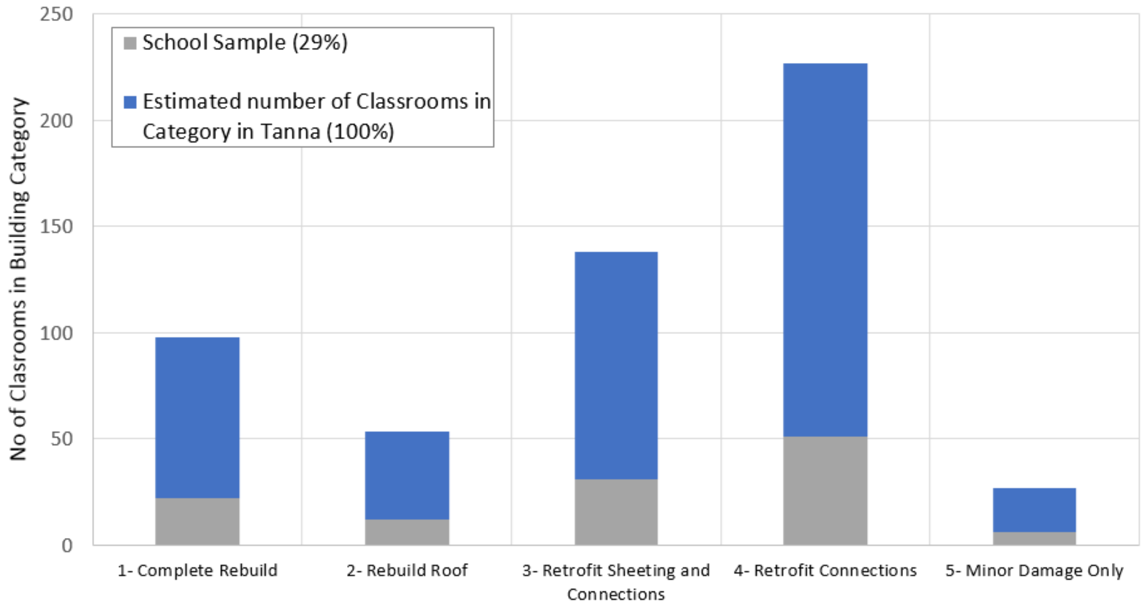


Figure 5: Estimate of classrooms to be reconstructed or retrofitted on Tanna

It should be noted that the findings above are based on a Rapid Visual Assessment (RVA) of each building, with the intent of examining the key vulnerabilities of structures and trends in damage of the whole building stock. To determine the full scope of works and suitability of retrofitting structures, a detailed engineering assessment should be undertaken for each building. This may involve some minor destructive testing/ scabbling of walls to determine the strength of concrete and location of reinforcement. Engineering judgement must be used to determine the extent to which existing buildings are worth retrofitting, or where new construction may be a safer and more cost effective solution.

[3] This assumes that the schools surveyed are a representative sample of the schools across Tanna and that there are a similar number of classrooms in the remaining 71% of schools.

5.3.2 Other School Buildings and Infrastructure

Other buildings on the school site were also surveyed during the mission, but detailed assessments were not carried out for these elements at each school. Brief summaries of the observations are given below.

Administration Buildings

Administration offices in smaller schools were typically a room located centrally between two classrooms, while in larger schools they were often separate buildings. Structural typologies and levels of damage in these buildings were similar to classroom structures. Administration buildings have an important role in the function of a school for the storage of resources and materials. Robust office buildings are important to ensure materials and resources are not damaged during disasters, allowing schools to return to operation quickly.

Sanitation Facilities

The schools surveyed typically had basic sanitation facilities that consisted of a pit toilet with lightweight walls and roofs. Most of these structures were destroyed during TCP. At most schools, following TCP at least one facility for each of girls and boys had been constructed using recycled materials. These reconstructed facilities offered varying levels of privacy. The destruction of sanitation facilities was reported to be a deterrent to students and in particularly to girls, from returning to school.

Water Supply

Schools typically rely on rainwater for drinking and hand washing facilities, which is stored in tanks adjacent to classroom buildings. Many schools reported damage to guttering and pipes from strong winds and as a result had problems collecting water in the wake of TCP. With many schools used as evacuation centres, increased demand on water supplies can leave schools with scarce supplies after a disaster.

Robust fastening of gutters, or the provision of gutters that can be removed in preparation for cyclones is a way to ensure water can be collected readily following a disaster. If schools are to be used as evacuation centres adequate numbers of tanks must be provided to ensure sufficient water supplies exist for users.

Staff Housing

Most teachers and principals come from other parts of Vanuatu and are typically placed by the MoET in schools for periods of up to three years. Staff generally live in houses on the schools grounds that are built by the school community. In many schools, teachers' houses were destroyed during TCP, forcing them to move into classrooms, storage rooms or temporary structures. The reliance on the school community for the provision of housing meant that teachers at a number of schools were without adequate housing.

6 Construction Environment

6.1 Institutional and Regulatory Environment

Institutional

Prior to 1999, the engineering and architectural functions of the GoV were centralised within MIPU and the unit was responsible for all planning and building approvals. In 1999, the 'decentralisation' of the engineering and architectural functions saw the creation of Facilities Units within the MoET, Ministry of Health and Ministry of Trade, Tourism, Commerce and Industry. Following this, each unit became responsible for the technical aspects of infrastructure (design, delivery, construction, and approvals processes), as well as asset planning, funding and operations. For the MoET, this decentralisation has left it without the full suite of capabilities it needs in order to fulfil its role. The MOET's Facilities Unit currently includes two qualified architects but lacks structural engineering capability. Structural engineering capability is not readily available outside of the MOET as there is, at present, only one professionally qualified structural engineer in Vanuatu.

Opportunity 9: Structural engineering technical assistance could be provided to the MoET's Facilities Unit on a short-term basis to supplement the existing architectural capability. The TA could build the capabilities of the existing architectural staff by providing training in the identification of key structural vulnerabilities and assist in the incorporation of safer schools measures into the MoET's standard designs, specifications, contract documentation and handover/maintenance documentation. The TA could additionally provide input into the rationalisation process and identification of schools to be used as Evacuation Centres.

It is also recommended that a training and scholarship program is developed for the GoV to address the longer term requirement for locally based engineering input into public infrastructure across the country.

Regulatory - Planning

The Physical Planning Act was passed in 1988 and GIZ, the German corporation for international development, has been working with GoV to develop planning and zoning policy. These regulations are currently focused around the major population centres and are unlikely to incorporate the planning of school infrastructure throughout the country in the near future.

Opportunity 10: Based on the hazard mapping undertaken by the NDMO and VMGD, Technical assistance could be provided to the GoV to assist in the development of planning guidelines and land use maps which extend across the remainder of the country. This would help to limit development of schools in areas that are most vulnerable to natural hazards.

Regulatory - Building Code

A National Building Code (NBC) was developed for Vanuatu in the late 1980s funded by the Australian overseas aid program, with a draft code issued in 2000[4]. In 2013, the Building Act was passed in Parliament to legislate the building code, however the uptake of the code has been limited outside of the capital, Port Vila. It is understood that the NBC is based on codes from Australian and New Zealand and has been adapted to suit local conditions.

[4] Arup sighted, but did not undertake a detailed review the NBC during the mission due to its limited availability.

It is understood that in Vanuatu all code compliant buildings are designed for the same basic wind speed of 70m/s and unlike in Australia and New Zealand, different importance levels are not provided for buildings based on their post disaster use. For a potential reconstruction program, the importance levels of buildings should be evaluated and design loads increased accordingly, if they are to be used as evacuation centres.

Despite the presence of the NBC and some interim planning regulations, planning and building approval processes for schools largely appear to be ignored. The MoET's Facilities Unit is responsible for confirming that a proposed building design complies with the NBC, however the enforcement of these processes is, according to the MoET, challenging. Schools communities that do not receive funding from the GoV do not see the need to "respect the (GoV's) rules" and obtain the necessary approvals for new building works. School Councils do not appear to be obtaining MoET approval prior to undertaking work and international organisations that undertake works do not consistently obtain MoET approval (although MoET has been consulted on at least one occasion post-TCP) for reasons unknown. Currently there is insufficient capacity within the Ministry of Public Works or MoET to enforce the application of the NBC for the construction of schools.

Opportunity 11: A communication strategy could be developed that highlights the importance of obtaining MoET approvals for school infrastructure to ensure safe school construction. This strategy would target Principals and Teachers, School Councils and Committees, local communities, and international organisations and explain the reason why approvals need to be sought and the process that needs to be followed. For any strategy to be successful it must be backed by an efficient approval processes for new construction. The completion of the development of standard school building designs would assist MoET to respond to requests for documentation efficiently.

In the long term, to ensure the quality of construction across the nation, the GoV should work to enforce the building code for all new buildings. From a cursory review it appears that the technical content and language used in the building code may make it inaccessible to the general population. Development of a guidance document which highlights the critical components of the code and is contextualised to suit local construction practice may assist in the broader rollout of code compliant construction.

Governance and Management of Schools

Each school has a School Council comprised of a Chairperson and Council Members which include parents and teachers, who carry out the management and operation of the school. At some schools, the Principal and Teachers undertake maintenance activities as well as carry out repairs to buildings. At other schools, the School Council arranges for members of the community, who may include builders (trained locally or in Port Vila), carpenters, and/or parents to participate. At some schools, parents spend one day per week undertaking maintenance activities including ground maintenance. Unlike primary schools, secondary schools tend to have a staff member responsible for repairs and maintenance. Secondary school students typically come from outside the local area and the local community is therefore less involved. Teachers are Principals are typically not from the communities in which they work and are theoretically required to move schools every three years. Given the involvement of Principals and Teachers in the maintenance and repair of buildings, unless written documentation on maintenance and repairs is kept, this knowledge can easily be lost when staff relocate.

In addition to the Facilities Unit located in Port Vila, the MoET has six Provincial Education Offices. These Provincial Education Offices provide support to Principals, School Councils and Committees in the areas of school management, planning, maintenance and repair, and budgeting. Each Provincial Education Office is staffed with between six and eight staff. In Tanna, the Provincial Education Office is staffed with one Provincial Education Officer, one Provincial Maintenance Officer, one Administration/Finance Officer, Zone Curriculum Advisors, one Provincial Trainer and one Kinder Advisor.

6.2 Implementation Process

Table 5 below summarises the stakeholder responsibilities for school infrastructure during each stage of the asset lifecycle.

Stage	Task	Body Responsible	Description
Planning	Needs Assessment	Unclear	It is understood that MoET is responsible for the assessing the need for a new school. It is understood that school communities assess the need for new school buildings either alone or in conjunction with the MoET (Provincial offices).
	Site Selection	School Community	Schools are built on private or customary land which is leased or provided free of charge to the school.
Design	Design Development	MoET	MoET encourage schools to consult with them before construction. The MoET are developing standard school designs which will be available for use to inform construction.
		School Community	School communities carry out their own design for school buildings with no engineering or architectural input. MoET encourage communities to consult with them before commencing construction.
		Donors	Donors carry out their own design. MoET encourage donors to consult them before commencing construction.
	Building Permit	MoET	Schools are required to obtain approval from the MoET for construction of new school buildings. This requirement is not enforced, due to lack of awareness of new construction and lack of resources.
Construction	Procurement and Financing	School Community	School communities fundraise locally and procure their own materials and workforce.
		CTB	Central Tenders Board/ MoET are responsible for procuring government funded school infrastructure, depending on the construction value.
		Donors	Donors provide funds and carry out their own procurement.
	Contract Management	Various	It is not known if school communities use contracts to manage construction. MoET/ donors manage contracts for externally funded works.
	Supervision	Various	School communities supervise their own construction. Donor funded programs either engage third party supervision/ are unsupervised/ supervised by community.
	Occupancy Certificate	N/A	Not provided.

Operation and Maintenance	Maintenance and Repairs	MoET/ Schools	MoET provides quarterly school grants based on enrolment levels which are able to be used for school maintenance. School communities are responsible for maintenance of the school infrastructure and fundraise locally and provide in kind support. Donors assist some schools.

Table 5: Stakeholder responsibilities for school infrastructure

6.2.1 Planning

MoET's Facilities Unit is responsible for the planning, design and delivery of school infrastructure and can access technical assistance from MIPU as required. However, in reality most school infrastructure is currently planned and sited by school communities directly without the approval of, or assistance from MoET, despite MoET's desire for greater involvement in the process. The level of technical capability and capacity within MIPU to provide assistance to the MoET is unknown.

With an absence of planning regulations, there is little guidance available for the MoET and schools on the appropriate siting and physical planning of school sites.

Opportunity 12: A guidance note on site selection and physical planning could be developed, to assist the MoET and School Councils to address the key local hazards and physical planning issues which impact on school safety.

6.2.2 Design

The design of school infrastructure is the responsibility of MoET, however most schools are reportedly constructed without any technical (architectural or engineering) input. School communities (which may include builders with or without formal training) decide on all aspects of the building layout and structure. Some of the interviewees surveyed during the mission demonstrated an understanding of the correlation between architectural and/or engineering drawings and safer schools.

To address the issue of schools being delivered without engineered designs and drawings, the MoET are currently developing a suite of standard school building designs, which they intend to make available to School Councils for use in new construction. At present, preliminary designs (plan, typical section, elevations and some details) exist for standard Double Classrooms (with and without a central office) and Administration Buildings (for schools with 180 and 360 students). Development of these standard designs is underway using, as guidance, a suite of documents developed for a European Commission (EC) funded Education and Training Program (2005). In addition to these preliminary designs, the MoET's suite of standard documentation includes a Technical Specification (appended to the General Conditions of Contract (GCC) (refer below)) and Bill of Quantities (BoQ) (not sighted).

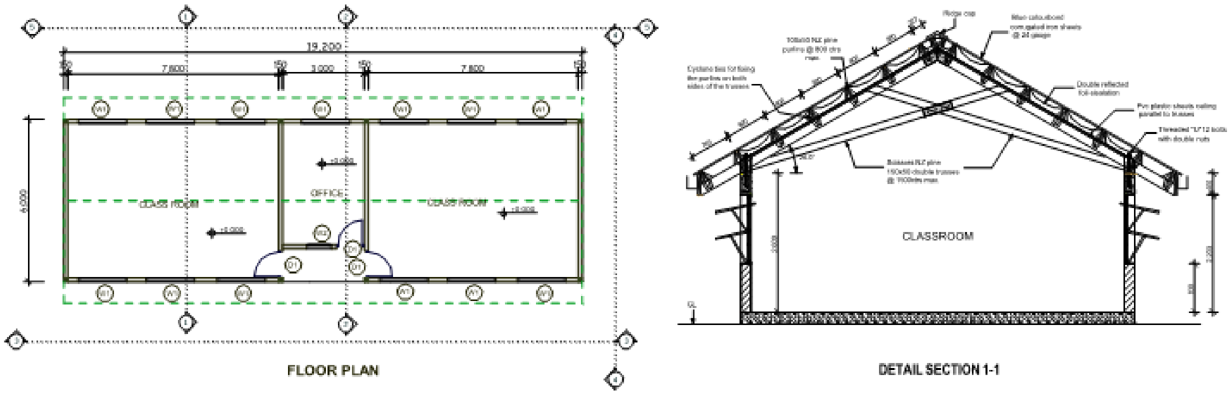


Figure 6: Typical plan and section from the MoET standard classroom design

At present, the Technical Specification and drawings are not coordinated, which is to be expected given the development process still underway. Any risks associated with the procurement of new buildings during this development phase are arguably dealt with by the order of precedence of documents, which gives precedence to the Technical Specification.

A cursory review of the Technical Specification found that, while it covers each of the key work scope items, including some safer school measures, it was not possible, without the BoQ and with the drawings in a preliminary state, to assess whether it was comprehensive. The review also found that the structure, level of detail, technical language and frequent references to Australian Standards (AS) may make the specification inaccessible to small contractors or community builders who rely on it for instruction. Requirements in the specification for inspections and/or testing were sometimes explicit and sometimes not. Given the importance of inspections and testing during construction for ensuring safer schools, requirements for inspections and/or testing (including notice periods) need to be set out clearly both in the Technical Specification and the General Conditions of Contract (GCC).

Opportunity 13: A well communicated set of standard school infrastructure designs and associated documents will provide a consistent approach to safer school construction, that takes into account the relevant hazards and ensures compliance with the NBC.

Technical assistance could be provided to the MoET to assist in the development of a set of coordinated documents, which would include design drawings, technical specifications and a bill of quantities. A key focus in this process should be on eliminating unnecessary documents and/or detail and improving accessibility. Designs could be included for classroom buildings, water supply, sanitation facilities, administration buildings and, if desired, staff housing. These documents could be collated to form a ‘Schools Design and Construction Manual’ along the lines of the MoET’s ‘Schools Maintenance Manual’ (prepared by the Public Works Department’s Training Unit) which would facilitate ‘on the job’ capability building.

The content of this ‘Manual’ should be tailored to the level of education and experience of the construction workforce. The use of clear, 3D drawings (or ‘axonometrics’) in addition to, or instead of standard architectural/engineering drawings would assist in the communication of construction details to workers who have no formal training. The manual could be augmented with ‘step by step’ (‘Lego’ style) drawings which would assist lower skilled workers to understand the staging of construction works. These drawings could also identify hold and inspection points which are key to ensuring quality control throughout the construction process.

Any standard designs must take into account the different site conditions across the country as well as the local hazards, and include options for and guidance on modifications to suit these specific conditions. Particular attention needs to be paid to hazards, such as corrosive gas emissions from active volcanos and proximity to the coast which are not covered in the NBC.

6.2.3 Procurement

Depending on the value of works, the responsibility for GoV contract procurement lies with the Ministry of Finance and Economic Management's (MFEM) Central Tenders Board (CTB), or directly with line ministries 'purchasing departments'. Works valued at less than 5M VT (USD44,800) can be procured directly through the MoET's purchasing department, who must obtain three quotations and approval from the Head of the Ministry. The procurement of works over 5M VT follows a competitive tendering process, administered by the CTB. For these works the CTB maintains a list of approved contractors that meet the CTB's requirements (which have not been sighted). It is understood that MIPU have a list of Island-Based Contractors for works valued up to 10M VT however they have not been through any prequalification process. For all GoV funded school infrastructure works the MoET purchasing department is responsible for the preparation of Request for Tender and Contract documentation.

The CTB operates in accordance with an Act of Parliament with a Chairperson and two full time employees. It is understood that there is a special provision within the Act that enabled the CTB to immediately approve the award of a contract to an approved contractor during the TCP recovery phase. Following recovery, during a reconstruction effort the standard tendering procedures must be followed. MFEM (and MIPU) is of the opinion that there will be insufficient capacity on the CTB's list of approved contractors to meet the demand during the TCP reconstruction phase and that assistance will be needed to mobilise additional capacity. It is also understood that the CTB may face capacity constraints themselves during the reconstruction phase and that MFEM is likely to advertise for an additional two staff. Members from the CTB were not interviewed during the mission and the capacity and capability of the department is not known.

Opportunity 14: Technical Assistance could be provided to review the CTB contractor approval requirements and expand the list of approved contractors to include contractors with the capacity and capability to deliver safer schools using a capacity building approach, by means of a regional, and if necessary international, prequalification process.

A feature of the GoV's procurement processes is that a tender will be assessed *"purely on price"*. The MoET's Request for Tender – specifically Clause 1.15.1 of the General Conditions of Tendering (GCT) – states that *"(t)he Contract will be awarded to the Tenderer whose Tender is substantially responsive and offers the lowest price"*. This focus on *"lowest price"* – as distinct from 'value for money' – puts the safety of school infrastructure at risk if MoET's requirements (as set out in the Request for Tender) are unclear and/or ambiguous.

Opportunity 15: To mitigate any risks associated with the focus on 'lowest price' the MoET could incorporate in the Special Conditions of Tendering (SCT) and the Tender Response Schedules provisions to enable the identification of a contractor with the capacity and capability to deliver safer schools using a capacity building approach. These could include, but are not limited to, widening eligibility criteria to include Non-Government Organisations; and/or including specific qualification criteria requiring evidence of the contractor's and its sub-contractor's past provision of capacity building on a construction project.

Technical assistance could be provided to assist the MoET develop a tender strategy which includes the requirement for Tenderers to attend a Pre-Tender Meeting for any school infrastructure works. At a Pre-Tender Meeting the MoET could introduce the principles of safer schools with a focus on the importance of materials selection and workmanship. A Pre-Tender Meeting also offers an opportunity to disseminate the principles of safer schools to contractors who may be engaged in school infrastructure projects in the future.

It is not known if Request for Tender documentation and GCC (or equivalent) exist for the procurement of Project Management, Superintendence (or supervision) and engineering services for the duration of construction phase activities.

Opportunity 16: Develop a GCC for Project Management, Superintendence (or supervision) and engineering services during the construction phase that includes specific requirements associated with 'on the job' capacity building in the areas of works supervision.

6.2.4 Construction

The construction of schools is currently the responsibility of school communities, however some schools benefit from MoET-funded infrastructure investment programs (typically using donor funds). With the population spread across 65 islands in the Pacific, the transport and sourcing of imported building materials can be both challenging and costly. All imported materials are shipped through Port Vila, with many sourced from Australia, New Zealand and Fiji.

Construction of school infrastructure in Vanuatu is undertaken by a range of actors including the private sector (International and Island Based Contractors (IBCs)), Non-Government Organisations (International NGOs, international and local service and religious organisations), training institutions and school communities. The capacity and capability of each to deliver safer school infrastructure varies.

A major vulnerability for the construction of school infrastructure is the lack of quality control processes during the construction phase. Due to the variety of actors in the construction industry, there are varying quality assurance and quality control measures in place. Currently, there does not appear to be a formal system in place for the quality control of construction nor capacity within the MoET to provide assistance from appropriately qualified staff. While the MoET General Conditions of Contract (GCC, the Technical Specification) includes requirements for inspections and/or testing by the contractor, these requirements are not always explicitly stated. Given the importance of quality of materials and quality workmanship and construction that is in line with the design intent, a quality assurance strategy which includes requirements for inspections and/or testing (including notice periods) need to be set out clearly both in the Technical Specification and the GCC.

A large scale reconstruction program will challenge the capacity and capability of the local construction sector as there is a shortage of local companies in Vanuatu that are of the size to manage such a program. Several international contractors have a local or regional presence and could fulfil the role of a managing contractor to oversee construction works by a number of smaller IBCs.

Sourcing local, qualified tradespeople in Vanuatu can be difficult. There are a limited number of skilled workers and the current demand for reconstruction in and around Port Vila has further reduced this limited supply. Currently there is a large supply of low skilled labour that could be drawn upon for a reconstruction program, however close supervision and training of these workers would be required to ensure that quality standards are being met. From the buildings that were surveyed it was clear that good supervision of low skilled labour can result in safe school construction, while a lack of supervision leads to poor quality buildings that are vulnerable to natural hazards.

Opportunity 17: Appropriate quality assurance and quality control processes must be established and carried out during a reconstruction and retrofitting program to ensure that new schools are safe and retrofitting improves existing school safety.

Quality assurance could be managed by the MoET through the provision of standard drawings and specifications and the provision of clear inspection and testing requirements for contractors during construction. Technical assistance could be provided to assist MoET develop explicit inspection and testing requirements for the GCC.

Quality control of sub-contractor works could be ensured by the Managing Contractor, through the monitoring of all site works by a qualified supervisor and use of ‘hold points’, where work must stop until inspected by an appropriately qualified and experienced inspector. It is recommended that these points be established at five key stages: before pouring the slab; during wall construction; at completion of walls; at completion of roof structure and at project completion. In addition, samples of all materials to be used during construction should be signed off by a supervisor before procurement and then checked again on arrival at site.

A Certificate of Completion (to be issued by the Managing Contractor) could be introduced which verifies that the building has been constructed in accordance with the specifications and drawings and that all required inspections and tests have taken place during construction. This Certificate would be given to both the school and MoET be included as a condition of Practical Completion.

Wherever possible, staff from the MoET should be involved in the process of developing inspection and test procedures and monitoring the quality of construction. Inclusion of MoET staff in this process will build capability within the MoET and assist to establish long term change in the way that school construction is supervised.

Trades training is currently delivered either by vocational education training centres (Vanuatu Institute of Technology (VIT), Australia-Pacific Technical College (APTC), Technical and Vocational Education and Training Sector Strengthening Program), and locally run Rural Training Centres (RTCs). The RTCs are already involved in the construction of school infrastructure. Working in collaboration with these organisations could help to identify suitably trained workers for the rollout of a larger scale construction program.

Opportunity 18: A construction program which utilises low skilled local labour is likely to provide higher quality infrastructure and long term improvements in construction practice when supplemented with training and capacity building. There is an opportunity for technical assistance to develop two discrete training programs that could be incorporated into construction works of new assets: one which build the capabilities of low skilled workers and another which provides site supervisors with the skills to manage and train low skilled labourers.

Program 1 could be a basic construction training course delivered ‘on the job’ to workers during construction. Short modules (approximately 4 modules of 1-2 days each) could be delivered to the workforce in parallel with works on site, at key stages throughout construction. These modules would focus on addressing the key structural vulnerabilities of buildings. To illustrate the vulnerabilities, simple, practical connection and bracing models using string and timber could be developed for trainers to replicate real-world details, allowing them to visually illustrate different structural concepts to workers. A practical approach, that teaches workers how to follow construction drawings, demonstrates why some details are stronger than others and allows workers to directly apply course material in a real world scenario, will likely lead to greater improvements in construction practice.

Program 2 could be a ‘Training of Trainers’ program, designed to up skill experienced local trades, who would be acting as ‘site foreman’, responsible for the supervision of low skilled labourers on site. A brief program of around one week to 10 days could provide workers with tools and techniques for the supervision and training of low skilled labour and equip them with skills around quality control, inspection and testing during construction.

Skills and experience from the existing in-country training organisations could be drawn upon for the development and delivery of these training courses.

6.2.5 Operations and Maintenance

Construction, repair and maintenance of school infrastructure is the responsibility of school councils, through a government policy of ‘School Based Management’. This policy places responsibility for building and operating schools directly with Principals and Teachers, under the direction of the School Council. Teacher salaries are paid by the MoET and additional funds are given in the form of quarterly grants. These grants are based on enrolments and are used to help cover all non-wage running costs of schools, to purchase materials, books and carry out any maintenance. The grants are rarely sufficient to meet demand, with the gap in funding filled by communities directly through fundraising and in-kind contributions. Due to the shortfall in funding and an apparent preference in the school communities for prioritising new construction over the maintenance of the existing assets, the preventative care for structures is often superficial and is rarely carried out until structures fail, or require major repairs. This trend leaves school infrastructure increasingly vulnerable to natural hazards. Bilateral donors, NGO’s and religious and international service organisations also assist school communities to meet the needs of school operations and maintenance.

Opportunity 19: Improved maintenance of existing structures would help to protect the existing building stock and reduce its vulnerability to natural hazards. Recognising that the decision making processes and prioritisation for the direction of school funds lies directly with schools, efforts could be focussed on training School Councils, Principals and Teachers in the benefits of preventative maintenance. The existing MoET ‘Schools Maintenance Manual’ (prepared by the Public Works Department’s Training Unit) should be updated and complemented with a training program to help reinforce the importance of regular preventative maintenance. This manual should address the local hazards to which school infrastructure is exposed.

Furthermore, the direct involvement of communities in a reconstruction and retrofitting program will increase community knowledge and improve the understanding of maintenance.

7 Financial Environment

7.1 Historic, Current and Planned Investment

Since independence in 1980, the construction of 'permanent' infrastructure in the education sector in Vanuatu has been largely supported by donors, with limited investment from the GoV. Currently, the Governments of Australia (GoA) and New Zealand with UNICEF provide financial support to the GoV via a Joint Partnership Agreement. This commitment is currently being delivered via the Vanuatu Education Sector Program (VESP). VESP provides direct support to the MoET's Facilities Unit (FU) in its efforts to improve the quality of school infrastructure. These efforts include updating MoET's standard designs; surveying all assets and developing an asset management strategy; constructing new classrooms to meet the current backlog and future demand; and undertaking refurbishments and maintenance. Table 6 highlights the current and proposed major donor investments in school infrastructure.

Organisation	Program	Scope	Value of School Infrastructure
Current Investments			
DFAT	Vanuatu Education Sector Program (VESP) (Total program: AU$40M)	Primary schools: Classrooms	AU$4M
MFAT	Small grants program	General grants (up to 5M VT) known to have been accessed to fund classrooms	Unknown
Proposed Investments			
DFAT	Australian Government Trust Fund (Total fund: AU$35M)	Primary schools: Classrooms (~40-50), water and sanitation (WASH) facilities.	AU$8M
ADB	Unknown	Secondary schools: Classrooms, WASH facilities.	US$3.5M
Japanese Embassy	Grant Assistance for Grassroots Projects	Direct donations to schools for infrastructure work	Variable

Table 6: Current and proposed major donor investments in school infrastructure

In addition to the MoET (supported by donors), school communities have historically been a primary source of support for school infrastructure. School communities are one of three primary funders of school infrastructure with support from the community equalling up to 50% of a school's total funding. In addition to raising funds, communities provide 'in-kind' support for the delivery of school infrastructure, either via direct or indirect engagement. Direct engagement means community involvement in construction activities while indirect engagement can include, but is not limited to, the provision of accommodation and meals for external contractors; the collection of materials from the wharf, transportation to site and secure storage; and cleaning and maintenance of the school grounds.

Community support for school infrastructure is a key strength of the school system in Vanuatu and any investment in school infrastructure in the future needs to maintain, and ideally strengthen, the current level of community engagement without compromising safe school construction.

Opportunity 20: Recognising that communities are already involved the construction and maintenance of school infrastructure, works should strengthen the current level of community contribution through the contribution of funds and/or 'in-kind' support.

It is recommended that 'in-kind' support follow MoET's preference to mobilise community support of construction activities, rather than in construction itself. Support of construction activities may include collection of materials from the wharf and delivery to site; provision of secure storage; provision of accommodation and meals for workers from outside the community; removal and recycling or disposal of waste building materials; and/or provision of locally available materials.

It is recommended that guidelines for community engagement should be developed. These guidelines would outline a process to consult with the community and agree on the level of contribution that they will make to construction. From this, a Community Participation Agreement could be established which would document the consultation outcomes.

Further guidance for community involvement in school construction is given in the GPSS document 'Towards Safer School Construction, a Community Based Approach'.

8 Schools as Evacuation Centres

Due to the frequency and intensity of cyclones in Vanuatu, communities across the islands require robust structures in which to shelter during storm events. Traditionally cyclone shelters were constructed using large diameter timber poles and a low roof that sat close to the ground. Whilst these structures have provided safe shelter in the past, the strength of TCP was such that many of these buildings were also destroyed during the storm. In many communities, the most robust buildings are school buildings. As a result schools are often used as shelter during cyclones, some for an extended period of time. Schools were reportedly used as shelter during TCP in one of three ways:

- for the duration of the cyclone
- for the duration of the cyclone and one to two weeks thereafter
- for the duration of the cyclone and up to eight weeks thereafter

On Tanna, schools used as shelter after TCP were mostly used for one to two weeks while people rebuilt their homes in their villages. During this period, a number of schools provided food *"rations"* and water at their cost from their school supplies. One school reported requiring recipients to provide in-kind support to the school as a means of recovering the cost of food rations. Students were not able to return to school until classrooms were available, with some waiting up to two weeks to return to school.

Enrolments have also been affected by the cyclone with a number of schools reporting lower enrolment levels post-TCP. For schools relying on fees, the impact of lower enrolments (or slowly increasing enrolments) means less funds are available for repairing cyclone-damaged buildings, as well as regular maintenance.

There is consensus within the GoV that, in the future, schools should double as Evacuation Centres where there are no other suitable structures or buildings in the community. A priority for MoET and NDMO is for schools to fulfil the two main functions of an Evacuation Centre as set out in the (draft) *Vanuatu National Guidelines Selection and Assessment of Evacuation Centres*: '(p)roviding immediate safe and secure shelter in anticipation of and during a disaster' and '(p)roviding a safe refuge following the event for those who have lost their shelter or are unable to return to their place of origin'.

MoET and NDMO are currently undertaking a natural hazard mapping exercise to identify which schools could be used as Evacuation Centres and where they may need to be supplemented with additional community refuges (proposed to be multi-purpose community centres). The draft guidelines for evacuation centre assessment examines a buildings suitability for use as evacuation centre based on a list of criteria including: location; structural integrity, size, WATSAN and cooking facilities, safety and protection attributes, electrical supply and access to communications systems. These guidelines note that structural integrity of buildings should be assessed by a qualified structural engineer.

Not all school buildings that were used as shelter during TCP survived and building failures meant that people needed to find alternative shelter (if it was available) during the storm. A number of school buildings surveyed during the mission had been refurbished by international organisations, which led communities to believe that these structures were safe for shelter. At one location, two of the refurbished buildings collapsed, leading to two fatalities. Based on the photos sighted and what could be observed during the site survey, it appeared that the refurbishment may have addressed non-structural items such as painting, cladding and roofing, but failed to address the key vulnerabilities of the structures. This highlights the importance of carrying out detailed structural assessments of buildings to be used as evacuation centres by a professionally qualified engineer. Buildings that be been appropriately designed and/or retrofitted should be clearly singed that they have been certified as suitable for use as a refuge during a cyclone.

Opportunity 21: Technical assistance could be provided to assist the MoET and NDMO in the process of identification and selection of school buildings to be used as Evacuation Centres. Key Evacuation Centre requirements should be incorporated into the MoET's school surveys and include consideration of factors such as water supply, sanitation facilities and storage for school resources that are essential for effective operations post-disaster.

This work could be extended to help develop operational procedures for the schools selected to function as Evacuation Centres.

9 Recommendations and Opportunities

Of the classrooms surveyed in Tanna, 95% displayed key structural vulnerabilities that placed them at risk of damage from natural hazards. Close to 20% of structures were damaged beyond repair and require full reconstruction while the remaining 75% of structures require varying degrees of retrofitting to make them safer and strengthen them against future hazards. As such, there are a number of opportunities for WB support to embed safer school principles in a school retrofitting and reconstruction program. These opportunities are summarised in a roadmap on the following page and expanded on in the following sections.

Recognising that not all buildings were damaged beyond repair and that there is value in the existing building stock, it is recommended that a school reconstruction and retrofitting program focus on two key areas of work, which would be divided into two works packages:

Package 1

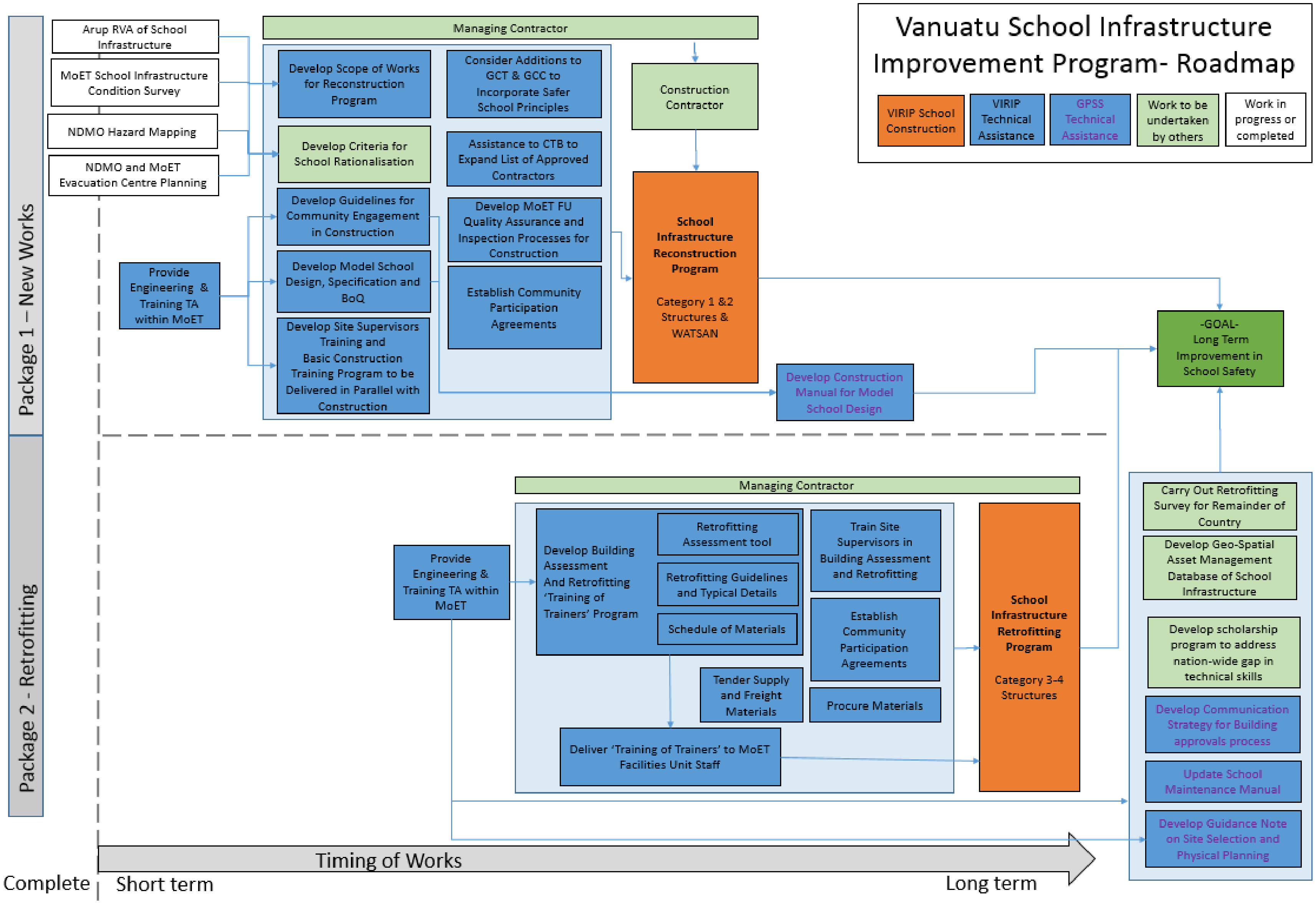
- Replacement of Category 1 school buildings with new engineered standard design buildings.
- Repair of roofs on Category 2 buildings with engineer designed roof structures and new roof sheet.
- Construction of supporting infrastructure such as administration buildings, sanitation facilities, water supplies and potentially staff housing with new engineered standard design buildings and systems.

Package 2

- Retrofit of Category 3 school buildings to make them safer, by replacing roof sheets and retrofitting engineer designed connections.
- Retrofit of Category 4 school buildings to make them safer, by retrofitting engineer designed connections.

The roadmap on the following page highlights the key components and opportunities for a WB funded school infrastructure improvement program. The TA associated with each of the two packages of works may be supported through funding from both the VIRIP and GPSS programs. In the roadmap, principal TA components for the packages have been allocated under VIRIP TA, with complimentary components listed as GPSS TA.

9.1 Roadmap



Vanuatu School Infrastructure Improvement Program- Roadmap
VIRIP School Construction
VIRIP Technical Assistance
GPSS Technical Assistance
Work to be undertaken by others
Work in progress or completed
Package 1 – New Works
Package 2 - Retrofitting
Arup RVA of School Infrastructure
MoET School Infrastructure Condition Survey
NDMO Hazard Mapping
NDMO and MoET Evacuation Centre Planning
Provide Engineering & Training TA within MoET
Managing Contractor
Develop Scope of Works for Reconstruction Program
Consider Additions to GCT & GCC to Incorporate Safer School Principles
Develop Criteria for School Rationalisation
Assistance to CTB to Expand List of Approved Contractors
Develop Guidelines for Community Engagement in Construction
Develop MoET FU Quality Assurance and Inspection Processes for Construction
Develop Model School Design, Specification and BoQ
Establish Community Participation Agreements
Develop Site Supervisors Training and Basic Construction Training Program to be Delivered in Parallel with Construction
Construction Contractor
School Infrastructure Reconstruction Program
Category 1 &2 Structures & WATSAN
Develop Construction Manual for Model School Design
-GOAL- Long Term Improvement in School Safety
Managing Contractor
Provide Engineering & Training TA within MoET
Develop Building Assessment And Retrofitting 'Training of Trainers' Program
Retrofitting Assessment tool
Retrofitting Guidelines and Typical Details
Schedule of Materials
Train Site Supervisors in Building Assessment and Retrofitting
Establish Community Participation Agreements
Tender Supply and Freight Materials
Procure Materials
Deliver 'Training of Trainers' to MoET Facilities Unit Staff
School Infrastructure Retrofitting Program
Category 3-4 Structures
Carry Out Retrofitting Survey for Remainder of Country
Develop Geo-Spatial Asset Management Database of School Infrastructure
Develop scholarship program to address nation-wide gap in technical skills
Develop Communication Strategy for Building approvals process
Update School Maintenance Manual
Develop Guidance Note on Site Selection and Physical Planning
Timing of Works
Complete
Short term
Long term

9.2 Package 1 - Reconstruction of Category 1 and 2 Structures and Supporting Infrastructure

It is recommended that Package 1 of the program focus on the construction of new buildings which were damaged beyond repair, the major repair of existing buildings that can be cost effectively made safe, and construction of other school buildings and supporting infrastructure where adequate facilities do not currently exist.

To assist the GoV to ensure that safer schools principles are incorporated into a reconstruction program, it is recommended that technical assistance is provided to review and update the **General Conditions of Tender and General Conditions of Contract**, to provide clauses which ensure that a suitably qualified contractor carries out the works. **Assistance could also be provided to the CTB** to expand the selection criteria and processes that they used for tender evaluation, including the **development of a list of pre-qualified contractors**.

To mitigate any risks associated with the focus on 'lowest price' it is recommended that the MoET incorporate provisions in the **Special Conditions of Tendering and the Tender Response Schedules** to enable the identification of a contractor with the capacity and capability to deliver safer schools using a capacity building approach.

It is recommended that a Managing Contractor be engaged to project manage and supervise the works on behalf of the MoET and would likely engage a number of smaller subcontractors to undertake the construction works. The Managing Contractor's scope of work would include an **on-site rapid appraisal** to corroborate the MoET PDNA and the Arup RVA and to confirm the exact number of: new classroom buildings required; buildings that require major works (and can be cost effectively made safe) and supporting infrastructure elements required at each school in the project area. A **detailed engineering assessment** may be required for some structures to confirm their suitability for repair.

The scope of works would likely include demolition of unsafe structures, construction of new classroom buildings (Category 1 structures), repair of buildings which require replacement of the roof and have sound walls (Category 2 structures) and the construction of administration buildings, sanitation facilities, and water supplies where required. There is also the potential to include staff housing in the scope of works.

The NDMO geo-hazard mapping (which is underway for the entire country) and Evacuation Centre planning exercises should be evaluated alongside MoET school surveys and planning priorities to inform the criteria for school rationalisation. **Assistance, specifically on safer schools could be provided as input into the school rationalisation process**. Technical assistance could be provided to the MoET and NDMO to assist in the process of **selection of school buildings to be used as evacuation centres.**

Technical assistance could be provided to the MoET to assist in the preparation of a set of documents incorporating **standard school building designs, specifications and bill of quantities.** The scope of standard designs could incorporate classroom buildings, water supply, sanitation facilities, administration buildings and if desired, staff housing. This complete set could be collated to form a cohesive **School Design and Construction Manual**, which would ensure design compliance with the NBC. Following the completion of a WB program, these designs could continue to be used by communities to undertake construction works and would provide a basis for the continuation of safe school construction into the future.

Recognising that communities are already heavily involved the construction and maintenance of school infrastructure, wherever possible, works should strengthen the current level of community contribution to the construction process. **Guidelines for Community Engagement** could be developed, which outline a process to consult with the community. From this process, **Community Participation Agreements** would be established at each school prior to the commencement of works, which would set out the level of labour, additional funds and in kind support that communities would commit to the project.

To facilitate long term change in construction practice two discrete training programs could be incorporated into construction works of new assets: one which build the capabilities of low skilled workers and another which provides site supervisors with the skills to manage and train low skilled workers.

The first program could be a **training course delivered 'on the job'** to workers during construction. Short modules (approximately 4 modules of 1-2 days each) could be delivered to the workforce in parallel with works on site, at key stages throughout construction. These modules would be very practical and focus on addressing the key structural vulnerabilities of buildings. Modules would teach workers how to follow drawings of good construction details, demonstrate why some details are stronger than others and then directly apply course material in the construction of school infrastructure.

Program two could be a '**Training of Trainers' program**, designed to up skill experienced local trades, who would be acting as 'site foreman', responsible for the supervision of low skilled labourers on site. A brief program of around one week to 10 days could provide workers with tools and techniques for the supervision and training of low skilled labour and equip them with skills around quality control, inspections and testing during construction.

Works could be delivered though **labour only contracts**, where imported materials are issued by a managing contractor directly to subcontractors. This approach could remove issues around the quality control of materials and open up works to smaller contractors, who may find it difficult to access capital to pre-purchase materials. A schedule of materials could be developed and tendered to suppliers through a **supply and ship contract**, which would set out unit rates for each material**.**

To ensure quality on site, the managing contractor must develop robust **quality assurance and quality control processes** for the supply of materials and inspection of construction activities. To assist the MoET Facilities Unit to develop skills in the area of in the monitoring of construction works, staff from the **MoET should to participate in the development of and carry out quality assurance and inspection processes wherever possible**. This may be facilitated by the secondment of MoET staff to the contractor during the program and would leave a legacy of trained staff within the ministry with capabilities to assist communities with construction in the future.

A **Certificate of Completion** could be introduced which verifies that the building is constructed in accordance with the specifications and drawings and that all required inspections and tests have taken place during construction.

9.3 Package 2 - Retrofitting of Category 3 and 4 Structures

It is recommended that Package 2 of the program focus on retrofitting buildings which were undamaged or partially damaged during TCP (Category 3 and 4 Structures) but have potential to be retrofitted to improve the safety and increase the lifespan of the structures. Recognising that there is sufficient capacity within communities, these works could be delivered through an 'on the job' training and capability building program, under the supervision of a Managing Contractor. Retrofitting works would focus on the replacement of roof sheets, retrofitting of connections and the replacement of cyclone shutters.

Technical assistance could be provided to develop an **'on the job' retrofitting training program** and a **series of retrofitting tools**. Under the supervision of an experienced trainer, the trainees would learn how to identify roof sheeting and/or connections needing replacement and prepare a scope of work and a list of the replacement materials needed. They would then undertake the works under supervision. The Principal and representatives of the School Council would participate in the initial inspection and, with the trainer, inspect the completed works for compliance with the agreed scope.

A building **retrofitting assessment tool and guidelines** could be prepared for trainees. This document would be structured around a decision tree, to assist workers determine the most appropriate retrofitting solution. The guidelines would contain a **tool kit of typical details** which address the key structural vulnerabilities and would be presented using clear 3D documentation, to convey details in a way that is relevant to the level of education and training of the construction workforce. All details would be approved by a qualified structural engineer.

Community participation agreements would be established prior to the commencement of works, which would set out the level of labour and in kind support that communities would commit to the project. Materials would be supplied by the Managing Contractor 'free issue', removing the need for small contractors to have funds available to cover the cost and ensuring quality control of materials.

This approach to retrofitting school buildings will assist to **embed in the community an understanding of key structural elements needing regular maintenance to ensure the safety of the school,** with a view to strengthening existing maintenance practices.

Staff from the MoET's provincial education offices could participate in this process, enabling them to support ongoing maintenance activities and provide guidance to communities in the future as needed.

9.4 Additional Opportunities

A number of additional opportunities exist which would assist in the provision of safe schools into the future. These are as set out below.

It is recommended that The **MoET's 'Schools Maintenance Manual' (prepared by the Public Works Department's Training Unit)** be updated to complement the 'on the job' retrofitting training program detailed in Section 9.3. These updates should provide specific maintenance recommendations to address the local hazards to which school infrastructure is exposed.

A **Guidance Note on site selection and physical planning** could be developed which would assist the MoET and schools to locate and plan infrastructure to minimise exposure.

Support could be given to the MoET to complete the survey of all school infrastructure across the country and incorporate additional components which address the key structural vulnerabilities of buildings. Results of this program could be combined with the NDMO hazard maps into a **GIS asset management database.** With this tool, MoET could provide guidance to communities on for the siting of new buildings to reduce exposure to natural hazards.

A **Communication Strategy** could be developed that highlights the importance of obtaining MoET approvals for school infrastructure to ensure safe school construction. This strategy would target Principals and Teachers, School Councils and Committees, local communities, and international organisations and explain the reason why approvals need to be sought and the process that needs to be followed. For any strategy to be effective, it must be backed by an efficient MoET approval process.

Additionally, a **training and scholarship program** could be developed by GoV or donors to address the longer term requirement for locally based engineering input into public infrastructure across the country.

10 Conclusion

The WB scoping mission to Vanuatu following TCP confirmed that damage to school infrastructure in Tanna was severe and widespread. All schools visited displayed some degree of damage, with levels ranging from minor through to catastrophic. Throughout the mission a range of stakeholders were consulted, informing a broad understanding of the way in which education infrastructure is funded, designed, procured, constructed, maintained and operated in Vanuatu. The reconstruction priorities of the MoET were also understood. The assessment found that there is a clear need for safer schools in Vanuatu, and a gap in the funding of school reconstruction post-TCP. Ultimately, the mission identified a number of opportunities for WB support of GoV priorities for the reconstruction of damaged schools.

The reconstruction of schools damaged by TCP presents an opportunity to improve the safety of schools in a way that:

- meets the MoET's goals for improving access to quality education infrastructure;
- enables schools to double as Evacuation Centres, with access to a reliable water supply and adequate sanitation facilities;
- maximises community participation in the labour force and strengthens the current level of community contribution to the construction process;
- compliments, not duplicates, the existing investments in school infrastructure; and
- leverages reconstruction efforts to embed the principles of safer schools in existing processes so as to ensure safer schools are delivered in the future.

The incorporation these opportunities into a reconstruction program, has the potential to provide new, safe schools, improve the safety of existing school infrastructure and maximise the continued engagement of communities in the management of school infrastructure. Achievement to these goals will reduce the risk posed to the education sector by natural hazards which will in turn help to ensure the continuity of children's education for future generations.

Appendix A

Document Register

A1 Document Register

Arup 2013, *Global Program for Safer Schools, Assessment and Delivery of Safe Schools*, London

Arup 2015, *Roadmap for Safer Schools, Guidance Note,* London

Christie, W and Laboukly, B, 2015, *Rebuilding a safer and stronger Vanuatu after Cyclone Pam,* Accessed online 13 October 2015. http://theconversation.com/rebuilding-a-safer-and-stronger-vanuatu-after-cyclone-pam-42181

Craig, G 2015, Presentation, *Asset management of Primary school facilities*, Port Vila

Cronin, S and Sharp, D, 2002, *Environmental impacts on health from continuous volcanic activity at Yasur (Tanna) and Ambrym, Vanuatu,* International Journal of Environmental Health Research 12, p109–123

DFAT 2012, *Vanuatu Education Sector Program,* Design Document (FINAL), Canberra

GIZ 2012, *Vanuatu Land Use Planning & Zoning Policy, Re-draft*, Port Vila

Global Alliance for Disaster Risk Reduction and Resilience in the Education Sector, 2015, *Towards Safer School Construction, A community-based approach.* Online

Government of Vanuatu, 2015, *Vanuatu, Post Disaster Needs Assessment, Tropical Cyclone Pam,* Port Vila

Government of Vanuatu, 2012, *Vanuatu Education Sector Public Expenditure Review, Final Report.* Port Vila

MoET 2015, *Ministry of Education General Conditions of Contract & Standard Technical Specification*, Port Vila

MoET 2015, *Request for tender (RFT) Goods - Supply and Delivery of Building Materials for Tautu, Lenakel Habour View, Maumau and Manua Primary Schools New Double Classrooms under the 2015 GGP (RFT G15/05, 2015)*, Port Vila

MoET 2006; *Vanuatu Education Sector Strategy 2007-2016*, Port Vila

MoET 2009, *Vanuatu Education Road Map*, Port Vila

MoET 1980s, *Schools Maintenance Manual,* Port Vila

NDMO 2015, *Vanuatu National Guidelines Selection and Assessment of Evacuation Centres (draft)*, Port Vila

NDMO 2008, *Republic Of Vanuatu, Final Report, Education On Natural Disaster Preparedness For Sustainable Development*, Port Vila

PCRAFI 2011, *Country Risk Profile, Vanuatu*, Washington DC

United Nations Disaster Management Programme, 1999, *Report on the Vanuatu National Building Code Promotion and Application,* Fiji.

Vanuatu Education Cluster 2015, *Tropical Cyclone Pam Response, Lessons Learned,* (MoET, Save the Children, UNICEF), Port Vila

World Bank, 2015, *Doing Business- Dealing with Construction Permits in Vanuatu*. Accessed online 13 October 2015, http://www.doingbusiness.org/data/exploreeconomies/vanuatu/dealing-with-construction-permits/

Appendix B

Hazard Assessment

B1 Hazard Assessment

1 Introduction

1.1 Project Description

The aim of this study is to provide a high level summary of the natural hazards present across the island nation of Vanuatu. This will provide a basis for the design and construction of safer schools within this region.

2 Site Description

2.1 Site Location

Vanuatu is an archipelago island chain consisting of over 80 islands in the Pacific Ocean, approximately 2,000km east of Australia. Vanuatu has a population of approximately 272,000[5] divided into six provinces across 65 islands as shown in Figure 7.

[5] Vanuatu National Statistics Office, 2015

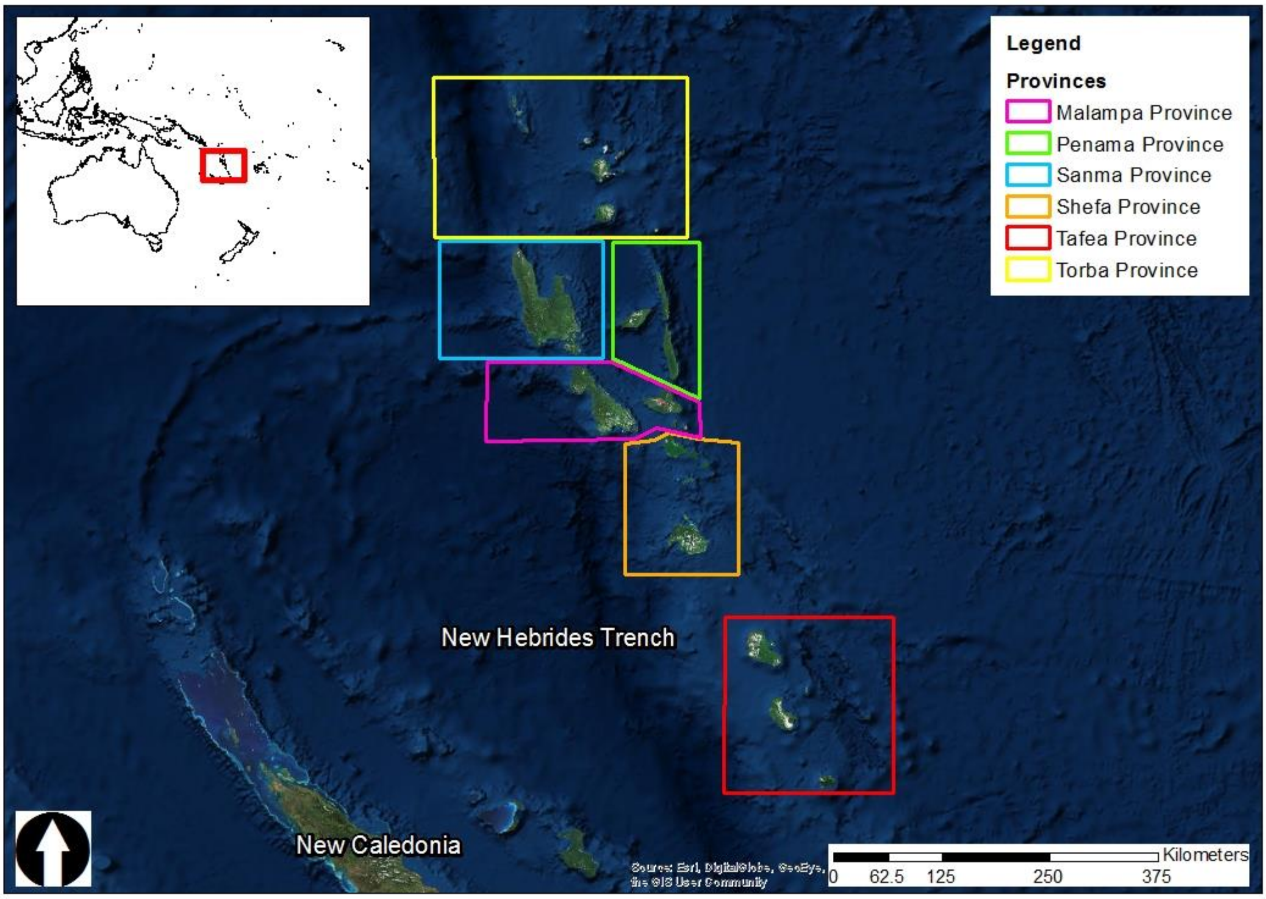


Figure 7: Location of Vanuatu and its provinces[6]

2.2 Existing Land Use

Current land use across Vanuatu is predominantly agriculture based, namely livestock, copra (coconut oil) and fishing. The majority of settlements are rural, with the major cities being the capital, Port Vila, on Efate (population approximately 45,000) and Luganville on Espiritu Santo (population approximately 15,000). Tourism is becoming an increasingly important aspect of the economy.

[6] National Disaster Risk Management, 2008, *Education on natural disaster preparedness for sustainable development*

3 Project Setting

3.1 Tectonic Setting

Vanuatu is a volcanic island chain located on the New Hebrides Ridge in the Pacific Ocean. To the west of the country the Indo-Australian Plate subducts underneath the Pacific Plate at a rate of between 12-16mm/yr. The subduction of the Indo-Australian plate causes a build-up of stress within the crust. The sudden release of this stress occurs as an earthquake.

The tectonic subduction causes partial melting of the Indo-Australian Plate and the release of magma up through the overriding Pacific Plate. The rising magma results in the creation of volcanoes on the Pacific Plate.

3.2 Topography and Bathymetry

Due to the nature of formation of the islands, topography varies significantly, from sea level to up to 1800m above sea level on Espiritu Santo. The islands commonly have elevations of between 200m and 800m above sea level and rise sharply from the sea as shown in Figure 8.

Bathymetry in the vicinity of the islands varies significantly. To the west of the islands lies a convergent tectonic plate boundary, the New Hebrides Trench. At the trench the sea floor depth is between 4,000m and 6,000m. To the east of the islands the depth to sea floor is much less, between 1,000m and 2,000m. In the vicinity of the islands the sea floor drops dramatically to depths less than 500m.

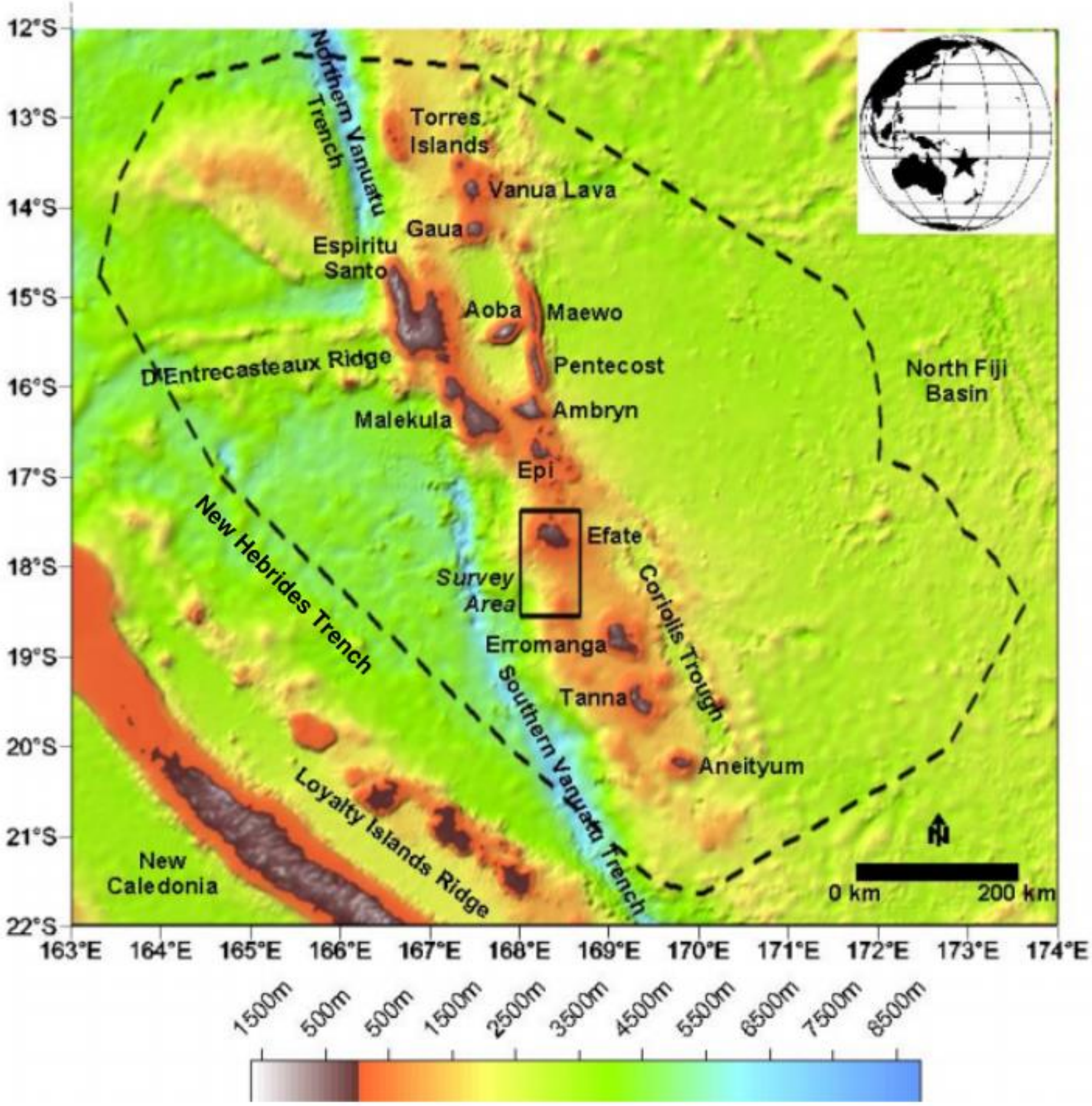


Figure 8: Topography and bathymetry of Vanuatu and surrounding areas[7]

[7] Secretariat of the Pacific Community, 2008, *Vanuatu technical report. High resolution bathymetric survey of Nefete*

3.3 Geomorphology

Vanuatu is a chain of islands formed in the back arc of a subduction zone. The topography of each island is controlled by the volcanic processes that formed the island chain. The geomorphological domains across each island include:

- Volcanic cliffs
- Coastal plains
- Steep valley slopes
- Alluvial plains

3.4 Geology

The islands of Vanuatu are generally comprised of igneous rocks associated with the volcanics, limestone associated with coral reefs and mudstones and sandstones associated with deep water sedimentation. The geology of each individual island is likely to differ from one to the next, and is dependent upon proximity to the subduction zone and size of the island. Quaternary fluvial and alluvial deposits are located alongside rivers and drainage systems that dissect local topography.

A geological map of each province is presented in Appendix A.

3.5 Climate

Vanuatu has a subtropical climate and is located between latitudes of 12° and 20° south of the equator. The temperature remains relatively consistent throughout the year with a maximum of approximately 30° during summer months (November to March) and a minimum of approximately 20° in winter months (April to September).

The distribution of rainfall is dictated by local topography and each island location. In general, higher rainfall occurs during the summer months, with increasing amounts in the higher latitudes. The province of Tafea in the south has monthly average values of 250-350mm rainfall in January to March. In the remaining monthly rainfall is between 50mm-100mm. The most northern province of Torba has monthly average rainfall of 350mm-450mm between October to May. The remaining monthly average is 200mm-300mm. Historically across the islands, the wettest month is March, with the driest month being August.

The summer months correspond with the cyclone season and it is not uncommon for cyclones to cross Vanuatu. Within one cyclone season Vanuatu can typically expect to be impacted by between 1 and 3 cyclones of varying intensity. Historically, all provinces have been impacted by cyclones, and major events are discussed later in this report.

The predominant wind direction is from the east / southeast and are generally light, averaging 10 knots. During the winter months the winds are generally stronger and can gust up to 25 knots. During cyclone season the winds can become severe and cause significant damage and destruction across the islands.

The trend of sea level change across the Pacific Islands was estimated in 2009 through the Pacific Country Report and the Pacific Climate Change Science Program. Satellite data results for Vanuatu estimate an increase in sea level of 6mm/year, which is greater than the global average of 2.8mm-3.6mm.

4 Hazards

4.1 Seismic Hazard

Vanuatu is located within close proximity to an active plate boundary, and as a result has experienced a large number of significant earthquakes as show in Figure 9. Hazards associated with earthquakes are seismic induced ground motions, liquefaction and lateral spreading, earthquake induced landslide, fault surface rupture and tsunamis.

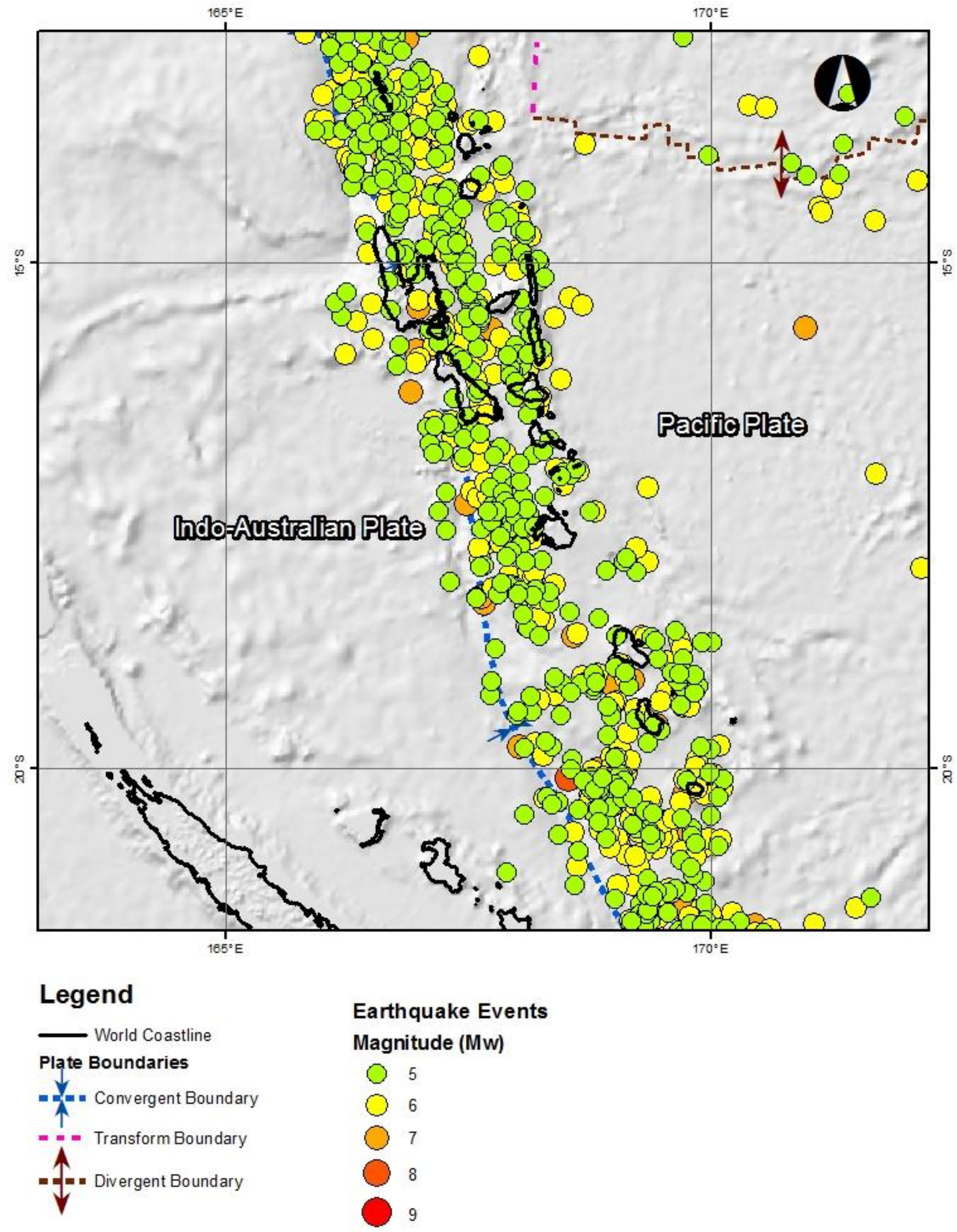


Figure 9: Earthquake catalogue of historical events >Mw 5.0 in and around Vanuatu (1900-2009)[8]

[8] International Seismological Centre, 2009, *Global Earthquake Catalogue (ISG-GEM)*

The largest historical earthquake in Vanuatu occurred in January 2002 in Shefa Province. The 7.2 Mw event caused a surprisingly small amount of damage for an earthquake of this size, mainly building damage from poor structural design and large landslides. The event generated a tsunami wave 0.8m in height that inundated the Port Vila Harbour.

Earthquake induced landslides and tsunami will be discussed in later sections.

Figure 10 shows the earthquakes of magnitude greater than 6 which have been recorded by the USGS since 1900 in the South Pacific area, indicating that large magnitude earthquakes occur regularly in the area surrounding Vanuatu.

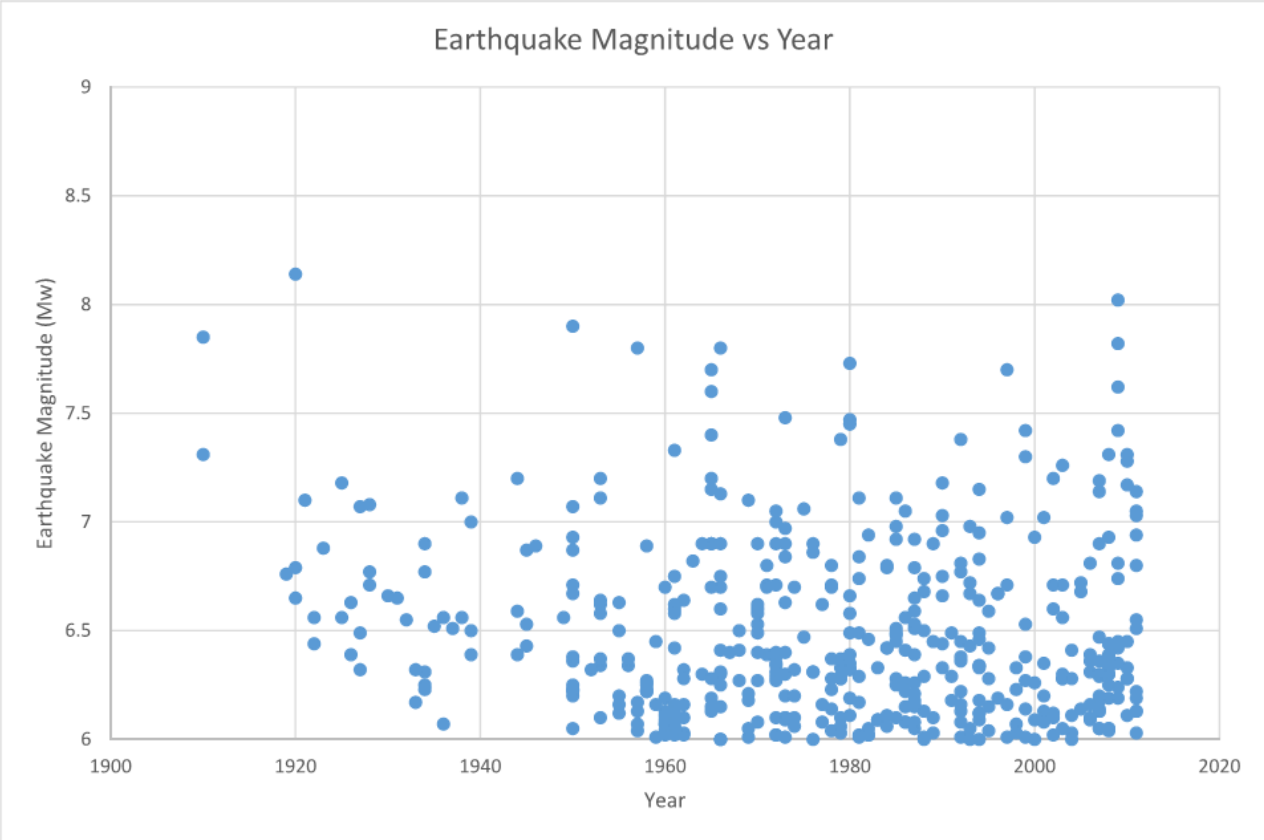


Figure 10: Recorded earthquakes in South Pacific from 1900- 2012[9]

Due to the proximity of the site to an active fault zone it is anticipated that ground shaking presents a moderate to high hazard to Vanuatu. Using Figure 11, based upon a 475 year return period, the anticipated Peak Ground Acceleration (PGA) across the islands is 0.8 – 1.0 G.

[9] United States Geological Survey, *Open File Report 2012-1087, Seismic Hazard of American Samoa and Neighbouring South Pacific Islands*

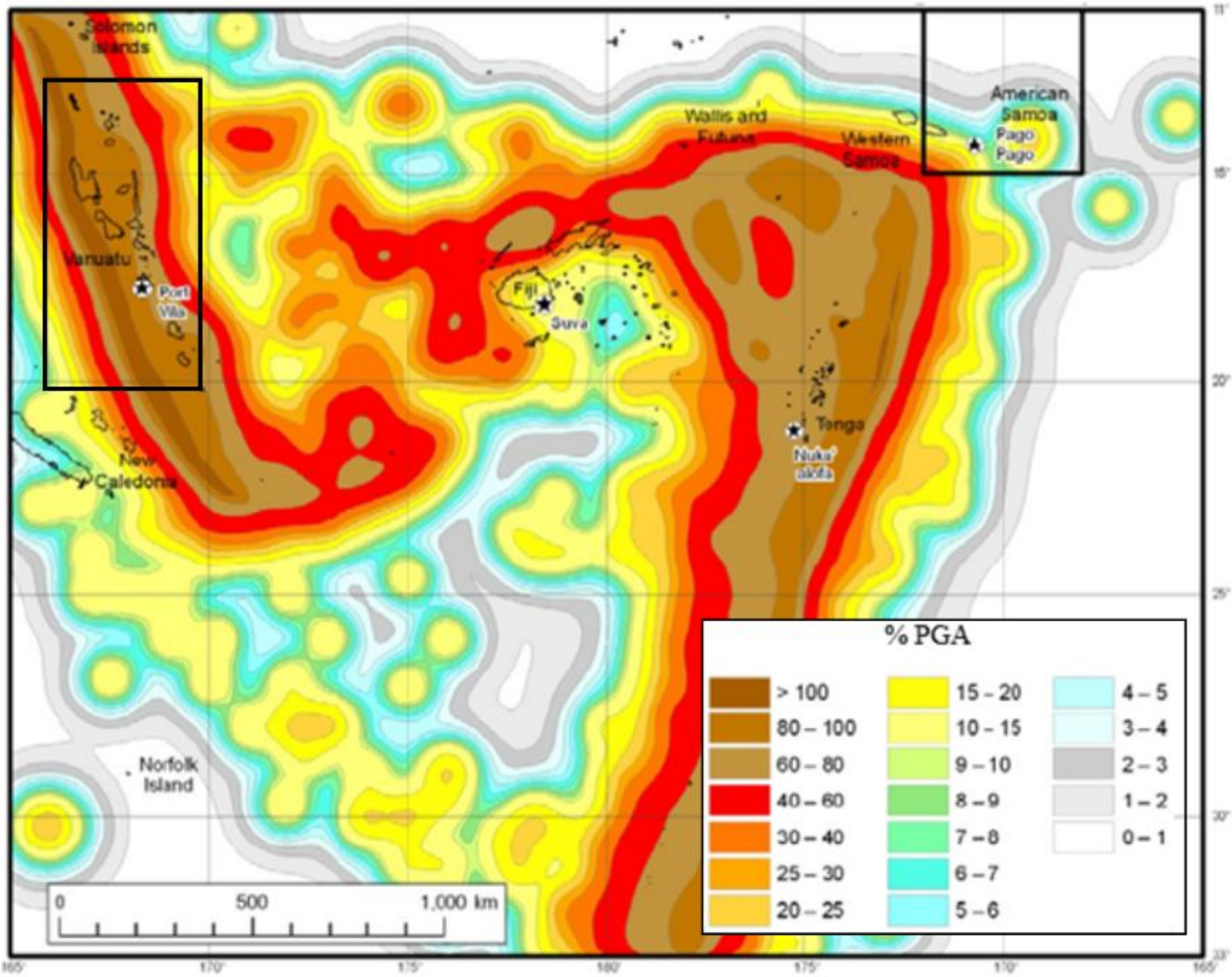


Figure 11: Seismic hazard map for the southern Pacific based upon a 475 year earthquake return period[10]

Table 7 shows the effects of a 80-100% PGA earthquake, with a corresponding perceived 'violent' level of shaking of and potential 'heavy' damage. Earthquakes of this magnitude pose a significant threat to the integrity of physical infrastructure.

Table 7: Peak ground acceleration, perceived shaking and potential damage

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

[10] United States Geological Survey, 2011, ESRI

4.2 Cyclone Hazard

Vanuatu is located in an area of the southern Pacific that is prone to cyclones. Figure 12 illustrates historical cyclone paths that have been recorded in the area since records began. Since 1980 Vanuatu has experienced 20 destructive cyclones, most notably Uma in 1987, Prema in 1993, Paula in 2001, Ivy in 2004, and Pam in 2015. The most recent event, Tropical Cyclone Pam, was a Category 5 storm which affected an estimated 188,000 people. The storm caused significant flooding, damage and destruction across 4 provinces, with some areas recording sustained wind speeds of 250km/hr and gusts peaking to 320km/hr[11]. In excess of 20,000 houses were damaged or destroyed, whilst on some islands, 90% of houses were reported as damaged[12].

The hazards associated with cyclones include damaging winds, flooding from storm surge and intense rainfall.

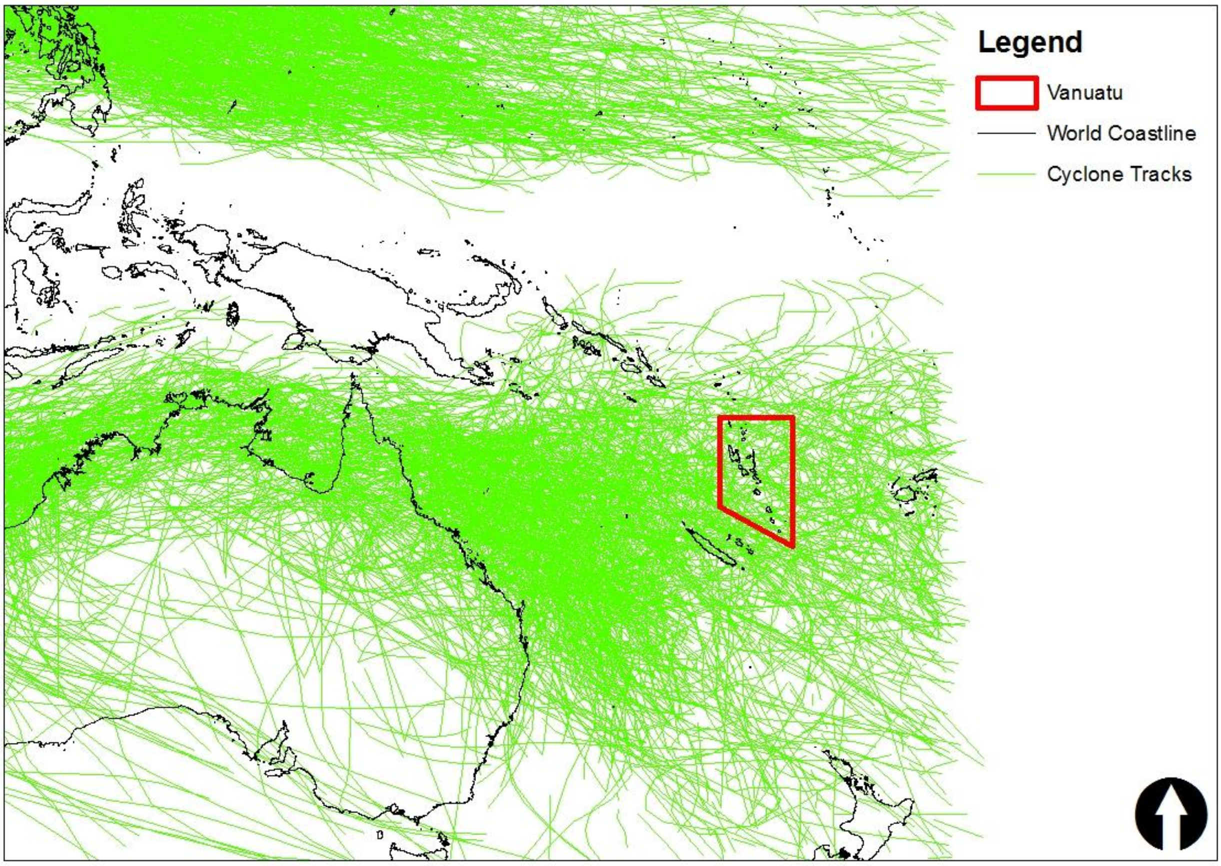


Figure 12: Historical cyclone paths in the vicinity of Vanuatu

[11] Austalian Bureau of Meteorology, 2015
[12] Vanuatu Shelter Cluster, June 2015, *Tropical Cyclone Pam Response, Lessons Learnt*

Table 8 defines the categories used to describe the magnitude of a tropical cyclone in Australia, combined with the typical effects that each category storm would have on different types of infrastructure. For any particular category, the level of destruction of infrastructure is also a function of the quality of construction, with poorly built structures being more vulnerable to the effects of cyclones.

Table 8: Australian tropical cyclone categorisation system[13]

Category	Maximum Mean Wind (km/h)	Typical Strongest Gust (km/h)	Typical Effects
1	63 - 88	< 125	Negligible house damage. Damage to some crops, trees and caravans. Craft may drag moorings
2	89 - 117	125 - 164	Minor house damage. Significant damage to signs, trees and caravans. Heavy damage to some crops. Risk of power failure. Small craft may break moorings.
3	118 - 159	165 - 224	Some roof and structural damage. Some caravans destroyed. Power failures likely. (e.g. Winifred)
4	160 - 199	225 - 279	Significant roofing loss and structural damage. Many caravans destroyed and blown away. Dangerous airborne debris. Widespread power failures. (e.g. Tracy, Olivia)
5	> 200	> 279	Extremely dangerous with widespread destruction. (e.g.Vance)

Vanuatu typically experiences the effects of 1-3 cyclones of varying intensity each year, as shown in Figure 13 below. It should be noted that due to climate change, the number and intensity of cyclone events per year is expected to increase, further increasing the risk to Vanuatu.

[13] Australian Bureau of Meteorology, 2015. http://www.bom.gov.au/cyclone/faq/index.shtml

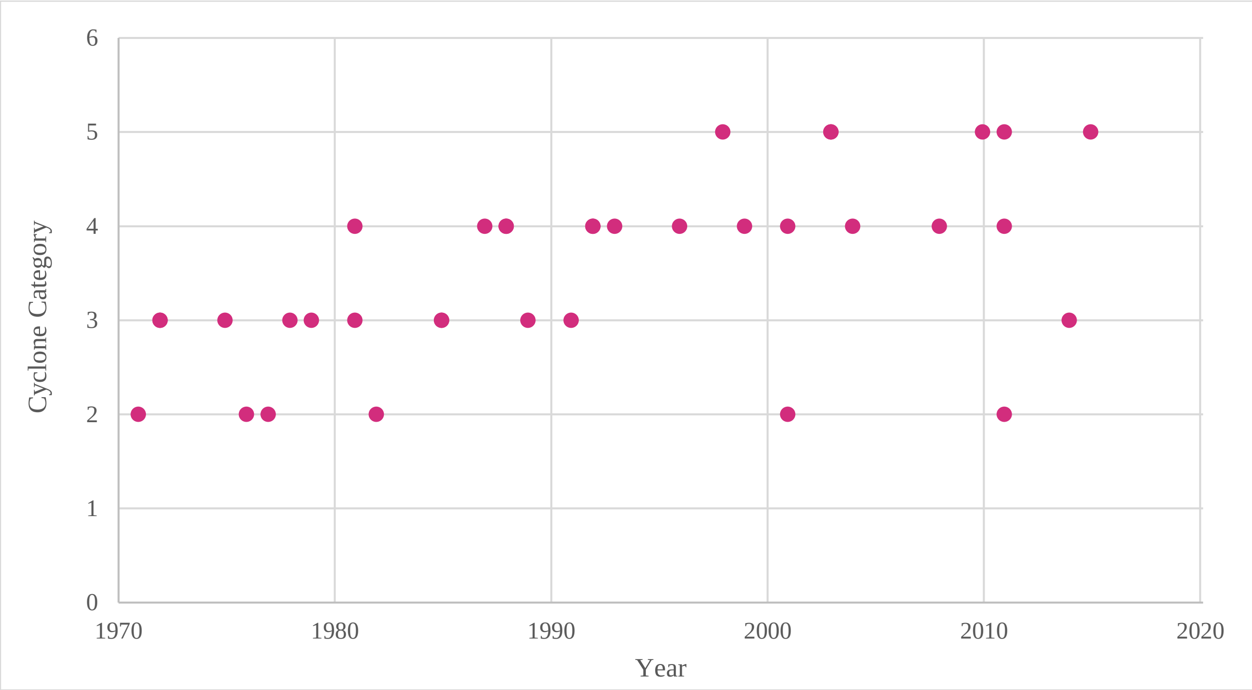


Figure 13: Tropical cyclones affecting Vanuatu since 1970[14]

Due to the frequency and intensity of storm activity around the South Pacific region, it is expected that cyclones present a high hazard to Vanuatu.

4.3 Landslide and Slope Failure

Landslides and slope failures are a likely hazard on Vanuatu due to the steep slopes and high topography. It is noted in historical literature that landslides have been recorded across many of the provinces. Triggers for landslides and slope failures are commonly earthquakes, cyclones and intense rainfall, all of which are common in Vanuatu.

Due to the predominantly volcanic nature of the bedrock, and the location of Vanuatu in the subtropics, it is highly likely that a deep weathering profile exists across the islands. The deep weathering profile, coupled with a likely highly fractured rock mass, presents a likely hazard of landslide and slope failure across Vanuatu.

The presence of steep topography and outcropping bedrock can lead to rockfall hazard in the areas underneath cliff outcrops. Triggering mechanisms for rockfall are earthquakes, cyclones and intense rainfall.

Past events include a landslide which occurred on Sanma Province following an earthquake in 2011 and another landslide in 2014 following cyclone Lusi.

[14] National Oceanic and Atmospheric Administration

4.4 Tsunami

Tsunamis are long period, low amplitude ocean waves that pose an inundation hazard to low lying coastal areas and they occur when the sea floor is rapidly displaced on a massive scale. Across the open ocean the waves are typically low amplitude, but as the waves reach shallower water depths, the amplitude and wave energy increases, causing significant run up on land.

Due to the location relative to seismically active regions, Vanuatu is at risk from tsunami events. The National Oceanic and Atmospheric Administration (NOAA) database records 33 tsunami run up events between 1863 and 2015 as shown in Figure 14, of which 30 were inferred to be caused by earthquakes, 1 by a volcano and 2 by unknown events. The largest tsunami run up was recorded in Malampa Province in 1965 and reached 7.0m inland, with another wave reaching 6.6m recorded in 1999. The majority of recorded tsunami run ups were less than 1m in height.

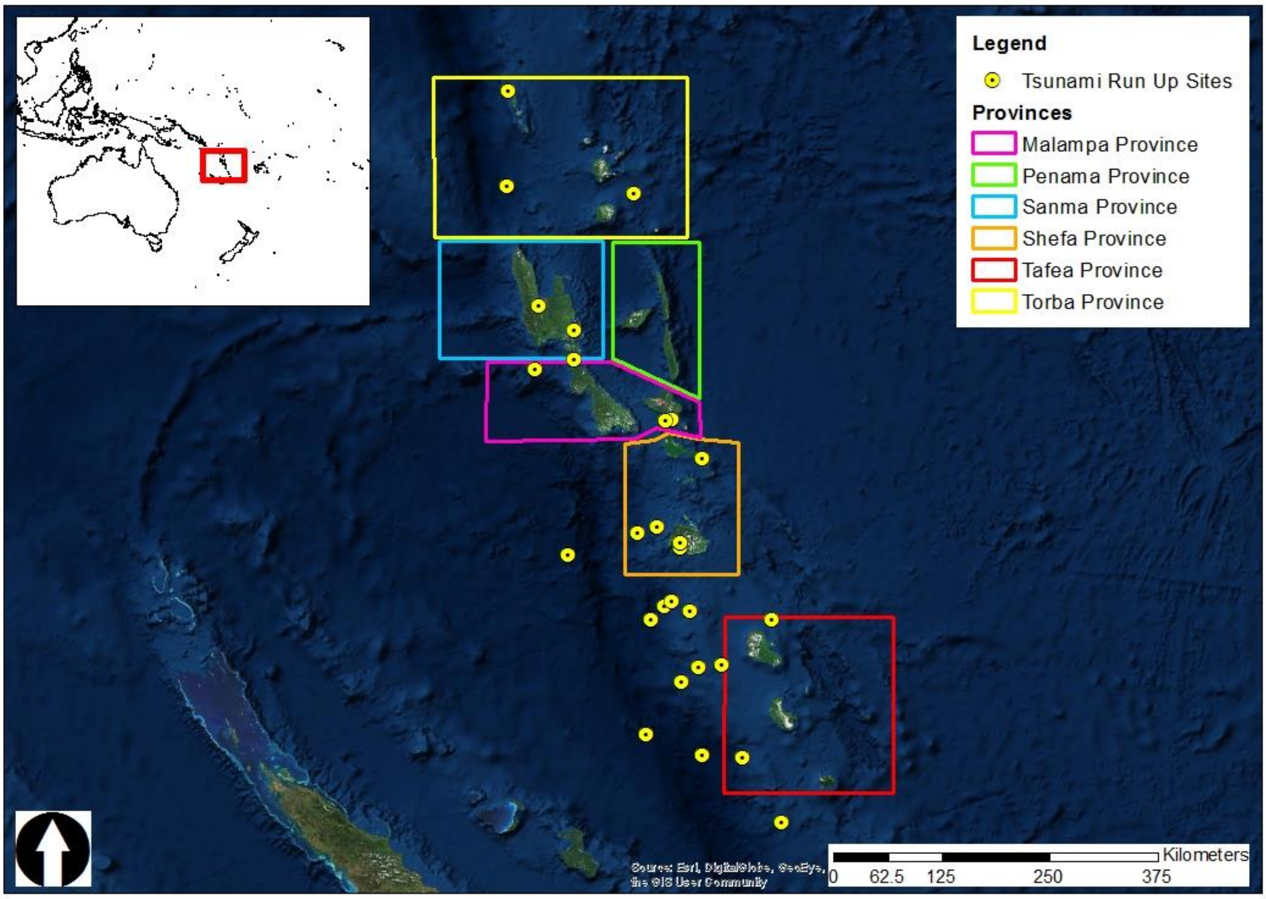


Figure 14: Location of tsunami run up sites across Vanuatu[15]

[15] National Oceanic and Atmospheric Administration

4.5 Flood Hazard

Due to the tropical climate and significant amount of monthly rainfall, flooding is a likely hazard across low lying areas, particularly when wet season, high tides and cyclone events coincide.

Based upon calculated trends[16], it is estimated that sea level will rise at a rate of 6mm/year in Vanuatu reaching to between 0.21m and 0.63m higher than present levels. Areas susceptible to flooding will be low lying, coastal areas. A more detailed topographic assessment will be necessary to ascertain exact extents of at risk areas, based upon the predicted sea level rise.

Flooding related to extreme weather is a likely hazard in Vanuatu, as has been experienced with recent tropical cyclones. Intense rainfall, storm surge and heavy swells are associated with cyclones, all of which can contribute to flooding.

Intense and prolonged rainfall can cause flooding in areas where rivers and drainages reach their lower course. These areas are prone to flooding hazards.

4.6 Volcanic Hazard

Due to the proximity of Vanuatu to a subduction zone, a number of volcanoes are located within the region. Currently there are 7 active terrestrial volcanoes and 3 submarine volcanoes located across 5 of the 6 provinces of Vanuatu as shown in Figure 15, all of which have had at least one eruption in the past 10 years. The most recent eruption was in 2014 in Shefa Province

The type of volcanism at convergent plate boundaries produces predominantly basaltic volcanoes that can have explosive eruptions due to the interaction of magma with water. The explosive eruptions have the potential to produce lahars (fluid mixture of volcanic debris and water) and pyroclastic flows (high speed cloud of hot ash and lava fragments) which can travel distances of up to tens of kilometres downslope. Lahars form through eruptions underneath a crater lake or through intense rainfalls during or after an eruption. These explosive eruptions present a great risk to the immediate areas surrounding the volcano immediately through lahar, pyroclastic flow and lava flow impact, and indirectly over time through crop destruction, deforestation and building damage.

Volcanic eruptions in the presence of water can produce explosive eruptions and large ash clouds, which can travel distances of up to hundreds of kilometres. Due to prevailing wind directions coming predominantly from the east, it is considered likely that ash falls from eruptions in the central provinces will impact adjacent islands to the west. It is considered unlikely that ash falls from eruptions in the northernmost and southernmost provinces will impact adjacent islands.

The emission of sulfur dioxide and hydrochloric acid from volcanic eruptions can combine with moisture in the atmosphere, which falls as acid rain. This dilute acid is a corrosive liquid, which can be damaging to metallic elements in buildings and impact on the quality of water collected from roof structures.

[16] Pacific Climate Change Science Program, 2009, *Pacific Country Report*

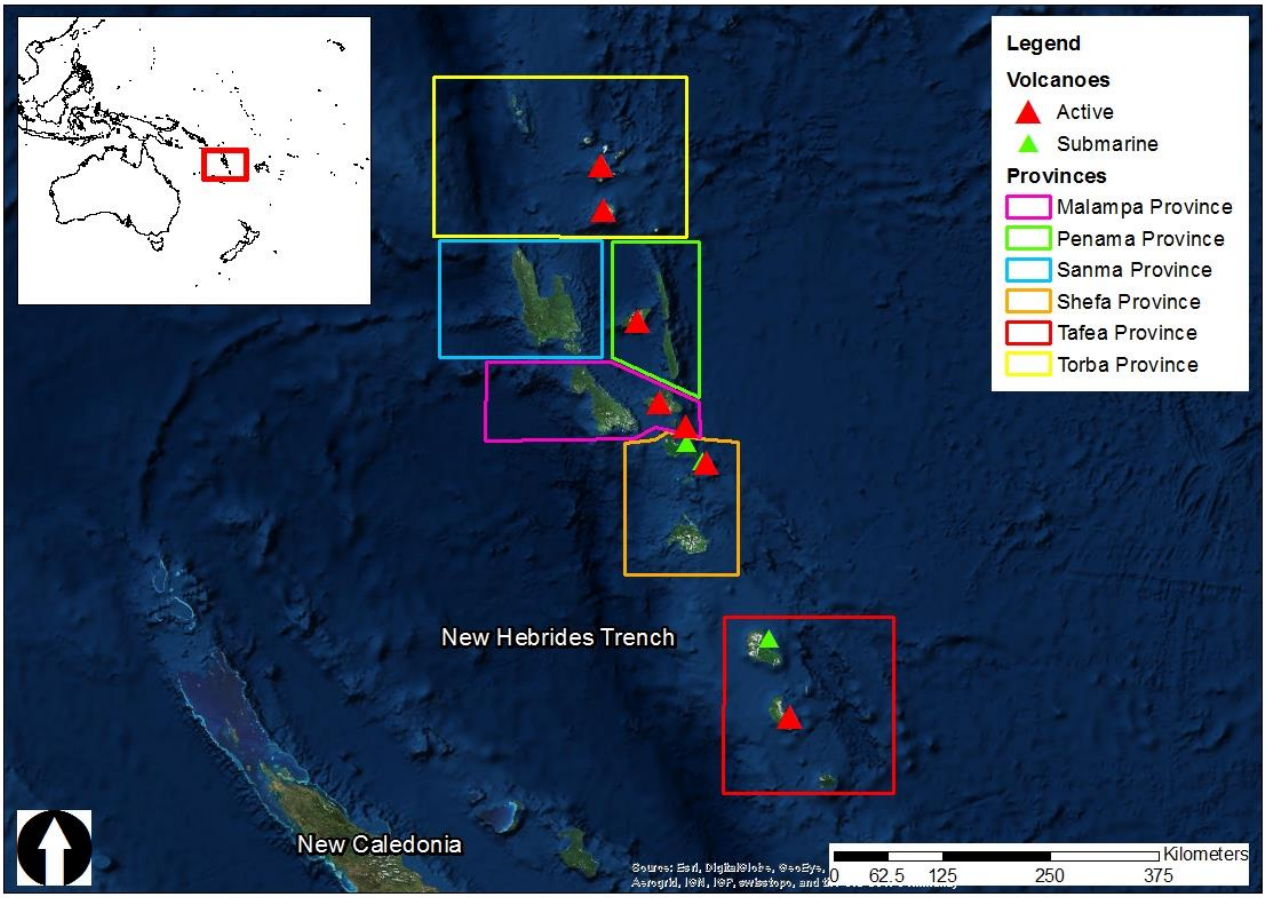


Figure 15: Location of active and submarine volcanoes in Vanuatu

4.7 Coastal Erosion

Coastal erosion has been noted to be a problem across some islands. In areas where alluvial deposits meet the coast, large deposits of sand are present. Unregulated mining of these sands has been historically recorded with up to 500m^3 of material a month being removed at some locations.

Extreme weather events can increase the rates of coastal erosion through increased wave action and intensity resulting in the removal of sediment into the sea. Low lying coastal areas with beach sediments are at risk from increased erosion during these events.

The seafloor bathymetry indicates the depth to sea floor increases dramatically away from the coast. This steep gradient can lead to unstable soil deposits on these oceanic slopes. Instabilities and slope failures can be triggered by ground shaking during an earthquake and the sudden deposition of sediments during a cyclonic event. The movement of large volumes of underwater sediment downslope may have repercussions in shallower areas through the movement of this material, as the reduction in material leaves openings for increased erosion in coastal areas.

4.8 Multi hazard

A combination of hazards can occur following extreme events. An example of this is a landslide that occurs across a river channel. The landslide debris may form a dam across the river creating a lake upstream of the failed landslide debris. After a period of time the water level behind the dam grows until the water pressure becomes too great. The dam fails suddenly resulting in a torrent of landslide debris and water flooding downstream areas. The sudden failure of these dams can be a significant hazard as they are difficult to monitor and predict effectively.

5 Summary

Vanuatu is at risk from a number of natural hazards and has been impacted by a number of earthquake and extreme weather events in recent history. These events are anticipated to present a continued hazard to Vanuatu, with the potential for significant damage to infrastructure and loss of life. Table 9 presents the main hazards that pose a risk to school infrastructure, and the risk reduction measures that can be put in place to reduce the vulnerability of infrastructure to these hazards. A graphical summary of the main regional hazards was also prepared by OCHA in 2011[17], and is tabled in Appendix B.

Table 9: Summary of hazards in Vanuatu

Hazard	Risk	Risk reduction
Seismic	Ground shaking, damaging structures	- The design of future structures to be capable of tolerating high ground motions - Retrofit existing structures to be capable of tolerating high ground motions - Utilise ductile and low mass building materials (eg timber, lightweight steel) to reduce the impact of ground shaking on structures
Seismic	Liquefaction and lateral spreading on sites within river valleys and alluvial plains	- Locate structures away from loose saturated sediments and areas with a high water table
Cyclone	Damage from high winds	- Design proposed structures and retrofit existing structures, to withstand cyclonic wind speeds
Cyclone	Flooding from intense rainfall or storm surge due to site being located near a river, drainage system or coastal area	- Locate structures away from low lying coastal areas and water courses - Elevate building floor levels - Monitor Vanuatu Meteorology and Geohazards Department (VMGD) for cyclone path and relocate if possible.

[17] UN Office for the Coordination of Humanitarian Affairs, *VANUATU: Natural Hazard Risks*, 2011

Hazard	Risk	Risk reduction
Landslide and slope failure	Impact from landslide debris due to proximity of the site to slope	- Locate structures away from steep slopes and other high risk areas. - Stabilise steep and high risk slopes through planting vegetation
Tsunami	Flooding from tsunami inundation due to site being on low lying coastal area	- Locate structures away from low lying coastal areas - Monitor VMGD for earthquake alerts and potential tsunami alerts - Prepare appropriate evacuation plan and prepare buildings to prevent inundation - Install early warning systems for the evacuation of communities
Flooding	Inundation due to sea level rise at site on low lying coastal areas Localised flooding	- Locate structures away from coastal areas and water courses - Elevate floor levels - Provide site drainage
Volcanic	Pyroclastic flow or lahar impacting site on slopes of active volcanoes	- Locate structures away from high risk areas - Monitoring of meteorological sites such as VMGD for alerts on volcanic activity - Appropriate evacuation plan in the event of an eruption
Volcanic	Ash fall causing roof collapse on site near an active volcano. Corrosion of structural elements due to acid rain	- Monitoring of VMGD for eruption alerts, in conjunction with weather reports to ascertain likely travel direction of an ash cloud - Develop preventative maintenance strategies for elements that are exposed to corrosion
Coastal erosion	Slope failure at a coastal site due to mass movement of underwater sediment following a triggering event	- Construction of proposed schools away from coastal areas

Appendix C

Mission Details

C1 Meetings

C1.1 Stakeholder Meetings

Organizations Present
MoET, World Bank, Arup
World Bank, Arup
MFEM, World Bank, Arup
DFAT, World Bank, Arup
MoET, World Bank, Arup
MoET, World Bank, Arup
MoET, World Bank, Arup
MoET, Arup
Save the Children, Arup
MIPU, World Bank, Arup
Kramer Ausenco, Arup
NDMO, World Bank, Arup
UNICEF, Arup
IOM, Arup
DFAT, World Bank, Arup
DFAT (W. Dabrowka), Arup
MoET, World Bank, Arup

C2 Assumptions and Limitations

Limitations

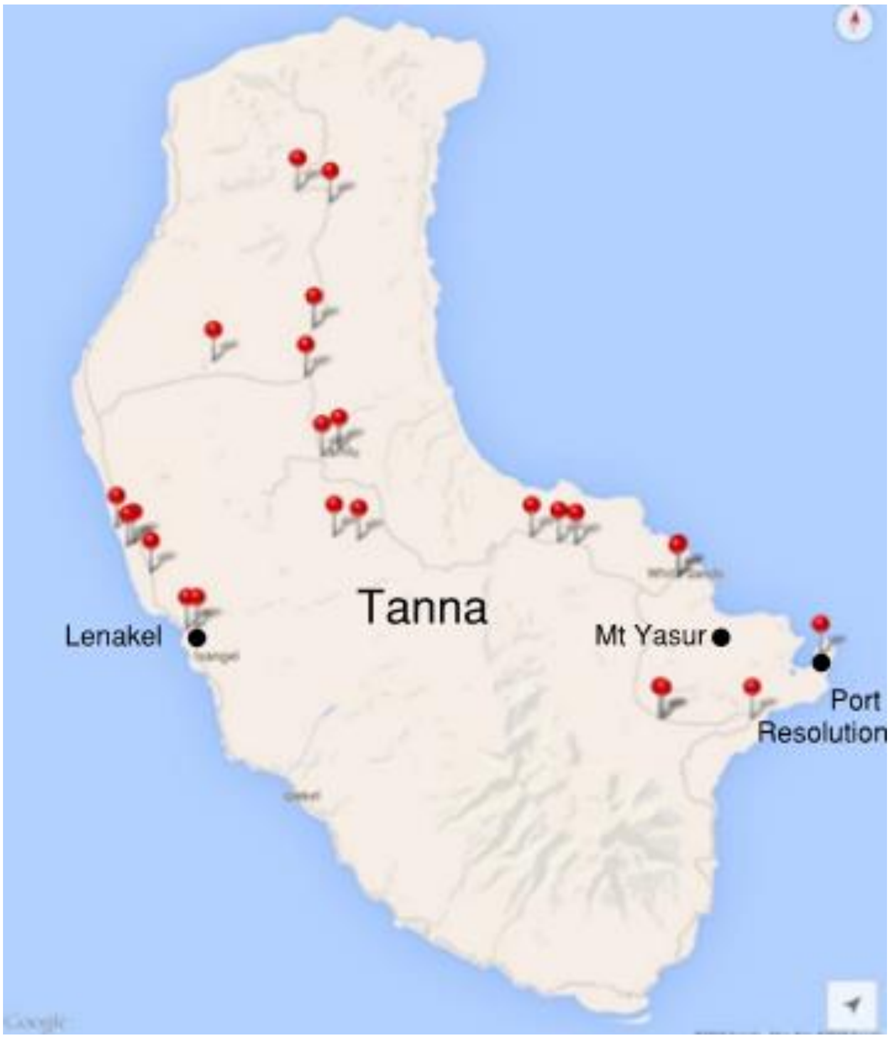
- Only schools in Tanna were included in the assessment.
- The time spent at each school varied and depended on the size of the school, the extent of damage, and the availability of a representative to show the team around and respond to questions.
- Not every building was assessed at each school. There were a range of reasons including access – some buildings were locked – and time constraints. Most houses were assessed from the exterior.
- Not every survey question was able to be asked at each school due to the limited time spent at some schools. Where time was limited, the focus was on the damage caused by the cyclone, the use of the school for shelter during and after the cyclone, how the building was maintained/repaired/modified.
- There was no representative of the school present at three schools (Port Resolution, Dip Point and Tuhu). At Port Resolution, the land owner (a nurse at the Health Clinic co-located with the school) led the tour of the school. At Dip Point and Tuhu, the MoET’s Provincial Education Officer was able to provide some background on the school buildings.

- Interviews took place in one or a combination of Bislama and English. Where Bislama was used, translation was provided by the MoET's representatives, the MoET's Project Officer, the Provincial Education Officer or both.
- The assessments took place either on a Saturday or during a week-long school holiday. Boarders were present at Lamapruan, a French Secondary School. Only one school, Lenekel Secondary School, had students in class at the time of the tour.
- Interviewees were not asked which classrooms were in use and which, if any, were yet to be returned to use. At some schools, classrooms were not furnished which may indicate that they were not in use.
- Interviewees were not asked directly whether they thought schools should be used as Evacuation Centres. They were, however, asked a series of open questions about the use of the school during and after TCP. In answering these questions, a number of interviewees expressed an opinion as to the use of schools as Evacuation Centres and the circumstances within which this would be acceptable/constraints that should be imposed/what should be provided if they are to continue to be used.
- Some interviewees were new to the school and their historical knowledge of the school limited. In some cases, a member of the School Council or a representative of the land-owner, was present and able to supplement the interviewee's knowledge.

Assumptions

- The survey assumed that responses to the questions were correct and able to be relied upon.

C3 Schools Surveyed



Locations of Schools Visited in Vanuatu

A list of schools visited is given on the following page. Full details of survey results can be seen in the separate file "GPSS Vanuatu RVA Survey Results".

Appendix D

Presentation to MoET

D1 Presentation to MoET

Appendix E

School Surveys

E1 Rapid Visual Assessment

The Arup team used 'Fulcrum'[18], a web based data collection App to design a Rapid Visual Assessment form which was used during the school visits. At each site, data was collected through two main channels:

- An informal user interview with key staff from the school.

  This interview gave information about the history of the school buildings (when/ how/ by whom were they built, who funded them etc.) and how the community and school infrastructure responded to hazards. It provided information on the *social* context in which the infrastructure is located.

- A site exposure assessment and structural assessment of school buildings.

  The site exposure assessment looked at the key factors that contributed to a school site being exposed to natural hazards.

  The building hazard vulnerability assessment was a visual, non-destructive structural survey of the schools buildings. Attention was paid to the key structural vulnerabilities that school infrastructure was exposed to. These surveys provided information on the *physical* context in which the infrastructure is located.

For each school visited, a pdf report was generated, which contains the key information gathered from the user interviews and the exposure and structural assessments. These findings were used to inform the general observations and opportunities for the report.

E1.1 User Interview Questions

Category	Item
Introduction	1. Introduction 1.1. Tell us about your school? 1.2. No of students/ staff? 1.3. When was it built?
Performance in a disaster	2. Cyclone Performance 2.1. What happened during the cyclone? 2.2. Where did you stay to be safe? 2.3. What happened to the building you were in? (Roof, walls) 2.4. What happened to the area around the building? (Flooding, drainage) 2.5. Where did you store your valuable items?
Role in a disaster	3. Schools as Evacuation Centres 3.1. What happened after the cyclone? 3.2. Was the school used as an evacuation centre? 3.3. How many people used it as an evacuation centre? 3.4. How long did you use it as an evacuation centre for? 3.5. Where did you get your water from after the cyclone? 3.6. Was there enough water? 3.7. What did you do for sanitation? 3.8. How quickly were students able to return to school? 3.9. Were there any issues using it as an evacuation centre?

[18] http://fulcrumapp.com/

Is it a Safe School? Construction	4. How was the school constructed 4.1. Why do you think your school responded in the way it did? 4.2. Do you know what makes a building safe? 4.3. Who decided on the site for the school? 4.4. Why did they choose that site? 4.5. Who decided where to put the buildings on the site? 4.6. Who designed the buildings? 4.7. Did you have any help on the design of your buildings? 4.8. Who helped? 4.9. Who decided what materials to use? 4.10. Why did they choose these materials? 4.11. Was a permit or approval needed before you started? 4.12. Who did you need approval from? 4.13. Who built the building? 4.14. How did you choose a builder? (if relevant) 4.15. How did the builder know what they should be building? 4.16. Do you know where they learnt do build? 4.17. What are they doing now?
Is it a Safe School? Maintenance	5. How is the school maintained 5.1. Who provides the funds to look after your school? 5.2. What is done to look after the buildings and grounds? 5.3. How often? 5.4. Who does it? 5.5. Where do you get the materials you need to maintain the school? 5.6. Where do you get the sand? 5.7. Where do you get the wood? 5.8. Where to you get other materials?
Is it a Safe School? Hazards	6. Understanding of Hazards 6.1. What other disasters are you exposed to? 6.2. Have you felt earth tremors? 6.3. How often and how severe are they? 6.4. Have you ever experienced flooding? 6.5. When? 6.6. How high did the water come? 6.7. How long did the water stay? 6.8. Are there things that you do to reduce flooding 6.9. Have you ever had a landslide near here?
Other	7. Any further comments?

E1.2 Site Exposure Questions

Question	Answer		
8. What is the slope of the site?	0, 1:10, 1:5, 1:3, 1:2		
9. Is the site elevated above the surroundings?	Yes	No	
10. Is the site at or near the base of a slope/ escarpment?	Yes	No	
11. Are there deep cuts into the hill/slope?	Yes	No	
12. What is the distance to the nearest ocean/ river/ body of water?	<50m, 100m, 500m, >1km, unknown		
13. What is the height above floodplain/ body of water	<1m, 2m, 5m, 10m, >10m, unknown		
14. Is there evidence of historic flooding on site?	Yes	No	
15. Are there any man-made drainage systems/ culverts on or near the site?	Yes	No	
16. Do the drains appear to be working?	Yes	No	
17. Are there any linear features or vertical offsets on the site, which could indicate an active fault?	Yes	No	
18. Is the site sheltered (shielded) from wind? (e.g. with natural wind barriers - trees)	NS	PS	FS
19. Are the buildings near large trees that can blow over?	Yes	No	
20. Are their signs of heavy erosion on the site?	Yes	No	
21. Is there any evidence of slope stabilisation?	Yes	No	
22. Are there any retention / wall construction on or near the site?	Yes	No	
23. Are there sufficient gaps between buildings to prevent pounding?	Yes	No	
24. Is there sufficient space to unsafe structures and potentially damaging debris?	Yes	No	
25. Are there good quality evacuation routes (roads) to/ from the school?	Yes	No	
26. Are there appropriate communication links from the school to emergency services?	Yes	No	

E1.3 Building Hazard Vulnerability Questions

Category	Item	
Questions About the Building		
Building Identifier		
Photo of building entrance		
Who built the building		
When was it built		
Function of building	Classrooms Auditorium / Gymnasium Cafeteria / Kitchen Maintenance Offices	House Church WATSAN Dormitory
Number of room 'units' in the building		
Building Configuration		
Building Shape		
What shape is the building	Rectangle (L<4B) Rectangle (L>4B) Square	L Shaped T Shaped
Photo of sketch plan		
Lateral Stability System		
Lateral Stability System	Braced Frame Portal Frame Shear Wall	No System Unknown Other
Photos of frame/stability system		
Comments on Lateral Stability System		
Soil and Foundations		
Soil Type	A - Hard rock B - Average rock C - Dense soil	D - Stiff soil E - Soft soil F - Poor soil
Comments on soil type		
Foundation type	Pads Strips Raft Piles	Mixed None Unknown
Photos of foundation:		
Comments on Foundation Structure		
Footing Condition	0% 10% 50% 100% Unknown	
Floors		
Floor Type	Concrete Slab Crushed Coral Timber	Particle Board Fibre Cement Sheet Earth
Photos of floor		
Comments on floor		
Is there a damp proof membrane?	Yes	No
Is there evidence of rising damp?	Yes	No
Floor Condition	0% 10% 50% 100% Unknown	
Walls/ Columns/ Facade		

Wall and Column System	Concrete Block Concrete- Mass Timber frame Steel Frame	Bamboo frame Stone Other
Comments on Wall Structure		
Wall Bracing Type	Concrete Columns Concrete- Block infill Cement Plaster Corrugated Iron Timber frame Timber Cladding Steel Frame	Bamboo frame Bamboo Cladding Stone Natangura Fibre Cement Sheet Asbestos Other
Photos of Walls/ Columns/ Facade		
Wall Bracing Type	Concrete Shear Wall Galvanised Iron Strapping Timber Strut Ply Sheet Bracing	PVC Sheeting Bracing Absent N/A Unknown
Comments on wall bracing		
Façade system description	Natangura Corrugated Iron Fibre Cement Sheet Asbestos	Cement Plaster Timber Bamboo Other
Comments on facade		
Façade Fixing Method	Screws Nails	Other Unknown
Comments on wall/ column system		
Is there evidence of rot in timbers	Yes	No
Is there evidence of termite or borer attack in timbers	Yes	No
Photos of Walls/ Columns/ Facade Issues		
Wall/ Cladding Condition	0% 10% 50% 100% Unknown	
Roof		
Photos of Roof		
Roof Structure	Timber truss Timber beam Steel truss	Steel beam Bamboo Other
Roof Slope (pitch)	Flat (0-5 Deg) Gentle (10-25 Deg) Steep (30-45 Deg)	
Roof Structure Tie Downs	Looped Reinforcement from below Galvanised Iron Strapping U bolts Bolts and brackets	Skew Nails Skew Screws Lashed (rope/fibre) Absent Other
Roof Material	Natangura Corrugated Iron Tiles	Concrete Other
Roof Fixing Methodology	Screws Nails	Unknown Other
Roof Bracing	Galvanised Iron Strapping Timber Strut Timber sheeting PVC sheeting	Absent Unknown Other
Is there evidence of rot in timbers?	Yes	No

Is there evidence or termite or borer attack in timbers?	Yes	No
Comments on roof issues		
Photos of roof issues		
Roof Condition	0% 10% 50% 100% Unknown	
Wall Openings		
Wall Openings	Timber- Shutters Timber- Louvre Metal- Shutters Glass- Fixed	Glass- Louvre Mesh/Screen No Covering
Reconstruction Category	1- Complete Rebuild 2- Rebuild Roof 3- Retrofit Sheeting and Connections	4- Retrofit Connections 5- No Action Required 6- N/A
Survey Close		
Any other comments on 'Building Hazard Vulnerability' section?		
Additional information		
Additional photos		
Comments/Recommendations		
Detailed Evaluation Required?	Yes	No
Record Completion	Draft	Complete

Appendix F

Building Characteristics

F1 Construction Typologies

Building Typology	Photo	Advantages	Disadvantages
Unreinforced masonry Concrete block with no reinforcement		• Durable • Easy to build • Cheap • Use of local materials	• Not suitable for use in seismic regions • Poor performance in cyclonic areas
Reinforced Masonry Concrete block with vertical and horizontal reinforcement		• Durable if material quality is managed • Seismic resistance if constructed properly • Use of local materials	• Slow to build • Requires an understanding of good seismic detailing • Requires skilled workers for correct assembly of reinforcement
Reinforced Concrete Frame with Masonry infill		• Durable • Seismic resistance if constructed properly (infill walls must be tied to columns) • Use of local materials	• Slow to build • Masonry façade may not be tied in • Complex seismic reinforcement detailing • Requires skilled workers for correct assembly of reinforcement
Timber frame Lightweight timber frame with timber or plywood cladding		• Easy to build • Quick to build • Timber frame is lightweight and ductile and thus is good for seismic	• Untreated timber susceptible to insect attack and weather degradation • Materials are imported • Requires regular maintenance • Vulnerable in high winds without good design • Requires careful connection detailing
Mixed Masonry and Timber Low level masonry skirt wall with timber at higher level		• Masonry wall at low level gives durability in splash zone • Lightweight upper level walls reduces seismic load	• Two different trades are required • Complex detailing between materials • Untreated timber susceptible to insect attack and weather degradation • Complex stability system

F2 Construction Methodologies

	Description	Type 1 Community Built and Financed Buildings	Type 2 Donor Built and Colonial Period Buildings
Typical Construction Elements	**Typical Structure**	 	 
	Slab/ Foundations	Thin slab (<75mm) with/ without footings	Thick concrete slab (~75-100mm) on strip footings
	Columns	Timber, embedded into ground or reinforced concrete columns	Reinforced concrete
	Walls	Timber frame, with/without concrete block 'skirt' wall	Core filled concrete block
	Bracing	Absent or nominal	Concrete shear wall
	Primary Roof Structure	Timber truss or beams with gang-nail or nailed joints	Timber truss with bolted or gang-nail joints
	Roof Structure to Wall Connections	Bent reinforcement from concrete columns under or skew nails from timber columns under	12mm diameter U bolts embedded in ring beam or 5mm steel strapping bolted to ring beam
	Batten to Primary Roof Structure Connections	Galvanised iron strapping intermittent across structure or skew nails	Galvanised iron strapping across majority of structure
	Roof Material	Corrugated iron	Corrugated iron
	Roof Fixings	Roof nails	Roof screws with/without cyclone hats

F3 Key Structural Vulnerabilities

Vulnerability	Description	Preventative Action	Photo
Age of Assets	Many schools are ~30 years old and are degrading due to lack of maintenance and the severe coastal environment	Maintain structures regularly to prevent degradation of materials.	
Maintenance of Assets	Corrosion of roof sheeting Degradation of window shutters	Provide preventative maintenance to roof sheet by painting regularly. Replace sheet once degraded, before supporting structure is damaged. Paint timber to prevent damage. Select durable materials (external ply), or clad with tin sheet.	 

Structural Stability	Lack of stability system. Non-engineered structures.	All school buildings should be engineered. Development of a standard set of drawings will enable MoET to freely distribute engineered designs to communities.	 
Structural form	Irregular structural form. Buildings have L>4B, making them more susceptible to earthquake loading.	Buildings should not be wider than 4 times their width. Buildings longer than this should be broken up into two separate structures.	
Unreinforced Masonry	URM is not suited to seismic zones due to its brittle failure mode.	All masonry structures should be reinforced vertically and horizontally, and core filled at all reinforcement locations. Corners and intersections of all walls should be linked with reinforcement.	 

Material quality and selection	Sea sand is often used in concrete and for making concrete block, where the salt content leads to corrosion of steel reinforcement and concrete spalling	Sea sand be stockpiled for six months and exposed to rainfall and/or washed with fresh water before use, to remove the salt.	 
	Timber degradation due to lack of maintenance or the use of untreated timber, leading to rot, termite and borer attack. Local timber used which is not strength or durability rated.	Preservative treated timber or hardwoods resistant to insect attack should be used. Knowlede of timber species is required if local timbers are to be used to ensure they are durable. A conservative approach to strength grading is required.	
Workmanship	A lack of site supervision allows poor quality workmanship to go unchecked. Reinforced masonry column not core filled Lack of screws at flashing ends	Site supervision by suitably qualified trades should be provided for all school buildings, to manage quality on site and ensure that buildings are constructed in accordance with the design intent.	 

Foundation Design and Construction	Lack of adequate foundations	All school buildings should be engineered. Development of a standard set of drawings will enable MoET to freely distribute engineered designs to communities.	 
Wall Design and Construction	Poor connection details making schools vulnerable to high winds. Bottom plate is partially anchored, but stud not anchored to bottom plate	Bottom plates on timber frame walls must be suitably anchored to skirt walls and/or slabs and walls must be strapped to bottom plates.	 
	Inadequate bracing in timber frame walls	Timber walls should be suitably braced with galvanised steel strapping or wall sheeting.	 

Wall Design and Construction	Poor quality galvanised nails initiate corrosion in wall sheets	Quality screws should be used for all corrugated steel cladding and roofing.	
	Reinforcement Lack of connection between columns and walls	Reinforcing bars should tie between walls and columns.	 
	Lack of bond beams at top of wall	Tie/bond beam should be provided along top of building to provide horizontal connection between columns.	

Wall Design and Construction	High level masonry in gable ends is susceptible to earthquake loads.	Eliminate high level masonry where possible, and substitute with lightweight cladding. Alternately, provide sloping bond beam at top of gable walls.	
Roof Design and Construction	Large Verandahs or eaves are susceptible to wind uplift.	Provide verandahs as a separate attached element to protect main roof in the event of roof failure. Alternately, engineer connections for full uplift.	 
	Trusses are not designed or constructed correctly.	Build trusses to an engineered design. Provide diagonal members that node out.	 

Roof Design and Construction	Beams are poorly connected at mid span.	Use continuous members wherever possible, or provide suitably robust splice at joints.	 
	Connections are susceptible to corrosion from proximity to the ocean and emissions from the volcano.	Use galvanised, large diameter bolts and 5mm min thick strip plate where possible for connections. Use stainless steel strapping. Maintain connections by regular inspection and re-application of paint.	 

Roof Design and Construction	a) Poor wall to roof structure connections are vulnerable to wind uplift. Reinforcement from the column below is looped over truss. b) Top plate anchored to wall, but inadequate connection of roof structure to top plate. c) Nails embedded into insitu concrete wall susceptible to shearing concrete under uplift	Provide robust anchorage of reinforcing bars to roof structure or use U bars cast into ring beam. Provide adequate strapping from truss to wall plate. Provide alternate fixing detail.	a)  b)  c) 
	Corrosion of gang nails.	Large diameter galvanised bolts should be used rather than gang nails for increased durability. If gang nails are used, they should be galvanised and painted regularly to inhibit corrosion	

Roof Sheet Design and Construction	a) Unsuitable ‘Z nail’ connection from rafter to wall plate. b) Unsuitable ‘triple grip’ connections from purlins to rafters. c) Unsuitable timber blocks used with skew nails to connect purlins to rafters.	Galvanised iron or stainless steel strapping should be used for all purlin to rafter connections, and for rafter to top plate connections where (spacing of rafters/trusses is small <=1.2m). Straps should loop over top member (rafter or purlin), with nails anchored in shear on both sides of bottom member (rafter or top plate).	a)  b)  c) 
	Nails are used in place of screws, which are vulnerable to uplift. Roof sheets are incorrectly lapped, leaving them vulnerable to uplift. Screws used without cyclone washers.	Use roof screw with cyclone washers for all roof sheet connections. Sheets should be screwed in accordance with manufacturers specification.	 

Site Location	Schools at exposed sites in close proximity to the coast in tsunami zones	Mitigation challenging when schools are required adjacent to population centres. Encourage development away from low lying coastal areas. Install early warning systems for tsunami hazard.	
	Schools adjacent to volcano with corrosive emissions and risk of ash/explosive emission fallout	Mitigation challenging when schools are required adjacent to population centres. Encourage development away from volcano.	
Physical Planning	Poor site drainage leaving classroom exposed to overland water flow. Bund wall erected to stop water flow into classroom.	Provide suitable site drainage. Lift building floor levels above surrounding area.