

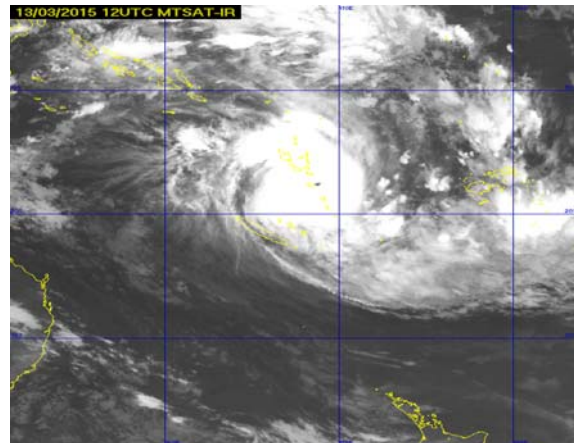


WORLD METEOROLOGICAL ORGANIZATION

**POST-TROPICAL CYCLONE PAM EXPERT
MISSION TO VANUATU**

PORT VILA, VANUATU, 20-24 APRIL 2015

MISSION REPORT



COVER PAGE PHOTOS

Left: Aerial photo taken flying over the capital Port Vila of the Republic of Vanuatu of properties devastated by Tropical Cyclone Pam, 15 March 2015

Right: Satellite image of Tropical Cyclone Pam, 13 March 2015

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Report of the WMO Post-Tropical Cyclone “Pam” Expert Mission to Vanuatu

20-24 April 2015

1 Introduction

1.1 Tropical Cyclone “Pam” is likely one of the strongest to make landfall in the Pacific region. It passed within 45 kilometres of the capital Port Vila of the Republic of Vanuatu at 1300 Coordinated Universal Time (UTC) (12 a.m. Vanuatu Time (VUT)) on 13 March 2015, made landfall on the island of Erromango at 1800 UTC (5 a.m. VUT) of 14 March and passed within 20 kilometres of the island of Tanna. “Pam” caused significant damages and disruption to socio-economic activities on the island of Efate and the capital Port Vila; and the islands of the Shepherds, Tanna and Erromango. The Vanuatu Tropical Cyclone Warning Centre (VTCWC) of the Vanuatu Meteorology and Geo-hazard Department (VMGD) issued the first information on 10 March while Tropical Cyclone “Pam” was 600 kilometres northeast of the Banks’ Islands and this is outside VTCWC Area of Responsibility (AoR), followed by further information, advisories and warnings on its movement and intensity. Whilst “Pam” caused considerable damage there were only 11 fatalities due in no small measure to the early and accurate information and warnings issued by VMGD and the subsequent preparations taken by government and citizens across Vanuatu.

1.2 After “Pam” hit Vanuatu and brought catastrophic disasters to the island of Efate and the capital Port Vila; and the islands of the Shepherds, Tanna and Erromango, the Government of Vanuatu through its Permanent Representative of Vanuatu with WMO, Mr Jotham Napat, requested that an assessment team be organized to consolidate lessons learned from Tropical Cyclone “Pam” from hazard monitoring and early warning perspectives and make recommendations on a way forward. In response to the request, WMO organized a Post-Tropical Cyclone “Pam” Expert Mission to Vanuatu to assess the current capacity and capability of VMGD and relevant authorities in Vanuatu, and make recommendations and develop a project proposal to address specific aspects identified by the gap analysis.

Organization of the mission

1.3 In consultation with Mr Napat and Mr David Gibson, Acting Director of VMGD, the WMO Post-Tropical Cyclone “Pam” Expert Mission was carried out from 20 to 24 April 2015. The mission team was composed of the Chair of the WMO Regional Association (RA) V (South-West Pacific) Tropical Cyclone Committee, an expert on Observations Infrastructure (Australia), a representative of the Regional Specialized Meteorological Center (RSMC) Nadi - Tropical Cyclone Centre/Fiji Meteorological Service (FMS) and a representative of the WMO Secretariat. The list of the members of the mission team and the Terms of Reference (ToR) of the mission are given in **Appendix I** and **Appendix II**, respectively.

1.4 The mission took into full account all information, data and assessment reports compiled and prepared by VMGD, the Public Works Department, the Secretariat of the Pacific Environment Program (SPREP) and the Secretariat of the Pacific Community (SPC), prior to arrival of the team in Vanuatu, including the first draft of the Chapter on Disaster Risk Management (DRM) and Early Warning System (EWS) in the Post Disaster Needs Analysis (PDNA) report, which is given in **Appendix III**. At the request of the Coordinator of the PDNA report, the mission team reviewed and submitted an updated version of the DRM/EWS Chapter for the PDNA report. These are also used as the basis for this report. The mission team coordinated its work with the Japan International Cooperation Agency (JICA) Expert Team’s mission which carried out its assessment in Vanuatu from 20 to 24 April 2015.

1.5 The WMO mission was organized to obtain valuable insights from hazards monitoring and early warning systems (policies, institutional coordination and operational aspects before, during and after the event) processes and products in the context of Tropical Cyclone “Pam” in Vanuatu. Since “Pam” was well forecasted several days in advance, in addition to the monitoring of the hazard, the mission looked very closely at gaps in understanding the impacts of the hazard, its

communication to all partners and to the public in order to appropriately prepare and put in place response measures. It sought to provide recommendations to VMGD and other relevant agencies in Vanuatu as well as their partners on how to further improve hazard monitoring, early warning, and understanding the impact of such a tropical cyclone on the population in order to reduce death, injury, damage and losses from future natural disasters. The information collected is also expected to help consolidate the lessons that can be learnt at the regional level by members of the RA V Tropical Cyclone Committee for the South Pacific and South-East Indian Ocean.

1.6 The mission utilized the concept of people-centered end-to-end hazard monitoring, early warning and identifying the impact of the detected hazard and make reference to the provisions of the Sendai Framework for Disaster Risk Reduction 2015-2030¹, particularly Priority Action 4: Enhancing disaster preparedness for effective response and to “build back better” in recovery, rehabilitation and reconstructions.

1.7 The programme of the mission, given in **Appendix IV**, included: (1) a meeting with the Minister, Ministry of Climate Change, Meteorology, Geo-hazard, Environment, Energy and Disaster Management (MCMGEED); (2) a meeting with the Permanent Representative of Vanuatu with WMO who is also the Director-General for the MCMGEED; (3) meetings with the Acting Director of the VMGD; (4) a meeting with the Director of the National Disaster Management Office (NDMO); (5) a meeting with staff of the Vanuatu Broadcasting and Television Corporation (VBTC); (6) individual discussions with the relevant staff of VMDG; (7) a meeting with the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA); (8) a meeting and discussions with a community at Black Sand area on the suburb of the capital Port Vila; (9) individual discussions with a few members of communities on the island of Efate; and (10) discussions with the JICA Expert Team. The list of persons consulted is given in **Appendix V**.

Severe Tropical Cyclone Pam

1.8 Severe Tropical Cyclone “Pam” was first analysed as a Tropical Disturbance (TD11F) on 6 March, approximately 800 kilometres northeast of the Torres Islands which are inside the RSMC Nadi AoR but outside VTCWC AoR. RSMC Nadi issued its first International Gale Warning at 1300 UTC (midnight VUT) on 7 March for an area of gale force winds to the north of the Tropical Disturbance. TD11F developed into a Tropical Depression on 8 March. It continued to intensify as it tracked towards the southeast and was eventually named as Tropical Cyclone “Pam” at 0600 UTC (5 p.m. VUT) on 9 March, approximately 600 kilometres northeast of the Banks Islands. “Pam” rapidly intensified during the following 30 hours and around 1200 UTC (11 p.m. VUT) on 10 March and classified as a Category 3 Tropical Cyclone with Hurricane Force winds close to its centre.

1.9 Under favorable environmental conditions, Severe Tropical Cyclone “Pam” continued to intensify and around 1300 UTC (midnight VUT) on 11 March, it was classified as a Category 4 Tropical Cyclone with winds close to the centre estimated at 90 knots (166 km/h). “Pam” slowed down in its movement and global models started to indicate that it would turn towards the southwest and tracked towards the central islands of Vanuatu. “Pam” moved slowly southwest and entered into VTCWC AoR at 1800 UTC (5 a.m. VUT) on 11 March about 360 kilometres northeast of the Banks Islands. Subsequently, VMGD issued the first warning on “Pam” at 2200 UTC (9 a.m. VUT) and the warnings were also started to be disseminated via SMS at 0200 UTC (1 p.m. VUT) on 11 March.

1.10 Severe Tropical Cyclone “Pam” continued to intensify and developed into a Category 5 Tropical Cyclone with winds close to the centre estimated at 120 knots (222 km/h) and with a central barometric pressure of 921 hPa. At this stage and around 1100 UTC (10 p.m. VUT), it was 370 kilometres to the northeast of Port Vila and just east of Penama Province, and continued to intensify as it tracked southwest and rapidly approaching the islands in the central parts of

¹ http://www.wcdrr.org/uploads/Sendai_Framework_for_Disaster_Risk_Reduction_2015-2030.pdf

Vanuatu including the island of Efate where Port Vila is located. “Pam” passed within 45 kilometres east of the Island of Efate and Port Vila at 1300 UTC (12 p.m. VUT) on 13 March 2015. It slowed down overnight and tracked towards the southeast and passed within 20 kilometres to the east of the islands of the Shepherd Group.

1.11 Severe Tropical Cyclone “Pam” made landfall on the northwest side of the island of Erromango at about 1700 UTC (4 a.m. VUT) before moving into the ocean an hour later. As it continued to track south-southeast, it passed just to the west of the island of Tanna. Whitegrass Weather Observing Station on the island of Tanna recorded the highest wind speed of 120 knots (222 km/s) and the lowest barometric pressure of 919 hPa between 2000 UTC (7 a.m. VUT) and 2100 UTC (8 a.m. VUT). “Pam” intensified further as its central pressure continued to decrease and estimated wind speed continued to increase. At its peak, its maximum wind speed estimated around 135 knots (250 km/s) with a central pressure of 896 hPa at 0100 UTC (12 p.m. (in that case 0000 UTC) or midday VUT) on 14 March. “Pam” remained Category 5 as it continued to track towards the southeast, and eventually entered into AoR of New Zealand’s Tropical Cyclone Warning Centre (TCWC) - Wellington, at approximately 1700 UTC (4 a.m. VUT) on 14 March. The preliminary analysis track of Tropical Cyclone “Pam” is given in **Appendix VI**.

Box 1. Dedicated VMGD staff and continuity of services

At 0800 UTC (7 p.m. VUT) on 13 March, after a gruelling 12 hours of working, the decision was made that none of the 3 weather forecasters who had just completed duty were to leave VMGD Headquarters building as it was too dangerous as Severe Tropical Cyclone “Pam” was rapidly approaching the islands of Vanuatu. This meant that there were 6 weather forecasters in the Office. At around 1100 UTC (10 p.m. VUT) when “Pam” was tracking southwestwards and approaching the islands in the central parts of Vanuatu including the island of Efate where the capital Port Vila is located as well as VMGD Headquarters, strong westerly winds battering the building. The strength of the winds forced water to enter the building through the rubber seals of the closed glass windows. The officers had to relocate personal computers to the centre of the building as these are the Tropical Cyclone Workstations located the closest to the windows. Two of the dedicated forecasters who were supposed to be off-duty had to continually mop the floor as water came pouring in through all the windows which were facing the west. At around 1200 UTC (11 p.m. VUT), the strength of the wind tore open the soffit (overhang) of the balcony of the building and timbers smacked onto the concrete wall and damaged a few of the glaze windows. This forced more water to enter the building through the Climate Division’s room and was threatening the Tropical Cyclone Workstations which were relocated earlier. Whilst the 3 forecasters were busy preparing and sending the warnings on Severe Tropical Cyclone “Pam”, the other 3 forecasters were busy mopping the floor. The preparation and issuance of warnings on Tropical Cyclone “Pam” were never affected.

Damages caused by Severe Tropical Cyclone “Pam” to the National Multi-Hazard Early Warning System

1.12 The Vanuatu National Multi-hazards Early Warning System (VNMHEWS) is managed and operated by VMGD. It was severely impacted by Tropical Cyclone “Pam” with observation and monitoring equipment, communication and office buildings being damaged. Replacement costs are estimated at US\$2,100,000 based on assessments conducted by VMGD with advice from the Public Works Department. A summary of information on damages to VMGD Headquarters building, synoptic weather stations and geo-hazard stations is given in **Appendix VII**.

Chronology of the VMGD's activities during Severe Tropical Cyclone "Pam"

1.13 VMGD responded to Severe Tropical Cyclone "Pam" as follows:



Figure 1: Track of Severe Tropical Cyclone "Pam (UTC Time/Date/Month)

9 March

- VMGD issued press release #1 on tropical depression (TD11F).
- VMGD and the National Disaster Management Office (NDMO) organized and conducted media briefing.

10 March

- VMGD issued tropical cyclone information #1.
- VMGD information relayed to NDMO, government, media & general public.
- VMGD issued tropical cyclone advisory #1 at 0800 UTC (7 p.m. VUT).
- VMGD relayed information to NDMO, government, media & general public.
- VMGD and NDMO organized and conducted media briefing.

11 March

- VMGD issued tropical cyclone warning #1 at 2200 UTC (9 a.m. VUT) (issued 3 hourly interval) including forecast track map, uncertainty track map and forecast positions.
- Areas warned were Torba, Sanma, Malampa and Penama provinces.
- VMGD relayed information to NDMO, government, media & general public.
- NDMO issued Colour Alert (YELLOW) for areas (Torba, Sanma, Malampa and Penama provinces) as warned by VMGD.
- VMGD and NDMO organized and conducted media briefing.
- At 0200 UTC (1 p.m. VUT) warnings were also started to be transmitted through the SMS.

12 March

- VMGD continued to issue tropical cyclone warning (issued 3 hourly interval) including forecast track map, uncertainty track map and forecast positions.
- Areas warned were Torba, Sanma, Malampa, Penama and Shefa provinces.
- Information relayed to the NDMO, government, media & general public.
- NDMO issued Colour Alert (YELLOW) for Torba, Sanma, Malampa, Penama and BLUE Colour Alert for Shefa Province.
- VMGD and NDMO organized and conducted media briefing.
- At 0700 UTC (6 p.m. Vanuatu Local Time), tropical cyclone warnings extended to Tafea province.
- NDMO issued RED Colour Alert for Torba and Penama provinces, and the rest of the provinces were on YELLOW Colour Alert.

- VMGD Offices in the outer-islands started reporting data from the weather observing stations every hour.
- All warning continued to be transmitted through the SMS (Digicel).
- All evacuation centres in the RED Colour Alert areas, islands and provinces are activated.
- Warnings continued to be transmitted via SMS (Digicel).

Box 2. Communities and stakeholders received warnings well in advance

As Tropical Cyclone “Pam” moved into VTCWC AoR at 1800 UTC (5 a.m. VUT) on 11 March 2015 about 360 kilometres northeast of the Banks Islands, VMGD issued the first warning at 2200 UTC (9 a.m. VUT) and this was about 2 days before “Pam” devastated the islands in the central and southern island including the capital Port Vila. One of the communities visited by the team confirmed that warnings were clear and received via the VBTC radio station and SMS well in advance before “Pam” brought strong and severe winds and devastated their house.



Photo: Community visited by the team

13 March

- VMGD continued to issue tropical cyclone warning (issued 3-hourly interval) including forecast track map, uncertainty track map and forecast positions.
- Areas warned were Torba, Sanma, Malampa, Penama and Shefa provinces.
- Information relayed to NDMO, government, media and general public.
- At 1600 UTC (3 a.m. VUT), NDMO issued RED Colour Alert for Torba, Penama, Sanma and Malampa provinces and YELLOW Colour Alert for Shefa and Tafea provinces.
- VMGD Offices in the outer-islands continued reporting data from weather observing stations every hour.
- At 0200 UTC (1 p.m. VUT), NDMO extended RED Colour Alert to Shefa province.
- At 0200 UTC (1 p.m. VUT), VMGD issued tropical cyclone warning every hour including forecast track map, uncertainty track map and forecast positions.
- NDMO issued and extended RED Colour Alert to all islands and provinces of Vanuatu.
- All evacuation centres were activated.
- All warnings continued to be transmitted through the SMS.

14 March

- VMGD continued to issue tropical cyclone warnings every hour including forecast track map, uncertainty track map and forecast positions.
- At 1900 UTC (6 a.m. VUT), VMGD cancelled tropical cyclone warnings for Torba province but maintained for the rest of the islands and provinces in Vanuatu.
- At 2100 UTC (8 a.m. VUT), NDMO cancelled RED Colour ALERT for Sanma and Torba provinces but maintained for the rest of the islands and provinces.
- At 2200 UTC (9 a.m. VUT), NDMO continued to maintain RED Colour Alert for Malampa, Shefa and Tafea provinces but cancelled for the rest the islands and provinces of Vanuatu.
- All evacuation centres remained activated and in operation.
- All warnings continued to be transmitted through the SMS.
- At 0200 UTC (1 p.m. VUT), VMGD cancelled warnings for Malampa province but remain in force for Shefa and Tafea provinces.
- At 0300 UTC (2 p.m. VUT), VMGD continued to maintain warning for Tafea province but

cancelled warnings for the rest of the islands and provinces of Vanuatu.

- At 0900 UTC (8 pm VUT), VMGD cancelled warnings for Tafea province, and this was also the last official information issued by the VMGD.

Box 3. Warnings disseminated via SMS saved lives

For the first time, Vanuatu used an SMS warning system to alert people of the approaching cyclone. Text messages, containing condensed versions of warnings from VMGD were sent every three hours as the cyclone intensified. The messages were then sent hourly as the cyclone came closer to making landfall.

For many in the outer islands, it was their only way of knowing where the cyclone was. Technical problems at the national broadcaster meant emergency radio bulletins were only reaching some of Vanuatu's 65 inhabited islands. Mr Kiery Manassah, a spokesman for the Prime Minister's Office, said he had no doubt the messages had saved lives. "I had the opportunity to go to some of the islands that were affected. I asked them about how they got the information and most of them, especially in Shefa province and outer islands, said they got the information from the SMS alerts," he said. Mr Manassah said the technology would likely be used for future disasters. "Penetration of mobile phones in Vanuatu is quite high, and I would estimate almost 100 per cent, probably between 80 and 90 per cent of people have access to mobile phones so it's a very useful means of communicating critical information to people."



Photo: A Vanuatu chief, in Central Pentecost, uses a smart phone for the first time

1.14 In totality, the number of information, advisories and warnings issued included: (a) media briefing; (b) tropical cyclone information; (c) tropical cyclone advisories; (d) tropical cyclone warnings; (e) forecast track maps and (f) uncertainty track maps.

2 Vanuatu National Disaster Management Arrangements

2.1. The United Nations International Strategy for Disaster Reduction (UNISDR) has defined the term 'Disaster Risk Management' as *the systematic process of using administrative directives, organizations, and operational skills and capacity to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster*². Such a definition would normally require a comprehensive description of potential disaster risk reduction and disaster management action required to address the impacts Vanuatu has experienced with Tropical Cyclone "Pam". However, given limitation and constraint in time, the primary focus of the mission was on some of the key challenges and issues that VMGD

² UNISDR, 2009

experienced in terms of its disaster preparedness and response capacity, during “Pam”.

Vanuatu National Disaster Act

2.2. The Vanuatu National Disaster Act No. 31 (Cap 276) of 2000 has set out the umbrella national arrangements for the management of disaster arising from natural and other hazards. Section 4(1) of Act No. 31 (Cap 276) of 2000 has established the National Disaster Committee (NDC). At the central government level, Section 4(2) of Act No. 31 (Cap 276) of 2000 has outlined the responsibilities of the NDC, and two of its functions are:

- (a) Section 4(a) of the Vanuatu National Disaster Act No. 31 (Cap 276) of 2000 - to develop strategies and policies for the prevention of, preparation for, response to and recovery from disasters; and
- (b) Section 4(b) of the Vanuatu National Disaster Act No. 31 (Cap 276) of 2000 - to ensure that such strategies and policies are implemented by NDMO, other government agencies and non-government agencies.

2.3. Furthermore, Section 6 of the Vanuatu National Disaster Management Act No. 31 (Cap 276) of 2000 has established NDMO and outlines its function. One of NDMO functions as stipulated in Section 6 (2) (a) of Act No. 31 (Cap 276) of 2000 is to implement the strategies and policies of the NDC. Reproducing Section 6 (2) (a) Act No. 31 (Cap 276) of 2000 without making reference to Section 4 (b) in a number of documents such as the National Cyclone Support Plans 2012-2013³ & 2014-2015⁴ might be misleading and to assume that NDMO would be the only government agencies to implement the strategies and policies developed and adopted by the NDC whereas Section 4(b) of the same Act specifically says that the NDC to ensure that strategies and policies developed by the NDC are implemented by the NDMO, other government agencies and non-government agencies.

Vanuatu National Disaster Committee (NDC)

2.4. Vanuatu National Disaster Committee (NDC) members, in accordance with Section 5 of the National Disaster Act No. 31 (Cap 276) of 2000 would comprise of three permanent members selected from the position they occupy in responding to any disasters in Vanuatu. The Committee is to meet as often as is necessary for the efficient performance of its functions. The Committee might adopt its own rules of procedure. NDC membership, as provided under the National Disaster Act No. 31 (Cap 276) of 2000 would include the following: Director-General of the MCMGEED as Chairman; Director of the NDMO as the Secretariat; Commissioner of the Vanuatu Police Force; Chief Executive Officer of the Vanuatu Red Cross Society; and 3 representatives of the Non-Government Organizations (NGOs).

Vanuatu National Disaster Management Office (NDMO)

2.5. Vanuatu National Disaster Management Office (NDMO) developed in consultation with stakeholders a draft National Disaster Plan in 2008 and this is in line with Section 9 of the National Disaster Act No. 31 (Cap 276) of 2000.

Vanuatu National Disaster Support Plan - National Cyclone Support Plan

2.6. Section 10 of the Vanuatu National Disaster Act No. 31 (Cap 276) of 2000 has called for the development of a National Disaster Support Plan for each kind of disaster in consultation with government and non-government agencies. The objective of a National Disaster Support Plan is to provide for nationally coordinated actions by government and non-government agencies in the

³ Section 4.0 of the National Cyclone Support Plan 2011-2012

⁴ Section 4.0 of the National Cyclone Support Plan 2014-2015

prevention of, preparation for, response to and recovery from the kind of disaster that the Plan covers. A National Disaster Support Plan for tropical cyclone as referred to as “National Cyclone Support Plan” is usually prepared for a period of 2 years. The National Cyclone Support Plan 2014-2015 has also outlined the role of VMGD in the following areas:

- (a) Section 9 of the National Cyclone Support Plan 2014-2015 calls for NDMO and VMGD to ensure that appropriate National Emergency Operating Centre (NEOC) Standard Operating Procedures (SOPs) are in place and to ensure that they are reviewed after each event. However, VMGD staff were not aware their roles in the NEOC.
- (b) Section 10 of the National Cyclone Support Plan 2014-2015 describes the designation of warnings, however it does not make mention of VMGD as the national source of warning as stipulated in Section 6 of the Vanuatu Meteorology Act No. 4 (Cap 204) of 1989. Furthermore, while there is a footnote making reference to the “Cyclone Directive 2015 (2015)⁵”, it would be useful to put the Cyclone Directive as an Annex to the Plan.
- (c) Section 11 of the National Cyclone Support Plan 2014-2015 is describing the alert and response phases actions to be taken by communities utilizing colour-coded system used by the NDMO which include; planning and preparedness in the pre-cyclone season; community response when cyclone response and; cyclone developing and potential tracks towards Vanuatu (72 – 24 hours out). Given the lessons-learned during Tropical Cyclone “Pam” there would be a need to review this and improve this part of the Plan, taking into accounts improving coordination, communication and partnership between the NDMO and VMGD during pre-cyclone season and during cyclone season (pre-tropical cyclone disaster, during tropical cyclone disaster, and post-tropical cyclone disaster).

Vanuatu National Multi-Hazard Early Warning System

2.7. Early warning is major element of disaster risk management. To be effective, early warning systems would need to actively involve communities at risk, facilitate public education and awareness of risks, effectively disseminate messages and warnings and ensure there is a constant state of preparedness⁶.

2.8. Monitoring and warning services have always been and will always be the core of early warning system. There must be a sound scientific basis for predicting and a reliable forecasting and warning system operating 24 hours a day. Continuous monitoring of hazard parameters is essential to generate accurate warnings in a timely fashion. Warning services for different hazards should be coordinated where possible to gain the benefits for shared institutional, procedural, resources and communications.

Vanuatu Tropical Cyclone Warning

2.9. Vanuatu Meteorology Act No. 4 (Cap 204) of 1989 has provided for the establishment of the Vanuatu Meteorological Services and its functions. Section 6 (1) (c) of the Meteorology Act No. 4 (Cap 204) of 1989 specifically has set out its exclusive responsibility for the issue of warnings of gales, storms and other weather conditions likely to endanger life or property, including weather conditions likely to give rise to floods or storm surges.

2.10. VMGD, before the start of each tropical cyclone season would develop and review VTCWC Directive. It outlines procedures for VMGD to activate and operate VTCWC during a tropical cyclone event.

⁵ Cyclone Directive (2015) 2015, VMGD, Port Vila

⁶ Third International Conference on Early Warning, 2006

Vanuatu Tsunami, Volcano and Earthquake Alerts and Warnings

2.11. The Council of Ministers Decision 33/2010 stipulated the transfer of the Geo-Hazards Section from the Department of Geology, Mines and Water resources to the Vanuatu Meteorology Services in 2010 to form VMGD with additional responsibilities to provide tsunami warning, volcanic activity alerts and earthquake information services in Vanuatu.

2.12. The Vanuatu Tsunami Warning Centre (VTWC)'s Tsunami Information and Advisories Summary of Procedures within Vanuatu has outlined procedures to activate VTWC whenever there are an earthquake, volcanic eruptions and landslides within Vanuatu or the region.

2.13. The Geo-hazards Duties and Operating Procedures (Version. 1, July 2014) has also described procedures of monitoring and reporting on volcanoes, earthquake and geo-engineering matters.

3 Role of VMGD in Supporting the Vanuatu National Multi-Hazard Early Warning System

3.1 VMGD's observing systems and networks supporting VNMHEWS are composed of.

Synoptic weather stations	7
Upper-air weather stations	1
Automatic weather stations	(2) ⁷
Agro-meteorology stations	6
Manual climate rain gauges	170
Automatic climate rain gauges	12
Tide gauges	2
Seismic stations	4
Automatic Tsunami Warning Stations	(2) ⁸
Volcano monitoring stations	11
Weather satellite data receiving facilities	2

3.2 The observing system and network supporting tropical cyclone warnings is given in **Appendix VIII**. Two Automatic Weather Stations (AWSs) are being installed at Bauerfield international airport, on the island of Efate and Pekoia international airport, on the island of Santo, under JICA project. **Appendix IX** shows locations of 2 AWSs and other monitoring equipment such as the Automated Tsunami Warning System (ATWS) and tide gauges.

4 Identification of Strengths, Challenges and Gaps, Opportunities and Threats for Enhancing the Vanuatu National Multi-Hazard Early Warning System

4.1 The mission team identified: (a) strengths; (b) challenges and gaps; (c) opportunities; and (d) threats for enhancing VNMHEWS operated and managed by VMGD during Severe Tropical Cyclone "Pam" related to infrastructure including observing and communication networks; capacity development including education and training; institutional development including policy and SOPs.

(a) Strengths

Legislations

(1) The Meteorology Act No. 4 (Cap 204) of 1989 has provided for the establishment of the Vanuatu Meteorological Services (now referred to as VMGD) and its functions including responsibility for the issue of warnings of gales, storms and other weather conditions likely

⁷ 2 AWS are being installed by JICA project and to become operational in June 2015

⁸ 2 ATWS are being installed by JICA project and to become operational in June 2015

- to endanger life or property, including weather conditions likely to give rise to floods or storm surges
- (2) The Vanuatu National Disaster Act No. 31 (Cap 276) of 2000 has set out the umbrella national arrangements for the management of disaster arising from natural and other hazards.

Vanuatu National Multi-hazard Early Warning System (VNMHEWS)

- (3) Vanuatu has established a multi-hazard early warning system, comprising of VTCWC and VTWC.
- (4) VNMHEWS has provided flexibility and capacity for VMGD to be utilized during cyclone events.

Government support

- (5) The Government of Vanuatu has continued to support the operation and development of VMGD as evidenced by the construction of the Headquarters building in the capital Port Vila in 2009, and increase in number of staff by 27.

Partnership and Coordination

- (6) Co-location of NDMO in the same building as VMGD has ensured effective communication and coordination between the two agencies.
- (7) VMGD's close working relations with NDMO led to strong engagement and commitment by the Government of Vanuatu to support pre-cyclone preparations.
- (8) VMGD has a very strong and supportive relationship with VBTC ensuring effective dissemination and communication of weather forecasts, cyclone information, advisories and warnings to the communities and public.
- (9) Well established VMGD's VTCWC Directives ensuring consistent and high quality levels of cyclone information, advisories and warning services to the communities and stakeholders.
- (10) Effective leadership and coordination at the provincial, local and communities level were demonstrated before, during and after Tropical Cyclone "Pam" as evidenced by the actions of village Chiefs and provincial leaders in organizing evacuation to safe centres and recovery operations.
- (11) There is willingness amongst all government and non-government agencies to cooperate in improving services through post cyclone reviews and to learn from other countries' experiences.

VMGD high profile

- (12) VMGD is regarded as a credible and well-respected organization by communities and stakeholders, especially the public in Vanuatu and in the Region.

Leadership

- (13) Strong leadership has ensured excellent and dedicated team work amongst staff within VMGD.

Highly skilled and dedicated VMGD staff

- (14) Cyclone information, advisories and warnings, including statements on the potential risks of floods, landslides, and storm surges were issued with sufficient lead time.
- (15) There are highly skilled and committed VMGD staff members at Headquarters in the capital Port Vila and its Offices in the outer-islands and provinces.
- (16) VMGD actively sought training opportunities for the Weather Forecasting Division/VTCWC staff to maintain their capability in weather and tropical cyclone forecasting. Training opportunities include the biennial Southern Hemisphere Training Workshop on Tropical Cyclones organized by WMO and ABoM.
- (17) Availability of Information Communication Technology (ICT) staff to provide good support during Tropical Cyclone "Pam".

Data-processing and preparation of tropical cyclone warnings

- (18) VMGD's Weather Forecast Division/VNTWC is equipped with modern weather and tropical cyclone forecast production systems including the ABoM Tropical Cyclone Module which is designed to manage and deliver tropical cyclone warning data and products.
- (19) The forecast of Tropical Cyclone "Pam" track and intensity supported by modern technologies such as meteorological satellites, numerical weather prediction (NWP) outputs including information and products from the Severe Weather Forecasting and Disaster Risk Reduction Demonstration Project (SWFDDP) as well as a range of products from RSMC Nadi.
- (20) VMGD ICT infrastructure is of high standard.
- (21) Internet access at least to VMGD Headquarters building has been reliable and available bandwidth is more than adequate.
- (22) A Quality Management System (QMS) framework established in VMGD Weather Forecasting Division contributed to the high standard of operations and high quality of services during Tropical Cyclone "Pam".

Backup system for continuity of services during cyclones

- (23) Continuity of services through Tropical Cyclone "Pam" at VMGD Headquarters building in particular at the Weather Forecasting Division/VTCWC was achieved through back-up power generator.
- (24) Exchange of information between VMGD Headquarters and its Offices in the outer-islands and provinces continued through HF radio communications until the equipment were damaged or destroyed.

Dissemination of warnings

- (25) VMGD website has proved to be very reliable for public to access cyclone information, advisories and warnings and continued to operate throughout Tropical Cyclone "Pam".
- (26) VBTC radio station is the main communication channel for tropical cyclone information, advisories and warnings to reach all areas of Vanuatu. VBTC radio station is transmitting on a number of different frequencies to ensure effective reach of their broadcasts.
- (27) Mobile phone coverage has reached about 85% of the population and provided a sound communication channel for dissemination of tropical cyclone warnings. 24 hours prior to the impact of Tropical Cyclone "Pam", the 2 telecommunication companies (Digicel and TVL) provided priority and free access to SMS for warnings.
- (28) Additionally, VMGD used a variety of communication channels such as television and commercial radio stations.

Communities understanding and response to cyclone warnings

- (29) There is strong awareness at least in communities on the island of Efate, of services including cyclone warnings provided by VMGD.
- (30) The gridded Tracking Map continued to be a valuable tool for communities without internet access to have a visual concept of the expected path of cyclones.

(b) Challenges and gaps

Limited coordination between VMGD and some stakeholders

- (1) There is a need to develop a close relationship between VMGD and all private radio stations and other media organizations.

Limited current skill and capacity of VMGD staff

- (2) The unavailability of current level of skill and capacity to fully couple the meteorological NWP and ensemble models with other hazard models and hazard mapping meant that the severity, timing and extent of the associated hazards (storm surge, landslides and flooding) were underestimated.
- (3) Lack of capacity to translate hazard information into impacts meant that impacts were under estimated by some communities.

Non-existing of verification tools in data-processing and forecasting system leads to limited knowledge of VMGD on quality and reliability of warnings

- (4) Lack of objective verification of forecasts may have resulted in lack of knowledge of the quality and reliability of forecasts and warnings.

Inadequate safety of VMGD staff during tropical cyclone events

- (5) Safety of staff undertaking operational work during cyclone events and other severe weather events is a major concern. VMGD Offices in the outer-islands and provinces are not built to high and cyclone-proof standards and staff members at risk if they are on duty during severe cyclone events.
- (6) Staff required to work during severe cyclone events can be distracted over concerns for the safety of their families.

Limited communication system for exchange of information including warnings between VMGD Headquarters and Offices in the outer-islands and provinces

- (7) Communications of data between VMGD Headquarters and its Offices in the outer-islands and provinces needs to be modernized through utilization of the digital communications networks now in place across Vanuatu.

Non-response by communities due to lack of understanding of warnings and associated impacts

- (8) Category 5 cyclones are rare events and therefore some communities did not clearly understand the likely impact of such severe disastrous event.
- (9) Lack of understanding the warnings by the public due to the use of scientific jargon, failing to communicate the severity and urgency in the warnings may have led to inadequate response by the communities and public.

No-response to warnings due to other factors

- (10) Cultural habits and beliefs may have contributed to non-action on the part of the recipients of cyclone information, advisories and warnings.
- (11) Lack of engagement of social sciences to understand behaviours and decision making processes of the population has a role in lack of proper response.
- (12) Inconsistency between public and marine forecasts and cyclone information, advisories and warnings might have contributed to communities and public confusion.
- (13) Limited tailored services for different sectors, e.g., land transport and marine.

Advance information of tropical cyclones from other sources

- (14) Competition including advance information and wider coverage of the region from non-competent and/or multiple service providers leading to public to confusion during times of disaster events.

Inadequate observing networks and data

- (15) Spatial distribution of existing observing networks across Vanuatu is inadequate. There is a need for additional synoptic weather observation sites through the northeast of the country.
- (16) The rain gauge network is less than adequate and a wider network would provide an adequate basis for flood warning services associated with tropical cyclones approaching land.
- (17) Temporal frequency of observations needs to be significantly improved. The replacement of manual observations with automatic observations is seen as a high priority.

(c) Opportunities

Strengthen partnership and coordination

- (1) Improve VMGD existing relationship with VBTC by conducting informative talkback shows.

- (2) Organize media training for media personnel on understanding weather including cyclones and for VMDG staff handling the media during disasters.

Enhance skill and capacity of VMGD staff

- (3) Strengthen training of operational staff for betterment of products dissemination.
- (4) Revive the previous practice of work attachments and exchange programs for weather and cyclone forecasters with RSMC Nadi or Tropical Cyclone Warning Centre in Brisbane, Australia (TCWC Brisbane).
- (5) Enhance knowledge of weather and cyclone forecasters to understand, analyse and interpret new Himarawi satellite imagery.

Improve communication system for exchange of information including warnings between VMGD Headquarters and Offices in the outer-islands and provinces

- (6) Improve internet accessibility for exchange of observation (e.g. SYNOPs and METARs), weather forecasts and warnings between VMGD Headquarters and its Offices in the outer-islands and provinces.

Improve safety of staff and continuity of services during disastrous events

- (7) Install cyclone shutters and other emergency facilities for security of staff and service continuity at VMGD headquarters building.
- (8) Ensure secure and suitable housing for the VMDG staff in the outer-islands and provinces.
- (9) Review the Business Continuity Plan of VMGD.

Improve data processing and preparation of warnings

- (10) Explore the avenues of utilizing “user friendly” forecasting system, which are more graphical based rather than text based.
- (11) Enhance utilization of the Severe Weather Forecasting and Disaster Risk Reduction Demonstration Project (SWFDDP).

Improve communities’ response to warnings

- (12) Strengthening of impact-based forecasting and risk-based warnings to engender more effective response from the recipients of such information.
- (13) Strengthen public engagement in public awareness, education and outreach on tropical cyclones.
- (14) Review and simplify the contents of weather forecasts and tropical cyclone information, advisories and warnings disseminated especially through the SMS for both Digicel and TVL.

Improve observing networks and data

- (15) Enhance the synoptic weather observation network by extending the Automatic Weather Stations (AWSs) currently installed at the Bauerfield airport on the island of Efate and at the Pekoa airport in the island of Santo to the rest of the existing synoptic weather stations.

(d) Threats

- (1) Increased reliance on technology that may be vulnerable to tropical cyclones.
- (2) Competition from non-competent and/or multiple service providers leading to public confusion during times of crises.
- (3) Lack of response from media agencies to improve coordination with the VMGD will affect the effectiveness of the dissemination of weather forecast and tropical cyclone information, advisories and warnings to the communities and public.

5 Recommendations and Proposed Projects

5.1 Based on the above analysis, the mission team made the following recommendations:

(a) Restoration and replacing the VNMHEWS observing/monitoring stations, systems and communication networks damaged during tropical cyclone “Pam”

As a matter of urgency:

- Replace damaged and existing synoptic weather observations system with automated systems to improve temporal frequency of observations and extend that capability to the remaining VMGD Offices in Malapa, Sanam, Penama and Torba provinces.
- Repair damaged building and replace all equipment at the upper-air weather observation station at Bauerfield airport on the island of Efate severely damaged during “Pam”.
- Replace damaged and existing rain gauges and agro-meteorological stations systems with automated systems.
- Replace damaged geo-hazards network including monitoring stations to ensure effective volcanic and seismic monitoring are sustained.

(b) Enhancing and improving VNMHEWS observing/monitoring stations, systems and communication networks

- (1) Installation of new and additional synoptic weather observation sites throughout the northeast of the country to improve the spatial distribution of observing networks across the country.
- (2) Installation of ground receiving equipment for new Himarawi satellite imagery.
- (3) Modernize communications through utilization of the digital communications networks across the country to improve exchange of data and information between the VMGD Headquarters in the capital Port Vila and its Offices and observing station across the country. This includes installation of internet capability in all VMGD Offices across Vanuatu. The existing synoptic weather observations network and the concept for an improved network are given in **Appendix X** and **Appendix XI**, respectively.
- (4) Install Chatty-beetles in all VMDG Offices across the country.
- (5) Consider the feasibility of installing weather radars as given in **Appendix XII**.

(c) Improving safety of VNMHEWS staff during tropical cyclones and other severe weather events.

- (1) Repair VMGD Headquarters building damaged during Tropical Cyclone “Pam” and install hurricane shutters.
- (2) Repair VMGD Offices and Government residential houses occupied by staff members to cyclone proof standards.
- (3) Develop operational and health safety plan and guidance for VMGD including operational work during cyclone events, severe weather events and other disasters.
- (4) Develop “Business Continuity Plan” for VMGD.

(d) Improving communities and stakeholders responses to tropical cyclone information, advisories and warnings.

- (1) Establish impact-based forecasting and risk-based warnings.
- (2) Install a forecasting system capable of producing graphical forecast and warning products.
- (3) Improve contents of weather forecast and tropical cyclone information, advisories and warnings.
- (4) Review and simplify the contents of weather forecasts and tropical cyclone information, advisories and warnings disseminated through the VBTC radio

stations.

- (5) Review and simplify the contents of weather forecasts and tropical cyclone information, advisories and warnings disseminated through the SMS.
 - (6) Use social sciences to understand behaviour and decision making processes of the communities' responses to warnings.
 - (7) Review the VTCWC Directive and internal instruction for each tropical cyclone season with relevant stakeholder to address in particular the criteria of when information, advisories and warnings are issued for tropical depressions or tropical cyclones and; inconsistency between public and marine forecasts and cyclone warnings issued during tropical cyclone events.
 - (8) VMGD to work with the relevant stakeholders to address specific needs and requirements of vulnerable members of communities especially those with disability, to access to tropical cyclone information, advisories and warnings.
- (e) Improving coordination of dissemination of cyclone information, advisories and warnings to communities and stakeholders**
- (1) Develop SOP between VMGD and VBTC relating to tropical cyclone information, advisories and warnings.
 - (2) Conduct informative talkback shows at VBTC radio station.
 - (3) Develop SOPs between VMGD and other radio stations.
 - (4) Organize training on media for VBTC, other radio stations and VMGD staff to improve understanding of cyclones and other severe weather events and how different media organizations operates.
 - (5) Develop Memorandum of Understanding (MoU) between VMGD and Digicel.
 - (6) Develop MoU between VMGD and TVL.
 - (7) Identify new and critical stakeholders and establish innovative ways for coordination and dissemination of cyclone information, information and warnings.
- (f) Strengthening public and community awareness, education and outreach on cyclones including warnings**
- (1) Strengthen public and communities' participation to increase and broaden public awareness, education and outreach on tropical cyclones and other severe weather events.
 - (2) Increase public awareness, education and outreach to improve understanding of warnings and scientific and technical terms used in the warnings by the public.
 - (3) Increase public awareness, education and outreach to improve understanding of tropical cyclones in communities where cultural habits and beliefs may have contributed to non-action on the part of the communities.
- (g) Human resources development and VMGD staff members to undertake the following areas:**
- (1) Integrate meteorological NWP and ensemble models with other hazard models and mapping of hazards (storm surge, landslides and flooding).
 - (2) Social marketing, social communication and community education to help translating hazard information into impacts.
 - (3) Work attachments and exchange program for tropical cyclone forecasters with RSMC Nadi or TCWC Brisbane.
 - (4) New Himarawi satellite imagery.
 - (5) Utilization of the Severe Weather Forecasting and Disaster Risk Reduction Demonstration Project (SWFDDP) products and services.
 - (6) Management and operation of NEOC during emergencies.
 - (7) Operation and maintenance of automated observing systems.
- (h) Improving VMGD access and utilization of weather NWP and ensemble data and products**
- (1) Access to forecast track data from the ECMWF that are not be easily ingested into

- the Tropical Cyclone Module.
- (2) Access to, and establish objective verification of forecasts to improve knowledge of the quality and reliability of weather forecasts and tropical cyclone information, advisories and warnings.
- (i) Improving VMGD data-processing and forecasting system**
 - (1) Install a weather forecasting system from IBL.
 - (j) Improving tailored weather and cyclone warning services to sectors**
 - (1) Improve tailored services for different sectors, e.g., land transport and sea transport.
 - (k) Improving climate/agro-meteorology and rainfall data network**
 - (1) Community-based climate field school to improve climate/agro-meteorology and rainfall data network.

6 Acknowledgement

6.1 The mission team would like to acknowledge with appreciation the support provided by Hon. Mr James Bule, Minister for Climate Change, Meteorology, Geo-hazard, Environment, Energy and Disaster Management (MCMGEED); Mr Jotham Napat, Director-General of the MCMGEED and Permanent Representative of Vanuatu with WMO, and his staff. The mission team would like to express a special acknowledgement to Mr David Gibson, Acting Director of the VMGD and the Focal Point of the mission, and his staff. The mission team would also like to acknowledge the significant contributions by all VMGD staff members, individuals, groups and communities who participated in the meetings and discussions during the mission.

Appendix I: List of members of the mission team

WMO Regional Association (RA) V Tropical Cyclone Committee (TCC) for the South Pacific and South-East Indian Ocean

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Appendix II: Terms of Reference

In close collaboration with the national counterpart authorities, the mission will perform the following tasks:

1. Assess the setup and configuration of the meteorological facilities and services, in particular:
 - (a) meteorological observing networks;
 - (b) communication facilities and coordination mechanisms for data transmission and reception on national and regional levels, including the reception of data and products from meteorological and environmental satellites, and if necessary, set up new coordination mechanisms at global and regional levels for meeting future needs;
 - (c) data processing activities and facilities; data utilizations in disaster risk reduction areas;
 - (d) weather forecasting activities and facilities in use; its technical capacity and capabilities;
 - (e) public weather services including all possible forms of communication and dissemination with the public in urban as well as rural and remote areas;
 - (f) early warning systems, including, capacities for:
 - i. monitoring, detection and forecasting of hazards;
 - ii. development of risk information and risk-based warning;
 - iii. communication systems and mechanisms to ensure that warnings reach the authorities in charge of emergency preparedness and plan at local and national levels and at-risk population
 - iv. emergency plans are available and can be activated with the issuance of warnings;
 - v. policies, legislation and institutional coordination, standard operating procedures and roles for agencies involved in the systems;
 - (g) mechanisms, formal and informal agreements, and linkages to authorities at all levels from national to district level, involved in disaster preparedness and early warning;
 - (h) available human resources and competences;
 - (i) the need to put in place proper awareness and education programmes for the emergency response and disaster reduction authorities as well as the public, on the expected impacts of severe weather events and in particular damage due to wind, water and storm surge (for coastal areas); and
 - (j) the need to educate all relevant authorities and the public on the possibility of occurrence of severe events (and their consequent impacts) in areas where such events had not previously occurred.
2. Assess the risks associated with specific contexts of tropical cyclone tracks/intensity, exposure and vulnerability vis-à-vis gaps in meteorological and early warning services.
3. Identify the requirements of the emergency response and disaster reduction authorities for meteorological services in order to provide timely and proper response to severe weather hazards.
4. Trace the flow of information from the observations to warning generation and dissemination as well as the 'last mile' from the local authorities to the communities.
5. Assess the range of meteorological products and services currently provided and the coordination with other relevant authorities responsible for the warning dissemination.
6. Identify the gaps and the corresponding short-term, medium-term and long-term requirements at policy, institutional and human resources levels with the key priorities, including implications for international/regional cooperation and support.

7. Discuss with the government authorities, and other partners/funding institutions, the possible measures to address the priority gaps for the improvement of meteorological and hydrological services as well as early warning.
 8. Submit a mission report to WMO and the Government of Vanuatu with specific recommendations and, as appropriate, a project proposal to address specific aspects identified by the gap analysis.
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Appendix III: First Draft of the Chapter on the Report on Disaster Risk Management and Early Warning System in the Post Disaster Needs Assessment (PDNA) Report

*Tropical Cyclone Pam
Post Disaster Needs Assessment*

Disaster Risk Management

Summary

This section of the Tropical Cyclone Pam Post Disaster Needs Assessment report identifies disaster preparedness and response capacity building recommendations for the consideration of the Government. The recommendations arise out of consultations undertaken with key national, regional and global actors that have been providing support to Vanuatu following the impact of Tropical Cyclone Pam.

The key areas to be addressed are in terms of: strengthening early warning systems; strengthening post disaster assessment, communications capability and information management, and; institutional strengthening and capacity building in disaster management.

The section presents an approach to the implementation of recommendations using established mechanisms such as the National Advisory Board on Climate Change & Disaster Risk Management (NAB). The detailed costing and implementation plan for the approved recommendations would be determined through the NAB-led mechanism.

Introduction

The UNISDR defines the term ‘Disaster Risk Management’ (DRM) as ‘the systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster’ (UNISDR 2009). Such a definition would normally require a comprehensive description of potential disaster risk reduction and disaster management action required to address the impact of disaster events such as Vanuatu has experienced with Tropical Cyclone Pam. However, given limitations in resources and constraints in time, this section of the Post Disaster Needs Assessment report will focus primarily on some of the key challenges and issues that face Vanuatu in terms of its **disaster preparedness and response** capacity. The resultant recommendations address the key challenges and provide a way forward for Vanuatu in these areas.

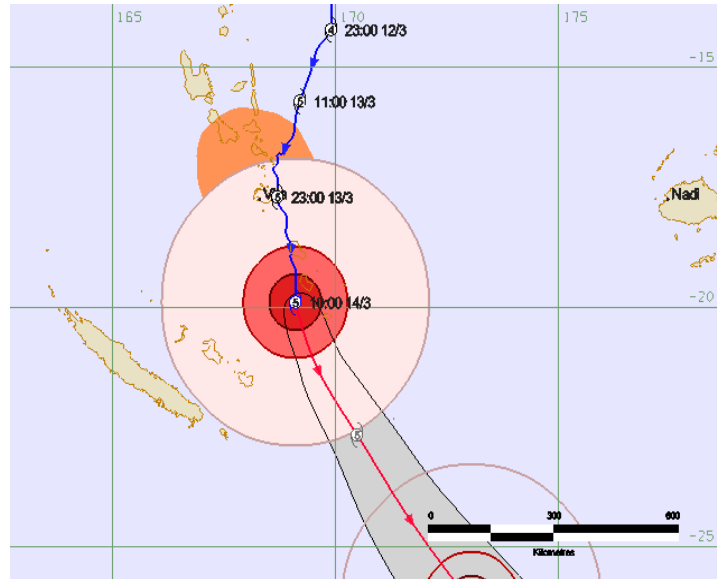
The key issues raised and the related recommendations were drawn from a series of interviews with key stakeholders (Annex 1) held from 9th – 14th April and a workshop conducted on 10th April 2015. Annex 2 includes the workshop agenda and participants list.

Tropical Cyclone Pam

Severe Tropical Cyclone Pam is likely one of the strongest cyclones to make landfall in the Pacific Islands region. A tropical low formed on the 6th of March 2015 near the Solomon Islands, 800 km north of the Torres Group. Favourable conditions allowed the system to develop and intensify, and by the 9th it had reached cyclone strength. The Vanuatu Meteorology and Geo-Hazards Department (VMGD) issued their first notice on Pam on the 10th while Pam was still 600 km northeast of Banks (and still outside of the area of the Vanuatu Tropical Cyclone Map and Vanuatu’s EEZ). The VMGD released their first advisory for Pam at 6pm on the 10th, and at 9am on the 11th the first warning was issued for the Northern Provinces. At this time the maximum sustained winds were estimated to be at 130 km/hr. Pam further intensified to a Category (CAT) 4 system on the 12th and to a CAT 5 on the

13th as it began to move south southwest. The Tropical Cyclone Warning Centre started issuing hourly warnings at this point (from the 3 hour warnings it had been issuing). Pam came within 45 km of Port Vila, Efate at 11pm on the 13th, made landfall on Erromango at 5am on the 14th, and passed within 20 km of Tanna at 8am. At its peak the maximum sustained winds were in excess of 250 km/hr (135 knots).

Analysis track and MTSAT Satellite image from VMGD



Source: VMDG, March 2015

Cyclone History

Vanuatu is located in an area known for frequent occurrence of tropical cyclones with damaging winds, rains and storm surge between the months of October each year to May the following year (PCRAFI Vanuatu Risk Profile, 2011). In the period 1985 to 2014, out of a total of 56 reported hydro meteorological disaster events, 50 were tropical cyclones. The rest comprised flash floods, severe storms and landslides. The cost of these events was reported at over US\$87,000,000 with tropical cyclones accounting for 97% of this amount. (PDalo 2015).

YEAR	NAME	Deaths	Population Affected	Total (USD)
1985	Eric	8	117,500	100,000
1985	Nigel	6	117,500	1,000,000
1985	Odette			10,000
1986	Patsy			100,000
1986	Keli			100,000
1986	Alfred			
1986	Lusi			100,000
1987	Uma	48	48,000	25,000,000
1988	Agi		5,000	500,000
1988	Anne		5,000	500,000
1988	Bola		47,000	5,000,000
1988	Dovi			10,000
1989	Ivy			100,000
1991	Tia		1,000	
1991	Lisa			
1992	Betsy	1	8,000	2,000,000
1992	Esau			

YEAR	NAME	Deaths	Population Affected	Total (USD)
1992	Daman			
1992	Fran		1,150	1,000,000
1992	Innis			
1993	Prema	1	20,000	5,000,000
1994	Sarah			500,000
1994	Vania			
1994	Theodore			
1994	Usha			
1995	Gail			
1996	Fergus			
1996	Beti			41,000
1997	Nute			
1997	Gavin			23,500,000
1998	Katrina	1		
1998	Yali		9,000	6,000,000
1998	Zuman		8,000	6,000,000
1999	Dani	2	100,000	3,000,000
1999	Ela	5	28,600	
2000	Jo			
2000	Iris			
2001	Paula	1	9,000	
2001	Sose	1	800	
2004	Ivy	1	54,000	8,000,000
2005	Kerry			
2006	Yani			
2007	Becky			
2008	Funa			
2008	Gene		578	
2010	Ului		2,821	
2011	Yasi	1	13	
2011	Atu		32,000	
2012	Jasmine		32,540	
2014	Lusi	10		
Total				87,561,000

Source: PDalo 2015

The costs shown are in nominal terms. Indexed to 2012 the value of the damage is estimated to be more than US\$143,000,000. (PDalo 2015).

Damage costs report for tropical cyclones far outweigh the damage costs reported for geological hazards such as earthquakes, volcano and tsunamis. For the period 1983 – 2013 the reported cost of damage for earthquakes was just on US\$14,000,000.(PDalo 2014). It should nevertheless be noted that efforts to cost disasters in Vanuatu in this period had not been made for all events. Only 22 of the 50 events reported as occurring between 1985 and 2014 were costed, with not one of the 10 events happening between 2015 and 2014 being costed according to regional records (Table). This means that the historical cost of disasters in Vanuatu is considerably underestimated.

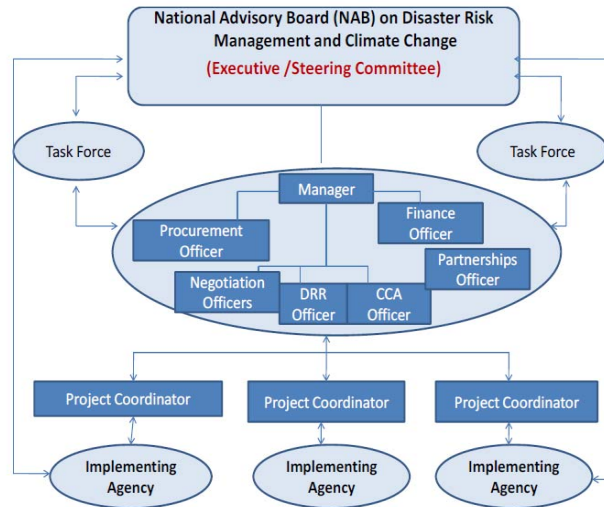
National DRM Arrangements

The National Disaster Act (Cap 276) of 2000 sets out the umbrella national arrangements for the management of disaster arising from natural and other hazards. Following the promulgation of the Act and consistent with the provisions of section 9, the National Disaster Management Office (NDMO) developed in consultation with stakeholders draft National DRM Arrangements (National Disaster Plan) in 2008. In 2012, the Vanuatu Humanitarian Team (VHT) was established as a formal mechanism to support the NDMO with disaster preparedness and response. The VHT has been a very

active part of the DRM landscape and has helped to galvanise NGOs and civil society in support of national arrangements. In January 2013 the Standard Operating Procedures (SOPs) for the functions of the NDMO were published.

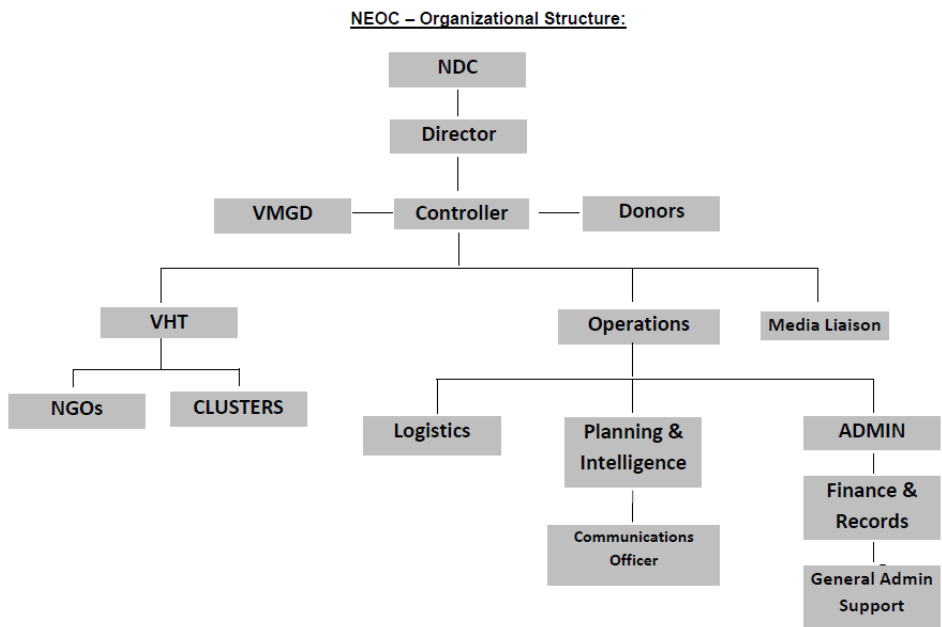
The following diagramme illustrates the linkages between key components of the national DRM apparatus as prescribed under the NDMO Standard Operating Procedures. There is a structure in place to support preparedness activities which demonstrates overall guidance by the NAB. A second set of arrangements illustrates the apparatus that is to be used to guide disaster response and recovery activities.

Preparedness Structure

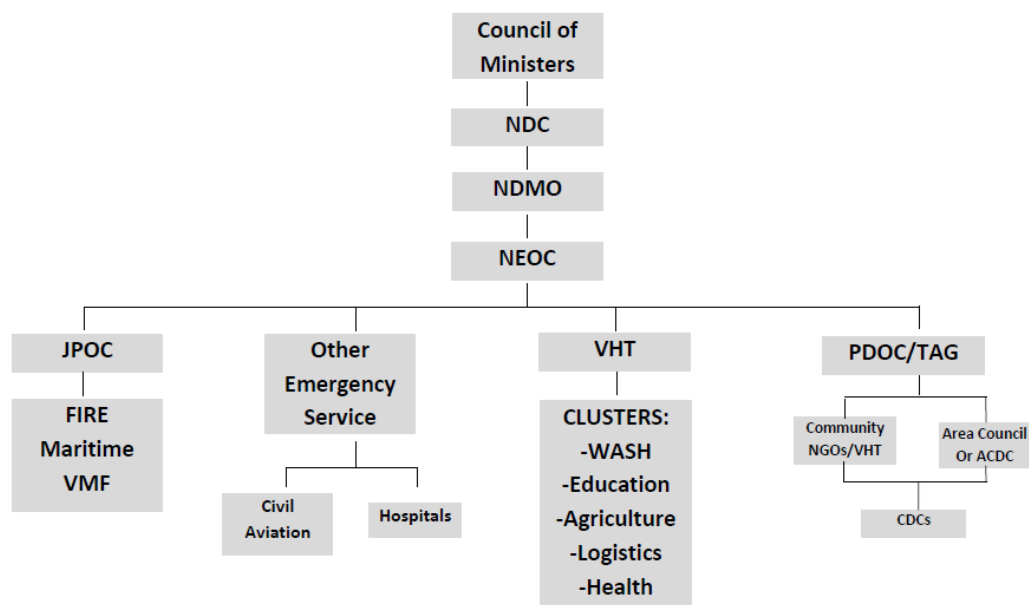


Source: NDMO Standard Operating Procedures, 2013

Response and Recovery (under the National Disaster Committee or NDC)



National Disaster Organizational Structure:



Source: NDMO Standard Operating Procedures, 2013

The above arrangements, as intimated above, are reflective of the dynamic evolution of DRM in Vanuatu. A number of aspects are however not consistent with the National Disaster Act in 2000 (NDA). It is therefore imperative that a comprehensive review of the NDA needs to be undertaken. This would facilitate the inclusion in an amended NDA of, for example, the Vanuatu Humanitarian Team, Humanitarian Response Clusters and the National Advisory Board on Climate Change and DRM.

The review should result in a platform that enables Vanuatu to more meaningfully strengthen the overall practice of DRM and also take into account strategic developments taking place at the national and regional levels. The development of a National Climate Change and Disaster Risk Reduction policy (currently on-going) is a significant initiative which will have some bearing on the future scope of a revised NDA. Some regional level initiatives are pertinent to strengthened approaches in DRM in Vanuatu in the future such as the Strategy for Climate and Disaster Resilient Development in the Pacific which advocates a greater emphasis on climate and disaster risk in the context of sustainable and resilient development; the on-going strengthening of the Cluster system of the Pacific Humanitarian Team, and; the emphasis on strengthening interoperability between key response agencies as being pursued by the Pacific Islands Emergency Management Alliance of which Vanuatu is a founding member.

The various challenges highlighted as part of the post Tropical Cyclone (TC) Pam operational response are captured in a sub section below. These have been combined with observations made independent of and prior to TC Pam which need to be taken into account in addressing DRM more effectively in Vanuatu.

An important element of Vanuatu's preparedness capability is represented by the elements of its early warning system (EWS). At a national level early warning is the overall responsibility of the Vanuatu Meteorological and Geohazards Department (VMGD). The following sub section highlights some of the key issues that arose following TC Pam

Early Warning System

The VMGD is responsible for providing warnings for severe weather, tropical cyclones, high seas, tsunamis, and other meteorological and geohazards within the area of 12°S to 23°S and 160°E to

175°E (roughly Vanuatu's territorial waters). In the case of a cyclone the VMGD uses a 4-tiered warning system for when a system enters Vanuatu's warning area and is a threat to any of their islands. Initially an **Information Bulletin** is released with details on the formation of a tropical low or cyclone that is not yet considered a threat. This bulletin is issued twice a day with information on position, intensity and distance from the nearest island, and a 48 hour forecast track. **Advisories** are issued at least 36 hours before the likely onset of gale force winds, and are issued every 6 hours until either a warning is necessary or the threat subsides. A **Cyclone Warning** is issued when gale, storm, or hurricane winds are expected to affect any islands within 24hrs, and warnings are issued every 3 hours. **Flash Warnings** are issued when there is a sudden and substantial change in a cyclone system which would invalidate the current warning. All advisories and warnings are issued after consultation with the Disaster Management Office (to determine the severity of the warning). Warnings consist of high wind advisories, sea state, flood advisories, and the timings and threat levels to specific islands/provinces.

For Severe Tropical Cyclone Pam the first information bulletin was issued on the 10th of March 2015 when the system was 600 km northeast of the Banks Group. An advisory was issued later on the 10th, and on the morning of the 11th the first warning was issued for the Northern provinces. As Pam further intensified and approached Malampa, Penama, and the Shepherds Group warnings were issued every hour. Even though Pam passed very close to Efate and caused extensive damage to the VMGD building warnings continued without interruption. Overall, 1 information bulletin, 3 advisories, 48 forecast track maps, 47 warnings, and 38 SMS warning messages were issued.

Experiences and Lessons Learned

In the face of the severe conditions imposed by one of the strongest cyclones ever recorded in the Pacific Islands, the VMGD was able to keep the public current on the progress of Pam and the dangers they faced. While 11 people were killed during the storm, much greater loss of life was likely prevented due to the timely and accurate warnings that were provided. The VMGD forecast unit benefited from their close proximity to the NDMO (they share the same building). As Pam approached SMS, phone calls, HF radio, and internet communications were used to transmit warnings. The cellular towers and HF radio antennas went down early on, but warnings were still sent over the internet. This demonstrates the importance of having a range of communications options. As of 10th April communications were still down in the hardest hit areas, thus there is a need for backup communications and spare parts for the HF radio network (a widely used communications option that can be repaired relatively quickly). One concern that was voiced was that the warnings could have been issued earlier (before Pam entered Vanuatu's territorial waters). However, there are legal challenges to this, as the VMGD is only responsible for Vanuatu's EEZ. This is not a problem that is unique to Vanuatu, but is faced by the Pacific Islands region as a whole. Another issue faced by VMGD (and not unique to the region) was caused by a combination of people turning to unreliable sources (including some that predicted that Pam would arrive 3 days later than it did), and members of the public who were hesitant to heed warnings.

Damage

Overall damage to infrastructure and equipment sustained by the VMGD are estimated at US\$1,124,000 (draft report compiled by VMDG, April 2015). Damage estimates will be revised as further information is received from the assessments being undertaken of infrastructure by Public Works.

Positive Results of Current Arrangements

Some of the good practices that were noted in relation to the DRM arrangements for TC Pam were:

- The existence of a working system of coordination that linked the national, provincial and community level. At the national level the National Disaster Committee provides overall

direction for DRM and this is mirrored at the provincial level by Provincial Disaster Committees who are in turn supported by Community Disaster Committees⁹

- A functional and dynamic national humanitarian cluster mechanism (Logistics, Education, Health & Nutrition, Agriculture & Food Security and WASH and Protection & Gender) bringing together NGOs and civil society under the banner of the VHT in support of the Governments preparedness/response efforts and providing complementarity to the global/regional cluster system. During the response new cluster groups were established and responsibilities were re-assigned (e.g. the Gender working group was given responsibility for shelters) based on needs that arose. Following the experiences of the TC Pam response an economic recovery cluster/working group is being considered. Further, the clusters were all working within the environs of the NDMO and this assisted coordination.
- Introduction of innovative practices by humanitarian clusters. For example the Food Security & Agriculture Cluster introduced 'fresh food' initiatives that facilitated the domestic supply of crops/planting material and fish between Santo and Port Vila
- Recognition of the need to effectively manage internally displaced persons.
- The training and related capacity building undertaken at national and provincial level has assisted somewhat in getting communities prepared. According to the NDMO seventy per cent of provinces have, for example, received training in Initial Damage Assessment methodology and templates. For the future this can be built upon to streamline initial assessments following disaster events resulting in a quicker turn-around of relief supplies to remote communities.
- International support was abundant in the early stages of the response and the presence of military assets through the governments of Australia, New Zealand, France, Fiji, Solomon Islands and Tonga were of significant value in terms of post disaster assessments, the distribution of relief and early recovery measures such as the repair of schools and augmenting health services in the islands.
- The national early warning system established and managed by VMDG issued warnings regularly using a range of media. Advisories were issued to the public every 6 hours and warnings at 3-hour and hourly intervals through SMS, the internet and through HF radios. Communities that lost main communications were informed via HF located in rural centres.
- Ongoing educational and awareness on national radio and media for the past 2 years contributed to a greater level of awareness and preparedness by the community. The number of fatalities attributed to TC Pam was only 11 and could have been greater.
- The support of the Port Vila municipality in the response effort through the cleanup of the municipal areas and distribution of relief supplies.
- In terms of logistics the international customs clearances, and identification of common storage locations were addressed at a very early stage of operations.
- There was a significant level of private sector support to the response through agencies such as airlines (Fiji Airways, Air Vanuatu), local stevedoring services (free heavy haulage & warehousing), local businesses such as Au Bon Marche (free logistics supporting food distribution) and Asco Motors (donation of vehicles to support logistics) as well Yacht Aid Global (super yachts)

Key Issues & Challenges

The key issues and challenges to effective DRM arising out of the experience of TC Pam are significant as follows:

Early Warning System

- (i) Early warning advisories should not be constrained by the legislation and protocols governing the VMDG. It was noted that the VMDG is only legally capable of issuing warning once the cyclone had crossed into Vanuatu territorial boundaries. This potentially deprives communities of invaluable advisories and VMDG must work with the NDMO to find a solution.

⁹ Community Disaster Committees are yet to be established across all communities in Vanuatu

- (ii) Most vulnerable members of society didn't receive warnings and the response machinery is generally not set up to deal with them especially people with disability.

Assessments

- (i) In terms of initial assessments, it was apparent that language barriers and the sensitivity of some of the questions (e.g. in terms of protection issues pertaining to women and children) prolonged survey interviews as more time was required to fully explain the intent of such questions. In turn, this created additional challenges when enumerators were not fully conversant with the assessment rationale. Some consideration needs to be given to addressing these issues in responses to future events.
- (ii) The use of a variety of assessment templates by teams rather than those developed by the NDMO in consultation with stakeholders prior to the event.

Communications and Information Management

- (i) Communication remains a challenge. Communication from the national to provincial and community level was problematic in the immediate post impact period.
- (ii) The flow of information between clusters and the central coordination apparatus and the community needs to be improved.

Governance

- (i) It was noted that the NDMO staff were unable to perform effectively in their assigned roles due, in some part, to the massive influx of external humanitarian personnel in the National Emergency Operations Centre. A further part of the challenge is that the current established national operational system is not consistent with developments that have taken place e.g. the cluster system and the need to strengthen interoperability between key response agencies. Given that the NDA is not reflective of the developments in DRM since 2000 a comprehensive review of the national arrangements is required and a new system introduced.

Operational Effectiveness

- (i) The introduction of an additional mechanism (central agency unit) to manage the response to TC Pam required an adjustment in the established system and reporting/accountability lines needed clarification.
- (ii) Heavy reliance on external assistance raises questions on the capability of national agency resources and gives rise to a need for more innovative approaches to preparedness and response.
- (iii) The apparent duplication of roles in some areas. For example, while a Logistics cluster is in existence, the National Emergency Operations Centre (NEOC) also provides for a Logistics role (amongst others) and clarity needs to be provided in terms of the scope of responsibility of each.
- (iv) There is a lack of understanding of operational protocols. Standard Operating Procedures should be documented and the relevant personnel need to be trained in them.
- (v) Lack of a monitoring and evaluation system to enable the NDMO to provide feedback to the Government on the effectiveness of operations.
- (vi) The timely movement of relief supplies were hindered by logistics that were at times uncoordinated. There were limited resources available to move supplies around where and when they were needed. This was a challenge particularly at some provincial locations.
- (vii) In terms of assisting communities with early recovery the process of distributing seedlings needs to be improved including the formulae for calculating distribution to households as this was not defined.
- (viii) The lack of appropriate dress and equipment put those involved in assessments and relief distribution at risk of injury
- (ix) Ensuring that the Cluster system took into account the needs of the most vulnerable in terms of the focus of the work and wherever possible the representation. It was noted that the Protection cluster did not have representation from the group(s) representing the disabled.
- (x) Government and other organisations do not have business continuity plans to enable them to function effectively in the immediate post disaster period.
- (xi) Limited operational coordination and tasking between the NEOC and the Police Joint Planning Operational Centre.

- (xii) The NDMO was storing and distributing relief items and this should not need be the case as there is a need to have a single logistics setup.
- (xiii) Need to improve messaging to the public to provide clarity about the purpose of relief items. For example, the initial 15-day food ration distribution was intended to supplement and not replace local food sources.

Lack of Public Experience with Cat 5 Cyclones

- (i) Although preparedness is an on-going activity supported by the NDMO and other organisations, the majority of the population had not experienced a large cyclone and so could not fully anticipate potential impact. The last major cyclone of widespread impact was TCs Eric and Nigel in 1985 which was assessed to have impacted 117,500 people at that time (PDalo 2015). Based on statistics provided by the Vanuatu National Statistics Office, of the overall population of approximately 270,000 (VNSO March 2015), only 23% (adults over 30) would have some recollection of the impact of TCs Eric and Nigel.

Human Resources Development

- (i) The need for more training and awareness across Government and for the wider community of the approved system(s) of disaster/emergency response to facilitate greater understanding of roles and responsibilities of structures and key personnel thus supporting a more streamlined and coordinated approach in the future.
- (ii) Training of NDMO staff, personnel of other agencies and other stakeholders need to focus on developing competencies in terms of the various roles that exist in relation to preparedness for emergency response. Generalist training on DRM is inadequate to properly prepare individuals for the roles they are expected to perform.

Traditional Coping Capacity

- (i) There is a concern that the availability of food relief following events may create a sense of dependency and thus less reliance on traditional food preservation which can sustain especially rural communities following cyclones.

Building Code

- (i) The resilience of buildings and infrastructure to withstand Category 5 force winds requires a more serious consideration of the development, implementation and enforcement of a national building code.

Emergency Shelter

- (i) There are no purpose-built emergency shelters with the public sheltering in public building such as schools and community halls. Given resource constraints attempts must be made at minimum to retrofit designated shelters to cyclone standard.

Recommendations

Taking into consideration the practices that worked well during the response to TC Pam and the key issues and challenges that arose, a series of recommendations has been developed to address these. The recommendations are shown in terms of:

- Short Term: to be implemented within 6 to 12 months
- Medium Term: to be implemented between 1 – 2 years
- Long Term: to be implemented between 2 – 5 years

The recommendations are categorised under a series of strategic themes as follows:

1. Early Warning System
2. Assessments, Communication & Information Management
3. Institutional Strengthening & Capacity Building

Early Warning System

Short Term

- Restore key observations capacity – namely aviation weather and RBSN synoptic stations and key geo-hazard stations
- Restore communications to all observations stations
- Document EWS experiences and lessons learned
- Evaluate options to ensure backup communications are available at all observation stations (backup RF radio equipment, access to backup communication stations if observation station is not the emergency communications centre)
- Review media communications protocols, work with forecasters and media to ensure effective communications (currently planned by SPREP/FINPAC project)
- Salvage and digitize paper records such as those stored at the Bauerfield observation station.

Medium Term

- Restore full operations to all VMGD buildings and equipment
- Review EWS SOP and collaboration with other agencies
- Ensure that observation stations have backup power and communications equipment
- Expand cyclone warnings area beyond EEZ
- Review EWS lessons learned, implement necessary changes
- Train VMGD staff to assist NDMO and NEOC during emergencies
- Improved forecasting/visualization software (such as SmartMet) to improve uptake and ease of forecast generation.

Long Term

- Review EWS lessons learned in a regional context, evaluate strength, weaknesses, opportunities, threats (SWOT analysis) regionally

Assessments, Communication & Information Management

Short Term

- Strengthen the assessment process to more comprehensively cover immediate relief needs at the community level, especially to include the needs of the most vulnerable groups such as women, children the elderly and disabled.
- Streamline the flow of assessment data to enable through analysis and timely decision making for response and early recovery
- Strengthen the information management system to allow for standardised compilation of survey data and a faster turnaround time of information compiled during assessments.
- Review the information management setup in the NEOC including the use of information technology.
- Develop an inventory of communication infrastructure that is functional and a directory of communication services/channels that can be used during emergencies.

Medium Term

- Develop a centralised information system, building on existing databases such as those maintained by the VNSO and others like the Pacific Risk Information System maintained by SPC, to capture all relevant data and information to support post disaster assessment and subsequent relief, early and long term recovery. Such data should include sex disaggregated and identify those living with disability.
- Clearly establish communication protocols and ensure personnel of the relevant agencies and organisations at national and provincial level are fully trained to manage communications in the period before and after disaster events.
- Establish an improved layout for the NEOC to allow for the use of a standardised incident management system that can then be mirrored at sub national levels as and when appropriate.

Long Term

- Develop and resource a maintenance plan for communications infrastructure

Institutional Strengthening & Capacity Building

Short Term

- Undertake a comprehensive 'lessons learned' exercise within 1 month following major events and ensure that the resultant recommendations which are approved by the Government are implemented.
- Reallocate resources to provinces including staffing to support Provincial Disaster Committees
- Strengthen the involvement of traditional chiefs in the disaster preparedness and response activities.
- Increase the awareness and practice of traditional coping mechanisms to help build community resilience and lessen dependency on organised food relief following disasters
- Ensure gender balance and inclusiveness of people with disabilities in committees
- Review current SOPs to improve Interoperability amongst clusters based on experiences and lessons learned.
- Improve agency understanding of roles and responsibilities for preparedness, response and early recovery phases of a disaster.
- Consider revising processes and roles for monitoring relief distribution at national and provincial level
- Review NDMO and NEOC layout with a view to providing ample space for NEOC operational functions, cluster liaison and cluster teams.
- Review and update NDMO Standard Operating Procedures and re-train NDMO and VMDG staff in the management of the NEOC.
- Develop and implement the training of NDMO personnel and related agencies in specialist NEOC roles such as Logistics, Planning, Communications
- Update SOPs for collaboration between the NDMO and the Police Joint Planning Operational Centre and undertake regular training and exercising in order that the Police can better support emergency operations.

Medium Term

- Undertake a comprehensive review of the current DRM arrangements to *inter alia*:
 - i. Streamline and strengthen links and operational relationships between the national mechanisms, for example the National Disaster Committee, NDMO, national Cluster system, National Advisory Board for Climate Change & DRM and regional/international humanitarian and development community
 - ii. Develop and strengthen the alignment and relationships between key emergency service organisations such as the NDMO and Fire Services currently under the Vanuatu Mobile Force.
 - iii. Strengthen relationships between the Government and regional and international humanitarian community through the NDMO, Vanuatu Humanitarian Team and established clusters and ensure clarity in the roles of each stakeholder group.
 - iv. Strengthen information management between all parts of the emergency management apparatus.
 - v. Institute the formal establishment of a national emergency services volunteer scheme that will augment capacities at national and provincial level for disaster preparedness and response
 - vi. Introduce a competency based system of training in order to strengthen the performance of individuals in designated roles at the national and provincial level
 - vii. Strengthen the conduct of initial damage assessments and follow-up comprehensive damage and loss assessments through the use of relevant methodologies in partnership with stakeholders
 - viii. Strengthen community participation in all facets of DRM and provide greater and more meaningful recognition to the contribution of the most vulnerable groups including women, children, the elderly and people with disability.
 - ix. Develop new legislation to support a more relevant and flexible system of DRM arrangements.

Long Term

- Develop, implement and enforce a national building code.

- Strengthen Police capability in maritime search and rescue

Implementation

In order to ensure the implementation of the above recommendations, (subject to the approval of the Government), the following outlines an approach for an integrated programme of capacity building.

1. **Formation of a Steering Group** - to guide the implementation programme. Such a group should be a sub-committee of the National Advisory Board on Climate Change and DRM (NAB). This will help to ensure the consistency and complementarity of planned activities with existing DRM initiatives currently underway.
2. **Communications Strategy** - the development of a communications (or public relations) strategy to clearly indicate to the public and wider stakeholder community the Government's intentions to bring about improvements in the overall system of DRM in the wake of TC Pam. Such a strategy should ensure on-going publicity in relation to the various institutional strengthening and capacity building interventions and facilitate feedback in order to strengthen ownership of the impending changes amongst the members of the community.
3. **Implementation Plan & Monitoring and Evaluation Framework** – under the guidance of the Steering Group a core team of relevant Government officials and representative of selected partner organisations, develop detailed plan to implement approved recommendations. Part of the process of developing the implementation plan will involve mapping of proposed interventions against existing/funded initiatives. This will provide the Government a realistic indication of the costs related to the capacity building exercise.
Linked to the implementation plan, a monitoring and evaluation framework should be set in place for capacity building programme. Ideally this will use the system already established by the Government through the NAB.
4. **Donor/Partner Liaison** – to galvanise support for implementation. Preliminary indications are positive of partner interest and support on this front. For example, the EDF10 ACP-EU project: Building Safety & Resilience in the Pacific managed by the Secretariat of the Pacific Community and the Pacific Risk Resilience Programme supported by the UNDP are keen to explore opportunities to facilitate their support.

Appendix IV: Programme of the Mission

Day	Description of Activities
Monday, 20 April	Meeting with Mr David Gibson, Acting Director of the VMGD.
	Meeting with Mr Shadreck Welegtabit, Director of the NDMO.
	Meeting with Mr Charles Bernimolin, Representative of UNOCHA.
	Meeting with staff of the VBTC.
	Review and submission of the updated draft of the DRM/EWS Chapter for the PDNA report.
Tuesday, 21 April	Meeting with the Hon. Minister James Bule, Minister for Climate Change, Meteorology, Geo-hazard, Environment, Energy and Disaster Management
	Meeting with a community at Black Sand area on the suburb of the capital Port Vila.
	Assessment of selected coastal areas impacted by storm surges.
	Review and submission of the updated draft of the DRM/EWS Chapter for the PDNA report.
Wednesday, 22 April	Discussion using the SWOT analysis technique.
	Discussions with VMGD's staff.
	Discussions with the members of JICA Expert Team.
	Review and submission of the final draft of the DRM/EWS Chapter for the PDNA report
Thursday, 23 April	Writing of the report.
	Discussions with VMGD's staff.
Friday, 24 April	Writing of the report (continued)
	Presentation of the zero-draft mission report to VMGD.

Appendix V: List of Persons Consulted

Name	Designation	Contact
Ministry of Climate Change, Meteorology, Geo-hazard, Environment, Energy and Disaster Management (MCMGEED)		
Hon. Minister James Bule	Minister	bjames@vanuatu.gov.vu
Mr Noel Lango	First Political Advisor to the Minister	nlango@vanuatu.gov.vu
Mr Jotham Napat	Director-General and Permanent Representative of Vanuatu with WMO	jnapat@vanuatu.gov.vu
Vanuatu Meteorology and Geo-Hazard Department (VMGD)		
Mr David Gibson	Acting Director	dgibson@meteo.gov.vu
Ms Esline Garaebiti	Manager, Geo-hazard Division	gesline@vanuatu.gov.vu
Mr Fred Jockley	Manager, Weather Forecasting Division	fjockley@mete.gov.vu
Mr Philip Malsal	Manager, Climate Division	pmalsal@meteo.gov.vu
Ms Patricia Mawa	Manager, Information Communication Technology and Engineering	patou@meteo.gov.vu
Mr Allan Rarai	Principal Scientific Office, Weather Forecasting Division	ararai@meteo.gov.vu
Mr Abel Kalo	Weather Forecaster	akalo@meteo.gov.vu
Mr Ian Nelson	Weather Forecaster	inelson@meteo.gov.vu
Mr Timothy Jerry	Weather Forecaster	jtimothy@meteo.gov.vu
Mr Tom Natic	Weather Forecaster	jnatic@meteo.gov.vu
National Disaster Management Office (NDMO)		
Mr Shadreck Welegtabit	Director	swelegtabit@vanuatu.gov.vu
Vanuatu Broadcasting and Television Broadcasting Corporation (VBTC)		
Mr Fred Vurobaravo	General Manager	gm@vbtc.vu
Mr Waren Robert	Manager, Department of Technical Services	
Ms Olivia Finau	Manager, Department News Production	
United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA)		
Mr Charles Bernimolin	Coordinator, Tropical Cyclone Pam Coordination and Humanitarian	bernimoli@un.org
Japan International Cooperation Agency (JICA)		
Mr Koji Kuroiwa	Chief Advisor	Koji.cyclone@gmail.com
Mr Sanjiva Nand Sharma		Sanjiva.nand@met.gov.fj
Secretariat of the Pacific Community (SPC)		
Mr Shohei Matsuura	JICA Expert /Disaster Risk Reduction Advisor for the Pacific Region Disaster Reduction Programme	shoheim@spc.int
Ms Litea Biukoto	Senior Advisor Risk Reduction for the Pacific Region Disaster Reduction Programme	liteab@spc.int
Black Sand Community Leaders		
Mr Silas Namataki	Chief	
Mr Latika Silas	Chief	

Appendix VI: Analysis Track Data of Tropical Cyclone “Pam” and Observations

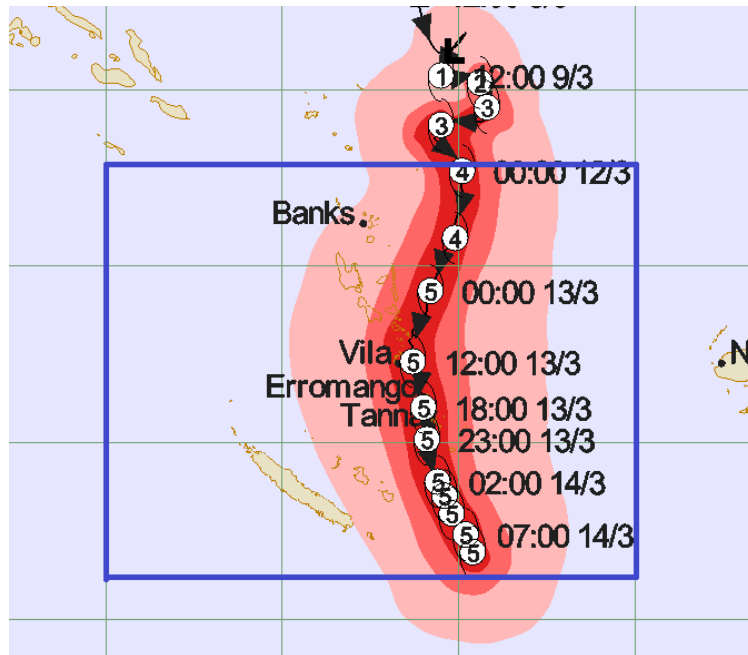


Figure 1: Analysis Track of Tropical Cyclone “Pam” and the horizontal extent of gale, storm and hurricane force winds (in UTC)

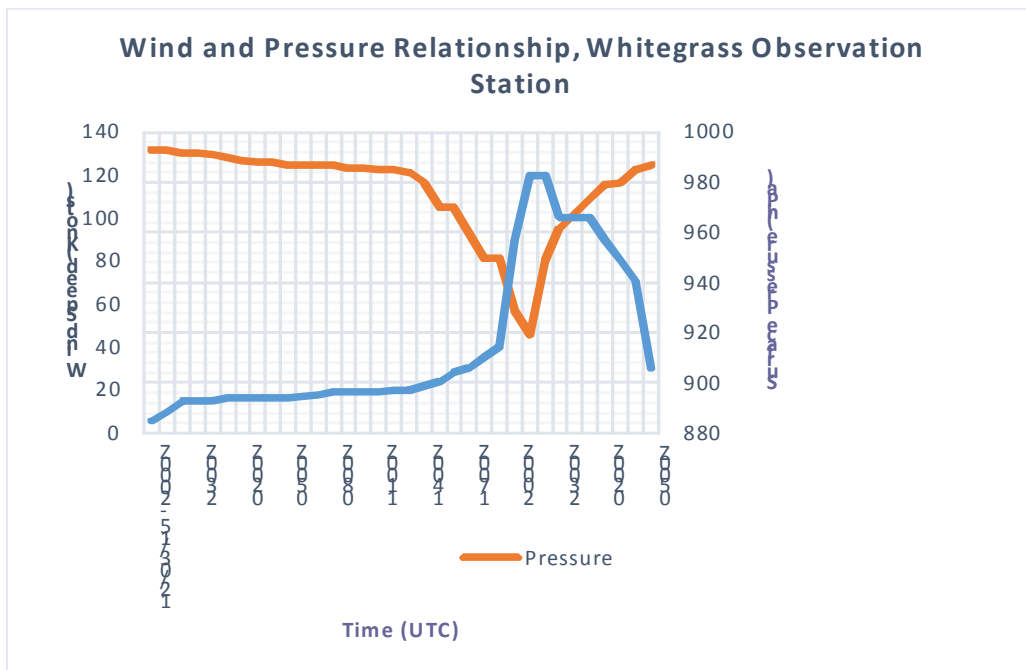










Figure 2: Graph of observations received from Whitegrass Station on the island of Tanna
Note: Maximum winds recorded = ~125 knots
Minimum pressure recorded = 919 hPa

Appendix VII: List of VMGD Headquarters Building, Facilities and Observing Stations Damaged by Tropical Cyclone “Pam”






Table 1: Damages to the VMGD Headquarters Building and Weather Stations





ITEM	DAMAGE	MAINTENANCE REQUIRED
<p>Steel roof cover</p> 	75%	<p>Replace all existing timber frame with steel frame and new CI sheeting screwed and rivet. Fix new steel flashing cover</p> <p>430 M² of roof cover</p>
<p>Soffit cover</p> 	20%	Replace where soffit covers are opened.
<p>Window glazing</p> 	5%	Replace one broken glazing to match existing 1.4M x 1.0M
<p>Aluminum railing</p> 	50%	<p>Replace damaged rail on south side</p> <p>25 Meters length</p>

<p>Security Door Lockset</p> 	<p>Not Functioning</p>	<p>Replacement required 4 no required</p>
<p>Roof Top exit Doors</p> 	<p>Not functioning</p>	<p>Require hardwood panel doors</p>
	<p>80% damage to the upper are facilities</p>	<p>Require new roofing and equipment</p>
	<p>60% damages to weather station office at Bauerfield airport</p>	<p>Require repair</p>

	<p>Damage to Stevenson screen</p>	<p>Require new Stevenson screen</p>
	<p>Damage to HF radio system tower</p>	<p>Require new tower</p>
	<p>Damage to upper air synoptic station building</p>	<p>Require repair</p>

Table 2: Damages to VMGD Geo-hazard (Seismic) Observation Stations

Name of the Station	Location	Details of Assessment	Photos	Recommendations
AMB1	Ambrym 16°16'58.60"S 168°7'24.70"E	Solar Panels are broken and electronic equipment are damaged		Replacement of Solar Panel, electronic and batteries required. Need reparation materials as well
WAMB	Ambrym	Solar panels were broken and Radio system is dead	(No picture available)	Requires new radio and Solar power System
RELAY MANTOWER	Ambrym 16°18'26.30"S 168°7'11.00"E	Radio transmission is broken. Tower is down	(No picture available)	Replace with new radios. Need tower reinforcement
PAAMA RELAY	Paama 16°27'8.29"S 168°14'37.67"E	Solar Panels are broken and electronic equipment are damaged		Requires new radio, new Solar power System and new webcam. Need tower reinforcement
LPV	Lopevi 16°30'46.00"S 168°19'18.00"E	Solar Panels are broken and electronic equipment are destroyed. Radio system is dead		Requires new radio and Solar power System. Need new shed
LONIALU TOWER	Tanna 19°29'51.4"S 169°22'40.3"E	The radio transmission card is faulty		Need to replace with new Radio
YASH	Tanna 19°30'51.50"S 169°26'29.10"E	Solar Panels are broken and electronic equipment are damaged. Radio system is dead		Requires new radio and Solar power System. Need repair materials

YAS	Tanna 19°31'32.00"S 169°27'7.00"E	Solar panels and radio system are smashed. Electronic equipment is destroyed		Requires new radio and Solar power System. Scientific equipment has to be replaced. Required new shed
RTV	Efate 17°47'18.17"S 168°25'50.27"E	The transmission system is faulty		Need to replace with new radio
CAMYASUR	Tanna 19°31'53.9"S 169°26'51.4"E	Solar power system, radios and webcam are broken and lost		Build new webcam station with new radio system. Required new shed
DVP	Efate 17°43'20.47"S 168°11'28.05"E	Solar Panel and radio system need to be replace		It needs new Solar panel and new transmission system. Need reparation materials as well

Appendix VIII: Networks and the Information Flow of Synoptic Weather Data

Vanuatu's primary synoptic observation network consists of seven remote observation stations. The frequency of reporting synopsis is three hourly via HF radio. The reporting frequency may increase during severe weather events.

JICA is presently installing two AWSs. They are located at Bauerfield international airport on the island of Efate and Pekoa international airport on the island of Santo to enhance the manual observations. Provision to add AWSs to the remaining five synoptic sites should be considered.

Communications infrastructure is available within Vanuatu that would allow for alternate communications methods, such as cellular. AWS data communications could also be made more reliable by installing a satellite unit, such as a Broadband Global Area Network (BGAN), to report synoptic data in the event of cellular network congestion or failure.

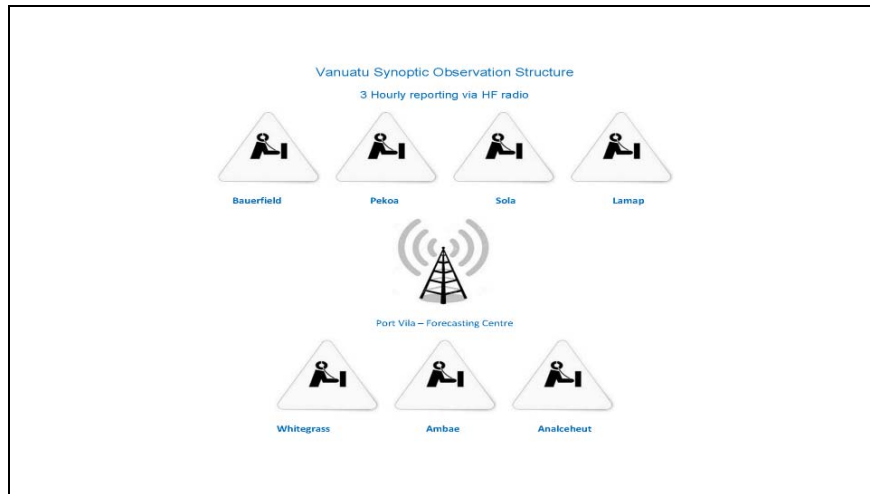


Figure 1: Synoptic Weather Observation Structure - April 2015

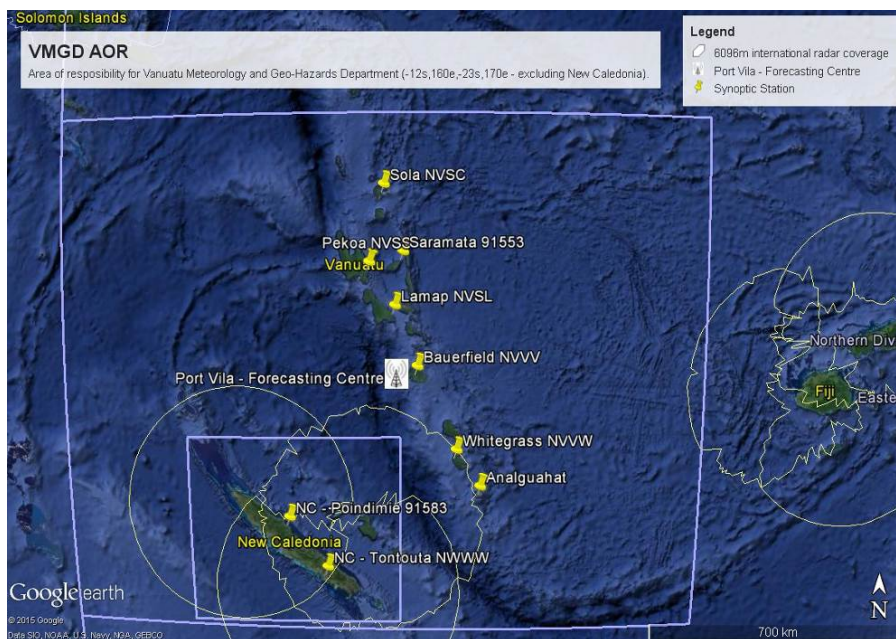
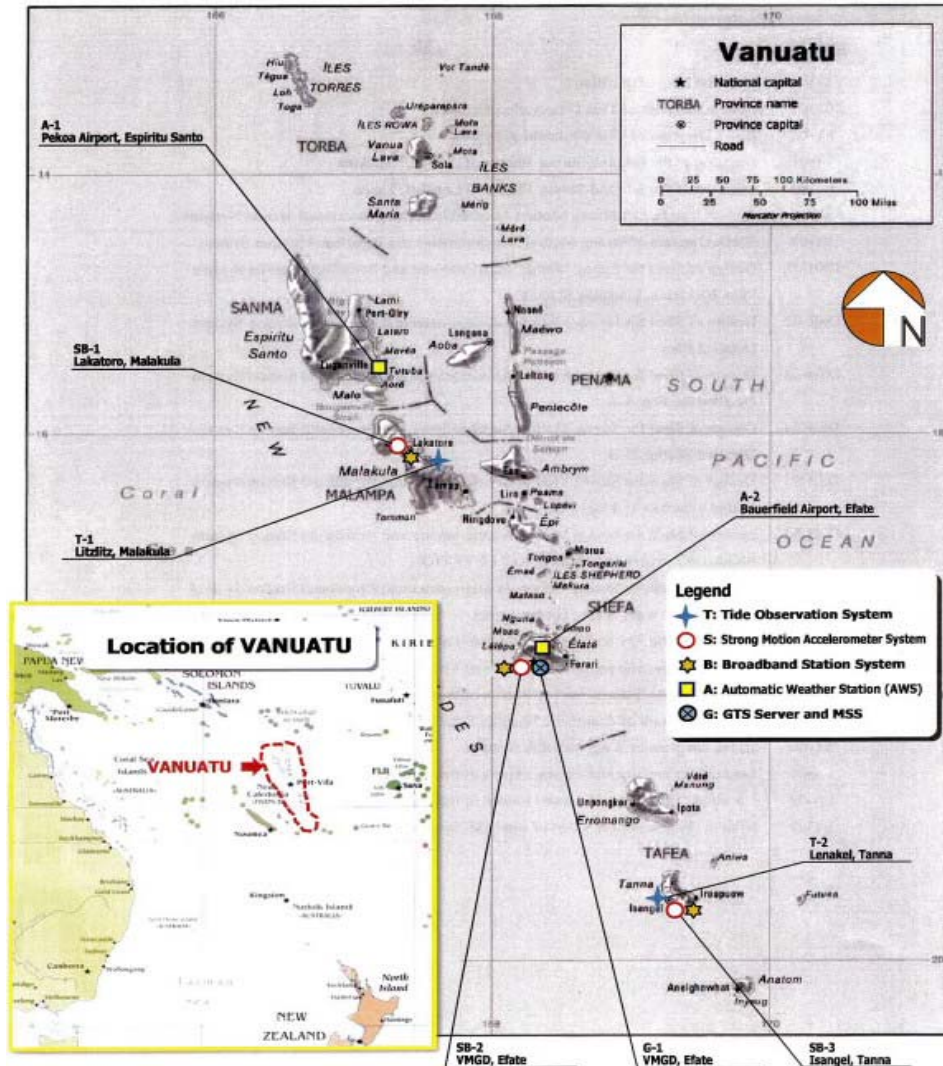


Figure 2: VMGD Synoptic Weather Observation Network

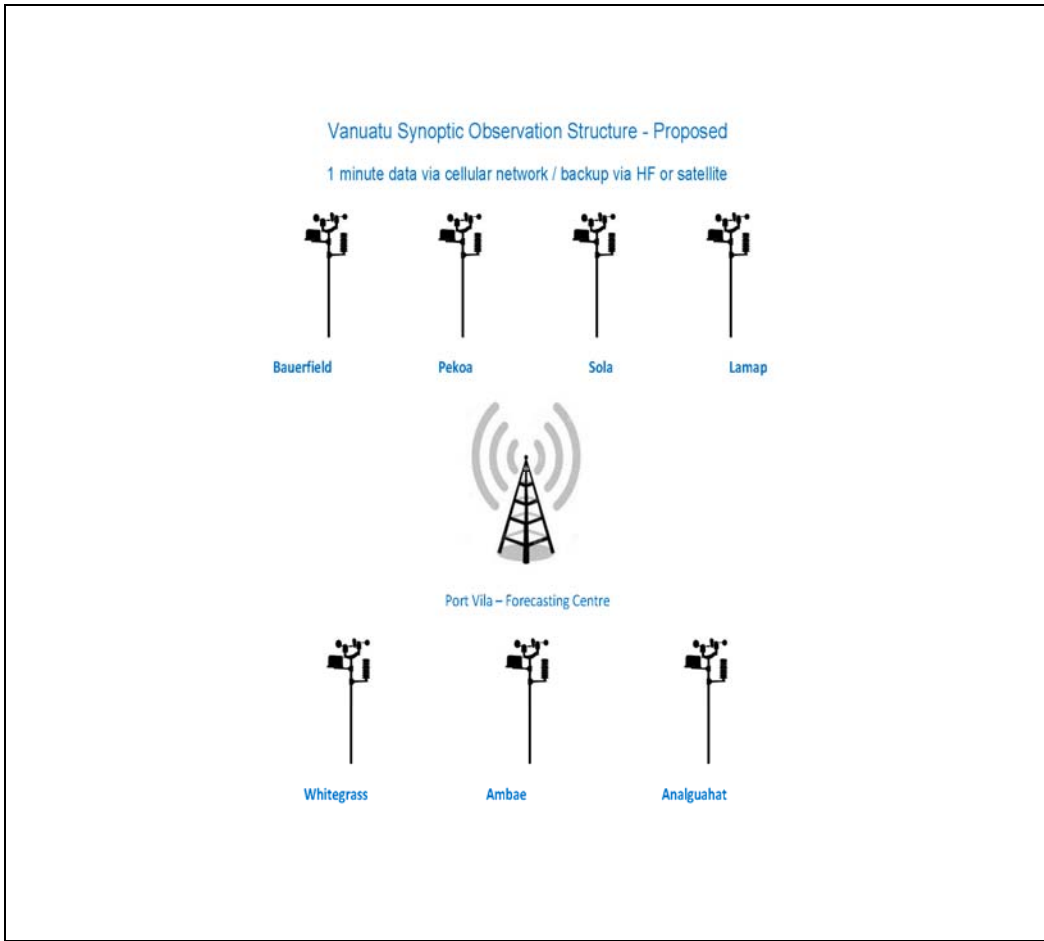
Appendix IX: JICA Project – 2015

Two new AWSs are being installed at Bauerfield international airport, on the island of Efate and at Pekoia international airport, on the island of Santo. They have high resolution data and redundant communications via satellite integrated into the systems. They are scheduled to come online by June 2015.



Site Map of the JICA Project

Appendix X: Concept for Improving VMGD Synoptic Weather Network



Appendix XI: VMGD's Potential for Weather Radar Coverage

As of April 2015, Vanuatu has no weather radar coverage. Some of the southern islands benefit from the Lifou Radar (New Caledonia). Due to the volcanic terrain of Vanuatu, any single weather radar will not see a full horizon. An example, as shown below, is radar that has good coverage over Port Vila, the main population centre, will result in reduced radar coverage to the North East of Vanuatu.

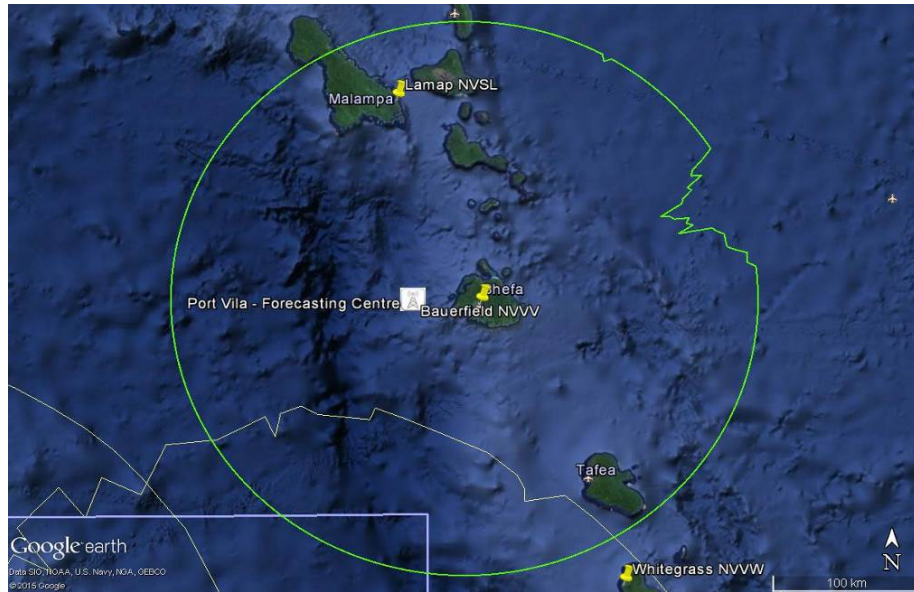


Figure 1: Simulated radar coverage to 10,000ft (3,048m) in altitude from 20 km North of Port Vila

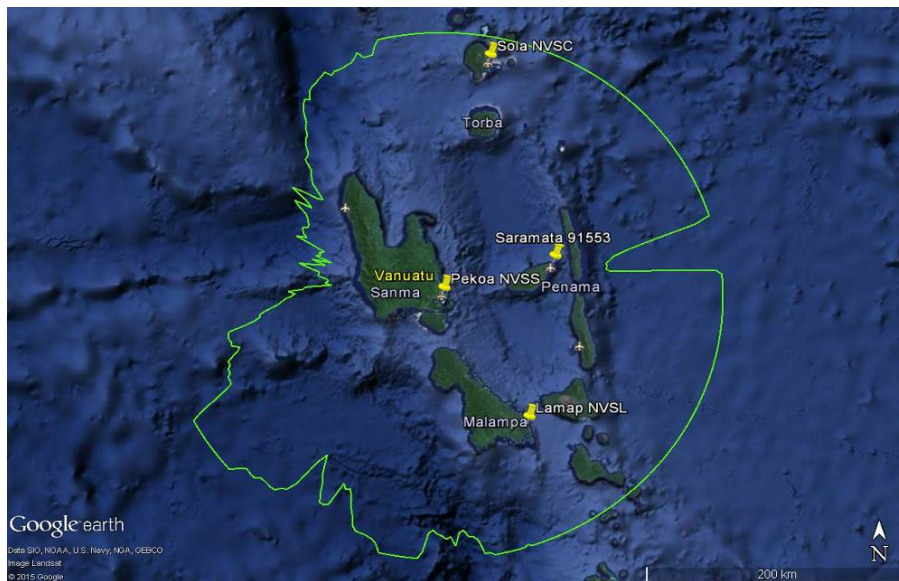


Figure 2: Simulated radar coverage to 10,000ft (3,048m) in altitude from Pekoia Aerodrome

