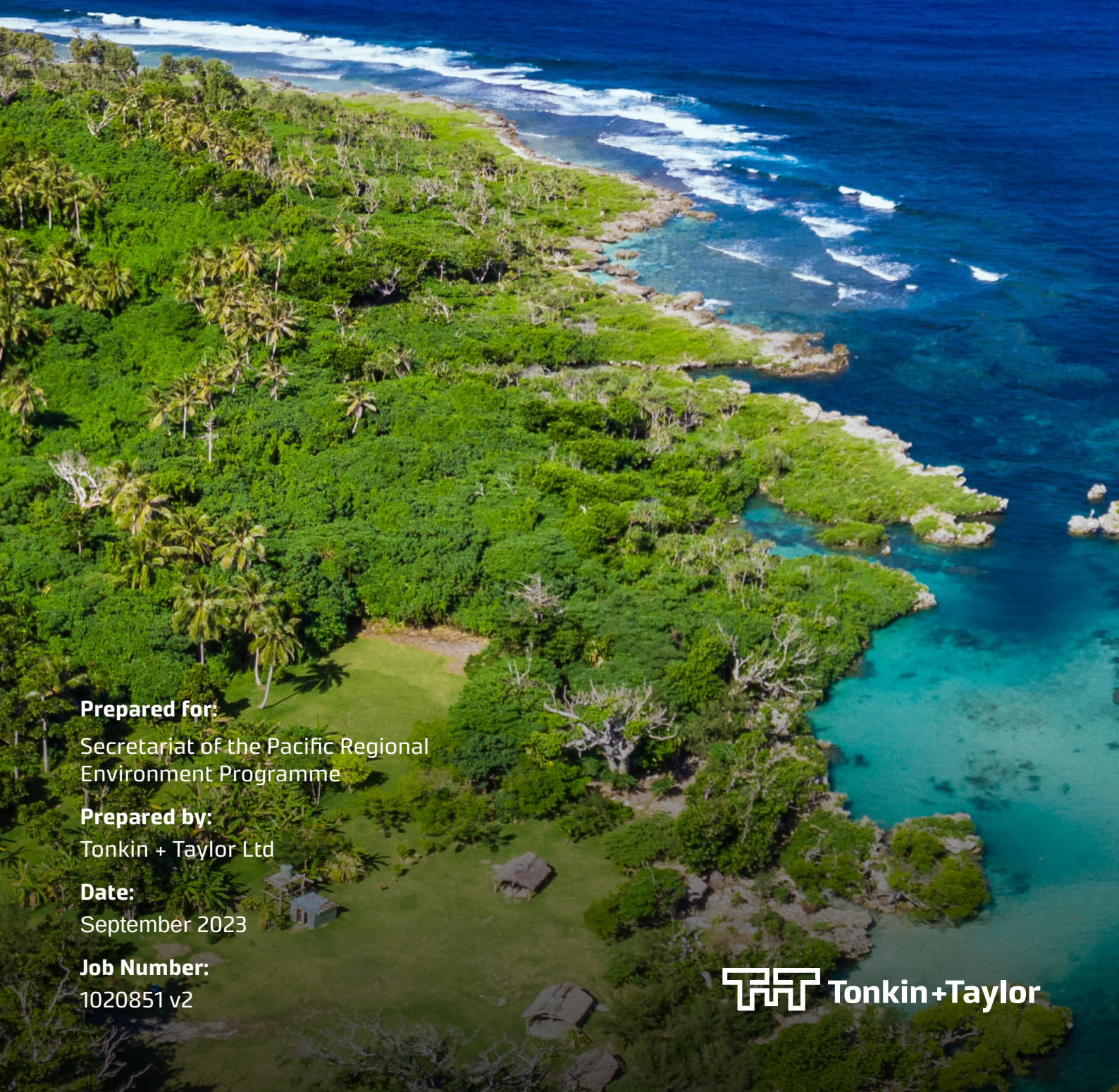
Sarakata-Luganville catchment

Flood Management Plan, Early Warning System and Standard Operating Procedures



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Acronyms

CDCCC	Community Disaster Climate Change Committee
CIS	Climate Information Services
CSIRD	Climate Information Services for Resilient Development in Vanuatu
DLA	Department of Local Authorities
DoWR	Department of Water Resources
DUAP	Department of Urban Affairs & Planning
EWS	Early Warning System
FMP	Flood Management Plan
GEDSI	Gender Equality, Disability and Social Inclusion
IWRM	Integrated Water Resources Management
M&E	Monitoring and Evaluation
MDCCC	Municipal Disaster Climate Change Committee
MEL	Monitoring, Evaluation, and Learning
MIPU	Ministry of Infrastructure & Public Utilities
MoCC	Ministry of Climate Change and Natural Disasters
MoLNR	Ministry of Lands and Natural Resources
MoU	Memorandum of Understanding
NDMO	National Disaster Management Office
NIWA	National Institute of Water and Atmospheric Research
NSDP	National Sustainable Development Plan
NPH	Northern Provincial Hospital
PDCCC	Provincial Disaster and Climate Change Committee
PDO	Provincial Disaster Officer
PEOC	Provincial Emergency Operation Centre
SITREP	Situation Report
SOP	Standard Operating Procedures
SPREP	Secretariat of the Pacific Environment Programme
TAC	Technical Advisory Commission
UFCOP	Urban Floods Community of Practice
Van-KIRAP	Vanuatu Klaemet Infomesen blong redy, adapt mo protekt
VMGD	Vanuatu Meteorology and Geohazards Department
WMO	World Meteorological Organisation

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1 Introduction

The Secretariat of the Pacific Environment Programme (SPREP) is implementing the Climate Information Services for Resilient Development in Vanuatu (CISRD), or Vanuatu Klaemet Infomesen blong redy, adapt mo protekt (Van-KIRAP) Project. As the first part of this project, Tonkin & Taylor International Ltd (T+TI) has been engaged to provide technical expertise to the Van KIRAP Project and the Department of Water Resources to review and update existing flood mitigation guidelines for the Sarakata catchment in Espiritu Santo Island, and to support the development of flood early warning systems in Sarakata.

This report details priority areas of intervention to support the development of a robust Flood Management Plan (FMP) and Early Warning System (EWS) for the Sarakata-Luganville catchment. Recommendations included in this report are informed by a stocktake and gap analysis of existing flood management and early warning practices, the Flood Mitigation Guidelines for Sarakata, Pepsi and Solwei Areas (2011), the Sanma Province Disaster Response Plan, and other relevant policies and plans. Information obtained through a desktop review was supplemented with information captured during discussions with key stakeholders and responses to a survey which was completed by ten respondents representing key stakeholders engaged in flood management and early warning activities within Vanuatu. The Sarakata Flood Mitigation and Early Warning System Gap analysis report is included in Appendix E.

The new FMP has been developed with consideration given to future climate change risks, and with reference to the Van KIRAP Gender Equality, Disability and Social Inclusion (GEDSI) Action Plan.

1.1 Background

Luganville is the second most densely populated urban centre in Vanuatu after Port Vila[1]. The total population of Luganville is 17,719 (2020 estimate), with an average annual growth rate (2.7% pa) slightly higher than the national average (2.3% pa). As the only urban centre on Espiritu Santo Island, Luganville serves as the island's primary economic hub, with economic activity centred around retail, wholesale, banking, hospitality, and tourism sectors. Luganville has one of country's busiest ports, with much of Vanuatu's copra and cacao shipments passing through it. The town is also served by the Santo-Pekoa international airport.

The Sarakata River passes through Luganville's main commercial, hospitality, and tourism precincts with numerous residential areas within the river floodplains (Figure 1.1).

Many of the fastest growing residential neighbourhoods in Luganville are informal settlements, including several located within flood-prone areas alongside the Sarakata River (Figure 1.2). Informal settlements are frequently situated on land with disputed tenure arrangements, making enforcement of land use controls and other regulation challenging (Beca, GNS Science and NIWA, 2015).

Land along the Sarakata River margins is vulnerable to fluvial flooding, particularly the numerous informal settlements established within the flood plains of the river. Elsewhere in the catchment, pluvial flooding is exacerbated by shallow groundwater and inadequate surface water drainage (Department of Water Resources, 2011). During heavy rainfall saturated subsoils prevent infiltration leading to high runoff volumes and frequent flooding. Natural stream networks throughout the lower Sarakata catchment have reportedly been modified, and in some instances filled, to accommodate agriculture and construction activities. Urban drainage networks throughout the catchment are reportedly in poor condition with many no longer maintained or functioning.

[1] 2020 National Population and Housing Census, VNSO

Figure 1.1: Map of Luganville area showing river (Imagery ©2023 CNES/Airbus, Landsat/Copernicus, Maxar Technologies).

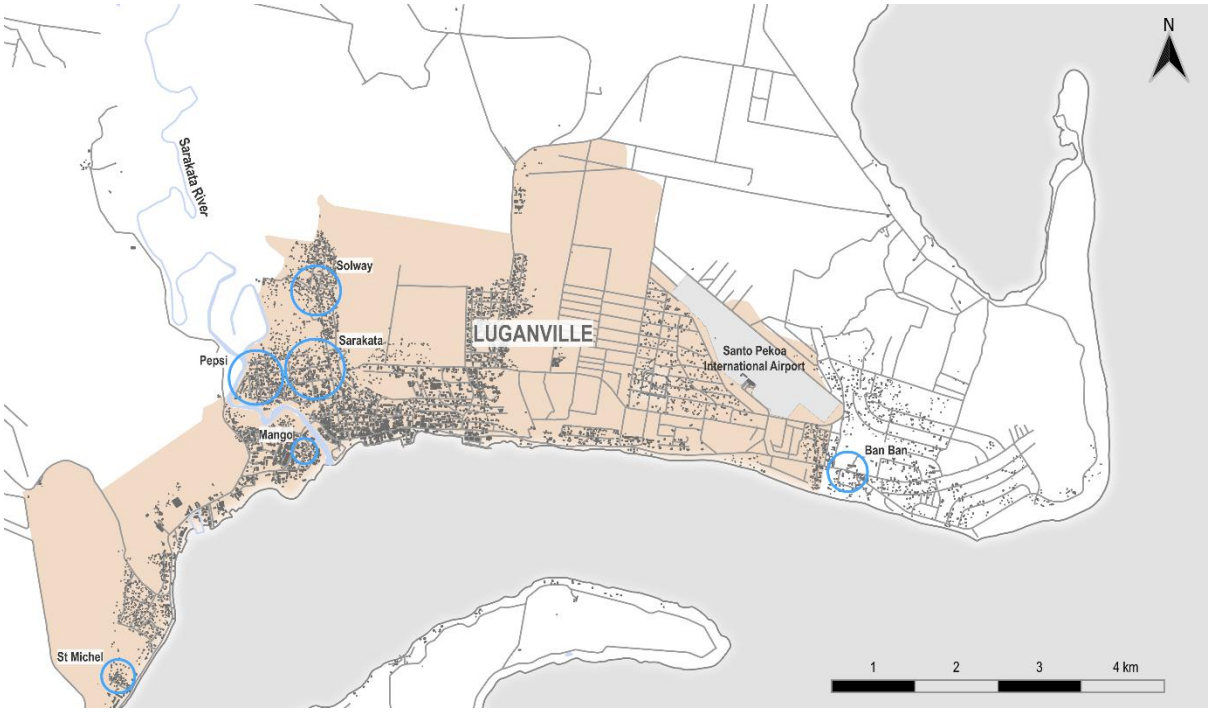


Figure 1.2: Map of Luganville showing locations of informal settlements (blue circles).

Flooding in Luganville and throughout the wider Sarakata catchment is a frequent problem. In recent years excessive rainfall has generated serious flooding and forced evacuations[2]. Climate change impacts are projected to increase the magnitude of extreme rainfall, both those rainfall events associated with tropical cyclones and non-tropical cyclone events, contributing to increased flooding impacts in future (Anil Deo, et al., 2021)[3].

1.2 Current flood situation in Sarakata

Flooding within the Sarakata catchment is well documented with river levels along the Sarakata River reportedly rising several metres during Cyclone Harold in 2020 and causing extensive damage to riverside communities[4]. The Flood Mitigation Guidelines for Sarakata, Pepsi and Solwei Areas (Department of Water Resources, 2011) report that flooding of low-lying settlements along the Sarakata River is a regular occurrence.

A risk assessment by Beca, GNS Science and NIWA (2016) identified 726 buildings exposed to moderate, heavy, or very heavy levels of potential damage due to flooding, and an estimated 1,811 people living in flood-prone locations who are exposed to moderate to very high levels of potential flood risk. Figure 1.3 presents the flood risk map for Sarakata Catchment for a 100-year average recurrence interval flood event.

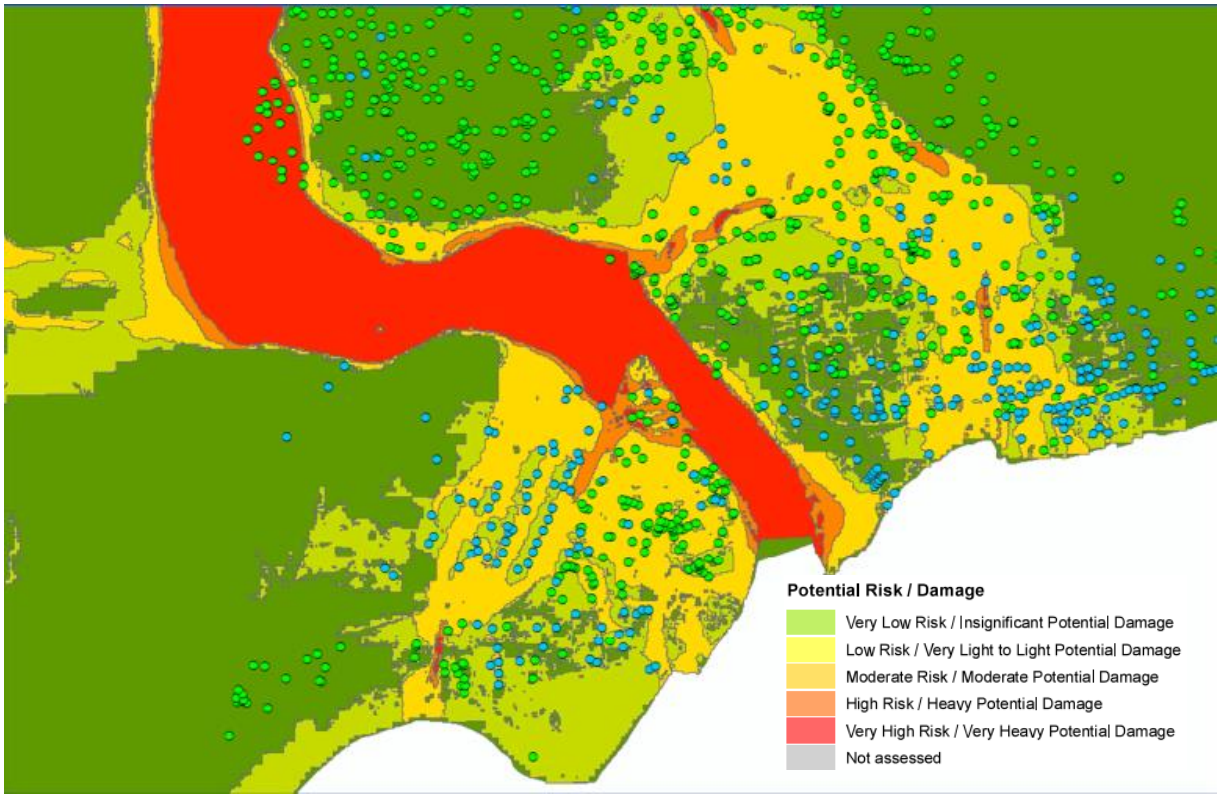


Figure 1.3: Flood risk from the Sarakata River for a 100-year average recurrence interval flood event overlain by household GPS points (green dots) and commercial buildings (blue points). Source: (Beca, GNS Science, NIWA, 2016).

[2] Three families evacuated in Luganville due to flooding | Cyclone Harold updates: Storm makes landfall on Vanuatu's Santo | RNZ News

[3] Australia-Pacific Climate Partnership (2021). 'NextGen' Projections for the Western Tropical Pacific: Current and Future Climate for Vanuatu. Technical Report, Australian Aid, CSIRO, SPREP

[4] 'It's all gone': Cyclone Harold cuts a deadly path through Vanuatu | Vanuatu | The Guardian

1.3 Report structure

This report is structured as follows:

- **Part 1: Sarakata Flood Management Plan and Early Warning System.** This part provides context on the flood management and early warning system within the Sarakata-Luganville catchment. It identifies the current practices and recommends key actions that are necessary to strengthen flood management over the medium and longer term.
- **Part 2: Sarakata flood response Standard Operating Procedures.** This part outlines the actions for relevant stakeholders in the event of floods. The Standard Operating Procedures (SOP) include a decision tree, and clearly outlines the roles and responsibilities of relevant stakeholders in any flood response.
- **Appendices**
  - **Appendix E: Approach for Flood Management Plan and Early Warning System.** This presents the approach to develop this FMP and EWS.
  - **Appendix B: List of stakeholders consulted.** This section includes the list of stakeholders consulted both online and in-person.
  - **Appendix C: Online workshop.** This describes the online workshop where feedback was gathered on the FMP, EWS, and SOP.
  - **Appendix D: In-country stakeholder workshop.** This covers the workshop that was held in the country to share the draft FMP, EWS, and SOP.
  - **Appendix E: Gap analysis report.** This provides a summary of the review of the existing guidelines on flood management and includes an identification and evaluation of gaps in the current status of flood management and early warning systems.
  - **Appendix F: Guidance on Memorandum of Understanding (MoU).** This provides guidance and recommendations on the development and signing of the MoU between DoWR and relevant stakeholders.
  - **Appendix G: SitRep Template.** This presents the SitRep template used by NDMO during emergencies.

2 Part 1: Sarakata Flood Management Plan and Early Warning System

2.1 Flood Management Plan and Early Warning System

The FMP and EWS for the Sarakata-Luganville catchment draw on best practice relating to early warning systems, and flood risk management:

- Flood management activities are reviewed with reference to the benchmarks outlined in the Urban Floods Community of Practice (UFCOP) Urban Flood Risk Management in the Pacific (Yeo, Esler, Taaffe, Jordy, & Bonte-Grapentin, 2017).
- Early warning system elements seek to align with the World Meteorological Organisation's "Early Warnings for All" (WMO EWS4All) initiative, and to draw on the WMO multi-hazard early warning framework and people-centric early warning guidelines (World Meteorological Organization, 2018).

These frameworks have played a significant role in identifying the six core themes for the approach to development of the FMP and EWS (refer Figure 2.1). These themes encompass:

- Flood risk management governance and planning.
- Flood risk management measures.
- Hydrological observation, monitoring, analysis and forecasting.
- Disaster Risk Knowledge.
- Warnings, dissemination and communication.
- Preparedness and response capabilities.

Each theme is an important component to ensure the integrated system functions efficiently, reaches the intended communities and stakeholders, provides useful warnings, and is understood and acted upon. Refer to Appendix A for a description of the FMP and EWS Framework.

Figure 2.1: Approach to Sarakata catchment's FMP and EWS using the UFCOP and WMO EWS framework.

The following sections provide a concise outline of each FMP and EWS theme, outlining the present circumstances and with recommendations. Each recommendation includes a brief explanation, a specified timeframe, and the responsible entities - both primary and secondary.

2.1.1 Flood risk management governance and planning

Governance and institutional arrangements play a crucial role in flood disaster management and preparedness. Effective governance involves the coordination and collaboration of multiple stakeholders, including government agencies, non-governmental organisations, and community members, to ensure a comprehensive and timely response to floods. This can involve implementing flood preparedness measures, such as early warning systems, evacuation plans, and infrastructure improvements, as well as providing immediate relief and long-term recovery support to affected communities. Good governance also ensures transparency, accountability, and the involvement of all stakeholders in decision-making processes, to build trust and promote a culture of resilience in the face of future floods.

2.1.1.1 Governance and institutional arrangements

Several governance considerations and institutional arrangements aimed at enhancing flood resilience and improving flood response have been identified across various plans and policies. At the national level, Department of Water Resources (DoWR) is responsible for monitoring surface and ground water levels, whereas Vanuatu Meteorology and Geohazards Department (VMGD) is responsible for assessing climate change risk, forecasting heavy rainfall, and for the development and management of early warning systems. The local flood response is conducted by either the Municipal Emergency Operation Centre (MEOC) or Provincial Emergency Operation Centre (PEOC) in coordination with the Provincial Disaster Officer (PDO). Additionally, several other essential stakeholders play crucial roles in effective flood management, including but not limited to:

- National Disaster Management Office (NDMO).
- Provincial Disaster and Climate Change Committee (PDCCC).
- Municipal Disaster Climate Change Committee (MDCCC).
- Community Disaster Climate Change Committee (CDCCC)/ Chief/ Community representatives.
- Technical Advisory Commission (TAC).
- Sanma Water Advisory Committee.
- Department of Local Authorities (DLA).
- Luganville Municipal Council.
- Luganville Community Climate Center.
- Vanuatu Red Cross Society (VRCS).
- Telecommunication agencies (e.g., Digicel).
- Media (TV and Radio).
- Vanuatu Police Force.
- Luganville Fire Service.
- Northern Provincial Hospital (NPH).
- Working groups.
- Partner agencies/organisations.

Inter-agency coordination is a key requirement for delivering effective flood management outcomes. However, it's important to note that the plans and policies guiding response efforts at the provincial

and local levels do not adequately address the challenges faced by subnational authorities. For instance, a significant challenge arises from the fact that there is only one PDO tasked with coordinating responses in the province. While this setup may function well during regular operations, it becomes severely constrained during disaster response times due to the lack of sufficient support staff. This limitation hampers the effectiveness of disaster response efforts.

Additionally, the available plans at the provincial level lack the necessary level of detail, particularly concerning the specific roles and responsibilities of various stakeholders involved in the disaster management process. This lack of clarity can lead to inefficiencies and difficulties in coordinating a comprehensive response.

Recommendation G1: Update Sarakata flood response plan to improve clarity on roles and responsibilities.

Timeframe: 2 years

Primary responsibility: NDMO

This recommendation underscores the need to explicitly specify the functions and duties of key personnel within the flood response framework. This may include designating a “Incident Commander" (or Flood Response Coordinator) who will provide overall leadership, decision-making, and coordination, an Emergency Operations Center (EOC) Manager responsible for managing the EOC's operations and information flow, and a range of specialised teams tasked with specific functions such as flood forecasting, evacuation, search and rescue, medical support, infrastructure protection, public information dissemination, and damage assessment and recovery efforts. Clear role definitions help everyone work together smoothly, eliminates ambiguity, and facilitates swift and effective decision-making in high-pressure situations.

Furthermore, clear channels of communication between response teams, relevant authorities, community leaders, and the public needs to be determined to ensure the seamless flow of information. The recommended protocols included in the SOP and Decision Tree (Section 3 – Part 2) encompass precise mechanisms for conveying flood alerts, evacuation orders, safety instructions, and real-time updates to all pertinent stakeholders. By establishing a structured communication framework, the objective is to minimise misinformation, maintain public trust, and enable swift and coordinated actions, thereby enhancing the overall effectiveness of the flood response plan.

Recommendation G2: Utilise existing forums to improve coordination and partnerships.

Timeframe: Ongoing

Primary responsibility: NDMO

Secondar responsibility: VMGD, DoWR

This recommendation emphasises the strategic use of existing forums, namely the TAC and the Sanma Water Advisory Committee, to significantly improve coordination and foster valuable partnerships in the context of disaster management. By leveraging these established platforms, the goal is to create a more effective and comprehensive approach to flood disaster preparedness and response. It encourages these bodies to serve as platforms for coordination, information exchange, and partnership-building, ultimately leading to more robust disaster response efforts that consider both technical expertise and sector-specific concerns. For example, regular meetings convened under the TAC's umbrella can facilitate collaboration among stakeholders from diverse sectors, including government agencies, non-governmental organizations, community leaders, and private entities. By bringing together this diverse expertise, the TAC ensures that disaster response strategies

benefit from a wide range of perspectives, leading to more informed decision-making, optimised resource allocation, and well-coordinated response actions during disasters.

The Sanma Water Advisory Committee acts as a conduit, facilitating communication and collaboration among water-related organizations, infrastructure maintenance authorities, health departments, and other pertinent entities. By integrating water supply, sanitation, and hygiene concerns into flood response plans, the Sanma Water Advisory Committee will play a pivotal role in safeguarding public health and ensuring the continuity of essential services during emergencies.

By capitalizing on the existing strengths of these forums, this recommendation sets the stage for a more unified, informed, and responsive approach to disaster preparedness and management, ultimately leading to enhanced community resilience and reduced flood impact in the Sarakata catchment.

Recommendation G3: Update the Disaster Risk Management Act No. 23 of 2019.

Timeframe: 3 years

Primary responsibility: NDMO

Relevant authorities should consider updating the Disaster Risk Management Act to allocate additional resources, both in terms of personnel and funding, to strengthen the capacity of disaster response efforts and address challenges arising from the limited capacity of a single PDO tasked with coordinating responses during disaster situations. This could involve provisions for establishing dedicated disaster response teams, including support staff such as logistics, communications, and administrative personnel, who can collaborate with the Provincial disaster officer. Adequate staffing ensures that responsibilities are effectively distributed, making disaster response more organised and responsive.

Recommendation G4: Strengthened policies and institutional frameworks at the provincial level.

Timeframe: Ongoing

Primary responsibility: DLA, DUAP

This recommendation aims to enhance the overall flood preparedness, response, and recovery capabilities within the province by strengthening the policies and institutions responsible for flood disaster management. It may involve a comprehensive review of the current policy framework to identify areas for improvement, alignment with national and international best practices, and the integration of lessons learned from past disaster events. It may also include strengthening the institutional framework by enhancing the capacity, coordination, and effectiveness of entities such as DoWR, other government organisations, PDMO, emergency services, local authorities, community-based organizations, and other relevant stakeholders.

2.1.2 Flood risk management measures

Flood risk management measures include a range of strategies, actions, and interventions devised to mitigate the impact of floods and reduce the potential risks they pose to communities, infrastructure, and the environment. It encompasses both structural and non-structural measures that focus on enhancing flood resilience, improving preparedness, and minimising the damages caused by flooding. By integrating both structural elements, such as levees and flood control structures, and non-structural aspects like early warning systems and land use planning, the challenges posed by floods can be managed in a way that reduces vulnerability and maintains the integrity of social, environmental and economic systems. This holistic approach acknowledges the

dynamic interplay between human activities and natural hazards, ultimately leading us toward sustainable flood risk management practices that protect lives, livelihoods, and the environment.

The existing Flood mitigation guidelines for Sarakata, Pepsi and Solwei areas (Department of Water Resources, 2011) provide a range of options to reduce and mitigate flood risk. The guidelines identify flood management actions including structural, source control, exposure and vulnerability reduction, and planning measures as part of a broader integrated water resources management approach. These actions have been reviewed and updated for inclusion in this FMP. These actions should be completed to progress the management of the Sarakata catchment towards the stated long-term objective of climate resilience.

2.1.2.1 Structural flood mitigation measures

In the Sarakata catchment, a small number of structural flood management measures have been strategically implemented to mitigate the impacts of flooding. While the region predominantly relies on non-structural approaches, existing structural measures within the catchment serve an important function, providing enhanced flood resilience and reducing potential damages. The key structural measures in the catchment include:

- Hydropower Dam: The hydropower dam, originally built in 1993 and subsequently improved in 2006, serves a diverse range of purposes. Besides generating clean energy, the dam provides the secondary benefit of flood control. By regulating the flow of water, the dam can effectively attenuate downstream floodwaters during periods of heavy rainfall. In 2022, the Government of Japan extended a substantial grant of approximately VT3.5 billion to facilitate two pivotal initiatives: the construction of an extra hydropower facility and the modernization of existing transformer facilities. This strategic project will strengthen the energy infrastructure while also carrying significant potential for enhancing flood management capabilities (DoE, 2022).
- There is an existing drainage network throughout parts of Luganville and the wider Sarakata catchment. However, the Sarakata catchment flood mitigation guidelines note that "*most of the stormwater drains around the Sarakata area are no longer functioning due to being blocked or damaged*" (DoWR, 2011, p. 9).

Recommendation F1: Detailed evaluation of possible options for structural flood mitigation measures within the catchment.

Timeframe: 5 years

Primary responsibility: DoWR, PWD

Secondar responsibility: MIPU, DLA, DUAP

A detailed evaluation of possible options for structural flood mitigation measures within the catchment is needed to identify and evaluate options for flood risk reduction. This evaluation is essential to determine the most effective, efficient, and sustainable ways to reduce flood risks. By examining different options for structural flood mitigation, the feasibility, benefits, potential drawbacks, cost-effectiveness, and their compatibility with the unique characteristics of the catchment needs to be assessed.

Detailed evaluation ensures that the selected structural measures align with the specific flood dynamics, local geography, environmental considerations, and socio-economic factors within the catchment. This process will assist in making informed decisions about the implementation of structural flood management measures. Options assessments should utilise the existing hydrodynamic flood models and hazard/risk assessments which have been prepared for the Sarakata catchment to prioritise interventions. Suitable analytical tools (cost benefit analysis, multi-criteria

analysis) should be used to evaluate the effectiveness of different options and inform the selection of structural interventions to be progressed further to design and construction.

The evaluation process usually includes, but is not limited to:

- Technical feasibility: Assessing whether the proposed structural measures are technically feasible given the catchment's topography, hydrology, and existing infrastructure.
- Environmental impact: Evaluating the potential effects of the measures on the natural environment, including habitat disruption, water quality, and erosion issues.
- Cost-benefit analysis: Determining the cost-effectiveness of each option, considering construction costs, maintenance, long-term benefits, and the avoided costs of potential flood damages.
- Social acceptance: Gauging community support, understanding any social implications, and addressing concerns related to the proposed structural measures.
- Integration with non-structural measures: Ensuring that the chosen structural measures complement and enhance non-structural approaches, such as early warning systems, land use planning, and community preparedness.

Structural flood management options may include:

- Construction of flood embankments and diversions.
- Detention basins.
- Bridge/culvert upgrades.
- Upgrades of critical drainage infrastructure.
- actions to enhance channel conveyance of the Sarakata River and tributaries including dredging, river widening and river maintenance.

2.1.2.2 Catchment management (source control)

Integrated water resources management is (and has previously been identified as) a priority for further development within the Sarakata catchment. As of July 2023, development of a catchment management plan is in progress.

Recommendation F2: Develop a catchment management plan for Sarakata.

Timeframe: 2 years

Primary responsibility: DoWR

Secondar responsibility: VMGD, NDMO

Further development of integrated water resources management (IWRM) is recommended as a priority within the Sarakata catchment. Previous work to progress IWRM within the Sarakata Catchment could serve as the basis for a renewed focus on integrated catchment management planning in Sarakata, for example:

- A participatory research project by the international water centre in 2009 established the Sarakata Catchment Group which identified priorities for IWRM in Sarakata from the perspective of the community (Hoverman, De Lacy, Ross, & Chan, 2009).
- The Global Environment Facility also supported a demonstration project which explored IWRM within the Sarakata Catchment (Global Environment Facility, 2014). Work towards a “ridge-to-reef” watershed management model was progressed through the Sanma Water Advisory Committee.

A comprehensive catchment management plan for the Sarakata catchment must be rooted in the principles of Integrated Water Resources Management (IWRM) and should embrace a collaborative, participatory approach. This inclusive strategy entails seeking input from a diverse range of stakeholders, including local community groups, provincial advisory committees, and representatives from both provincial and national government agencies.

One objective which the forthcoming catchment management plan will seek to achieve is the designation of a protective buffer zone along the river, a crucial aspect that aligns with the directives set forth in the Water Resources Management Act of 2002. This legislation provides a robust framework for safeguarding Vanuatu's water resources, underscoring the importance of balanced and sustainable river management.

2.1.2.3 Exposure and vulnerability reduction

Vanuatu remains highly vulnerable to external shocks, and reducing disaster vulnerability will be crucial for achieving the National Sustainable Development Plan (NSDP) 2016 to 2030 aspirations. Those living in poverty are more likely to reside in areas exposed to hazards and have less resources available to invest in risk reduction measures (UNDRR, 2023). As of August 2023, a significant gap exists in terms of a comprehensive relocation plan or policy for communities residing in flood-prone areas. This absence of a structured relocation strategy leaves these communities exposed to ongoing risks without a clear roadmap for a safer alternative.

Furthermore, a noteworthy challenge arises from the lack of effective enforcement and compliance with Acts, policies, and building codes at the provincial level. This gap in implementation hampers the ability to mitigate risks effectively and undermines the overarching goal of enhancing disaster resilience across the nation.

Vanuatu has made significant progress on poverty reduction over the past decade. In 2019, 8.6% of the population lived below the international poverty line, which is a decrease from 13.1% in 2009. Vanuatu also graduated from the official list of Least Developed Countries (LDC) in 2020, which reflects the significant improvements the country has made in development indicators. The Government of Vanuatu has prioritised poverty reduction in the National Sustainable Development Plan (NSDP) 2016 to 2030. One of aspirations in the NSDP is to achieve a stable economy based on equitable, sustainable growth that creates jobs and income earning opportunities accessible to all people in rural and urban areas – which will be delivered through the 15 National Sustainable Development Goals.

Recommendation F3: **Development of targeted policies focused on vulnerability reduction.**

Timeframe: 5 years

Primary responsibility: NDMO

Secondar responsibility: MoCC, MIPU, MoLNR

A range of targeted policies focused on poverty reduction is essential for reducing vulnerability to natural hazards. The NSDP outlines the following goals and objectives related to poverty reduction and human development:

- Stimulate economic diversification to spread the benefits of growth and increase economic stability.
- Promote broad-based growth by strengthening linkages between tourism, infrastructure, agriculture and industry in rural areas and diversify the rural economy.

- Increase the number of decent, productive employment opportunities, particularly for young women and men and people with disabilities.
- Ensure all people have reliable access to safe drinking water and sanitation infrastructure.
- Ensure that all public infrastructure, including health, education and sports facilities are safe, accessible, secure and maintained in compliance with building codes and standards.
- Improve access to markets through quality infrastructure, utilities, storage and processing facilities in rural areas.

2.1.2.4 Vanuatu Building Code

The Vanuatu Building Code includes provisions for site drainage and flood protection. The Code requires that the land '*immediately surrounding a building should be free of standing water within an hour of a storm with a 5-year return period*', and also requires that '*no flood water resulting from a storm with a 30-year return period should enter a building*' (Government of Vanuatu, 2000). However, the current building code, last revised in 2013, does not adequately align with the local context. This mismatch between the code and the unique conditions of Vanuatu undermines its effectiveness.

Vanuatu faces a shortage of building inspectors which creates a substantial workforce gap in overseeing construction projects and verifying their compliance with prescribed standards. Additionally, a crucial aspect contributing to this challenge is the lack of comprehensive training provided to inspectors in relation to national code compliance. This knowledge gap further compounds the difficulties in ensuring that construction activities align with the prescribed guidelines (Gwilliam; PRIF, 2021).

Recommendation F4: Update the Vanuatu Building Code to include consideration for climate change, disability design standards, and further detail on hazard-resilient buildings.

Timeframe: 5 years

Primary responsibility: MoIA, MIPU

Secondar responsibility: DoWR, MoJCS, MoCC, and other relevant stakeholders

The Vanuatu Building Code need to undergo a comprehensive revision to incorporate climate change considerations, disability-inclusive design standards, and more comprehensive guidelines for constructing hazard-resilient buildings. A task force consisting of architects, engineers, accessibility experts, and climate change specialists is suggested to lead the revision process. The updated code should include provisions for building structures that can withstand flood impacts, storm surges, and other climate-related hazards. It should also incorporate design elements to ensure accessibility for people with disabilities.

Recommendation F5: Training/capacity development of local building control officers responsible for administering the building code through the building permit process.

Timeframe: 5 years

Primary responsibility: PWD

Secondar responsibility: DUAP

A capacity development program should be organised to train and educate local building control officers in Sarakata on the updated Vanuatu Building Code and its implementation. The training should cover the newly included considerations for climate change resilience, disability design standards, and hazard reduction in building construction (refer to Recommendation F4). Building

control officers needs to be equipped with the knowledge and skills to review building permit applications, ensure compliance with the updated code, and enforce regulations related to flood-resistant construction practices. Regular workshops and follow-up sessions should be conducted to reinforce learning and address any challenges faced by building control officers during the implementation process.

2.1.2.5 Risk-informed land use planning

Vanuatu's existing land use planning processes include applications to register leases, planning permits for subdivisions and foreshore development, and environmental impact assessment processes. The Greater Luganville Development Control Plan includes special provisions for flood-prone areas requiring that "*Any development in these areas will be required to demonstrate that the area can be appropriately filled and drained to mitigate any flooding*" (Luganville Municipal Council & Sanma Provincial Government Council, 2017, p. 75).

Vanuatu's National Land Subdivision Policy (MLNR, 2019, p. 8) requires that "*All land intended to be subdivided for residential purposes must be filled and appropriately compacted to a level that ensures the land is not subject to inundation (e.g. coastal, riverine, fluvial). Adequate drainage must be provided to the land to avoid ponding of water or any other adverse environmental impacts. Any adverse impacts, including cumulative impacts, as a result of flooding must be minimised through drainage system to ensure unacceptable risk to people and property is not created*".

Recommendation F6: Update the Greater Luganville Development Control Plan to include conditions related to development in flood-prone areas and develop an action plan and training to support the implementation of the Control Plan for Greater Luganville.

Timeframe: 5 years

Primary responsibility: DUAP

The Greater Luganville Development Control Plan and the National Land Subdivision Policy would benefit from review and revision to include further conditions related to development in flood-prone areas relating to:

- The assessment of impacts associated with the placement of fill within the extents of the 100-year average recurrence interval flood.
- The identification of safe evacuation routes from proposed developments.

Implementation of the Greater Luganville Development Control Plan would be enhanced through the development of an action plan. This would include the development of appropriate risk/hazard assessment procedures and training for authorities responsible for approving development applications. Training could build on the "Introduction to risk-informed decision-making in urban development planning" training delivered by NIWA in 2015 which was attended by urban planners and engineers in Vanuatu, including members of the Sanma provincial disaster management office (Secretariat of the Pacific Community, 2015). The objective of this training would be to strengthen existing land use planning and disaster risk reduction processes through the integration of hazard information and risk-based decision-making.

2.1.2.6 Informal settlements

Many of the fastest growing neighbourhoods in Luganville are informal settlements, including several located within flood-prone areas alongside the Sarakata River. People living in informal settlements face severe limitations in accessing essential services like water, energy, health, and education, as well as suitable evacuation centres. This increases vulnerability to the impacts of disasters, especially

flooding. For informal settlements or communities aiming to relocate from hazardous areas, the process necessitates engagement with various government Ministries.

The Greater Luganville Development Control Plan highlights these informal settlements as flood susceptible and recommends they be relocated elsewhere within the peri-urban transitional zone between the Sanma provincial boundary and the Luganville municipal boundary (Department of Water Resources, 2011). Currently, there is no established plan at both the provincial and national levels to provide authorities with a systematic procedure for relocation.

Previous efforts to relocate informal settlements within Sarakata catchment have been unsuccessful (Beca, GNS Science, NIWA, 2016). Also, the lack of a designated "first point of contact" within the government makes it difficult for community leaders and Chiefs to seek guidance. Currently, these leaders turn to Area Councils, Provincial and Municipal Governments for aid, but the framework for these entities to access comprehensive support from different Ministries at a national level for displacement-related issues remains undefined. This lack of clarity regarding responsibility has led to ad hoc approaches in addressing these challenges (Government of Vanuatu, 2018).

Recommendation F7: Develop risk management approaches for existing informal settlements, including incremental relocation from flood-prone settlements in consultation with the community.

Timeframe: 5 years

Primary responsibility: MoLNR, DUAP

Secondar responsibility: Area Council, VMGD, DLA, and NDMO

Investment into the development of community-specific durable solutions plans for people living in informal settlements is required. Planned relocation of people living in flood-prone informal settlements should be undertaken in accordance with Vanuatu's National Policy on Climate Change and Disaster-Induced Displacement (NDMO, 2018). One approach to planned relocation may be to explore the potential of passive planning for upgrading and formalisation of existing informal settlements and incremental relocation away from flood-prone areas. Passive planning approaches in hazard exposed informal settlements can involve limited investment in basic services (for example water and sanitation infrastructure only) and secure tenure arrangements for limited durations (Government of Fiji, World Bank, 2017; Government of Fiji, Ministry of Economy, 2018).

2.1.3 Hydrological observation, monitoring, analysis and forecasting

Hydrological observation, monitoring, analysis, and forecasting are paramount components of effective flood management strategies. These integral processes form the foundation of understanding the complex interactions between precipitation, river flow, groundwater levels, and their impact on flood occurrence. Continuous hydrological observation enables the early detection of high intensity rainfall events, rising river levels, and potential flood triggers. Furthermore, analysis of hydrological records can be used to identify climatic trends, and project future flood risks. By coupling historical data with advanced modelling techniques, accurate flood forecasts can be generated, providing essential lead time for flood preparedness and response efforts. Such forecasts empower authorities, communities, and stakeholders to make informed decisions, implement preventative measures, and evacuate when necessary, ultimately minimising flood-related casualties and mitigating property damage. The integration of hydrological observation, monitoring, analysis, and forecasting is a critical foundation for comprehensive flood resilience and strategic preparedness.

2.1.3.1 Observation network

The performance of the whole system is limited by the extent of the network and the accuracy and timeliness of the data.

The monitoring network currently operating in the Sarakata catchment consists of two automatic weather stations (AWS) recording rainfall depths and river levels, with the capacity for river discharges to be computed in near real time, and a further two automatic rain gauges (ARG). The first automatic weather station, installed in September 2022, is located approximately 10 km upstream of the Luganville municipal boundary. The second AWS was installed in December 2022 at the Vanuatu Agricultural Research and Training Centre in Luganville. Installation of the two ARGs was also completed in December 2022 at Vunbev Village and the Sarakata Hydro station. The observation network within the Sarakata Catchment has improved dramatically both in terms of coverage throughout the catchment and the frequency of data collected. The information captured by the Sarakata catchment observation in the coming years will greatly enhance understanding of catchment hydrology and flood risk knowledge.

Despite the ongoing efforts to enhance the observation network, a shortage of personnel for data collection, equipment maintenance, and limited financial resources for sustaining the river monitoring network remains a barrier which could impede the advancement of these initiatives.

Recommendation O1: Continued development of monitoring instrumentation to support real-time data capture throughout the Sarakata catchment, and ongoing resourcing and capacity development for the maintenance and improvement of the existing monitoring network.

Timeframe: 2 years

Primary responsibility: DoWR

Secondar responsibility: VMGD

Advanced monitoring instrumentation, such as rainfall and river level gauges, weather stations, and soil moisture sensors, should be strategically deployed at key locations to gather critical data related to weather patterns, river flow, and soil conditions. Regular maintenance and calibration of existing monitoring equipment is important to ensure accuracy and reliability. Additionally, a team of trained technicians and hydrologists should be hired to oversee the monitoring network's operation and maintenance. Capacity development programs need to be organised to train local staff in data collection, analysis, and interpretation (refer to Section 2.1.2.6 for more details). This will empower them to manage the monitoring network effectively and troubleshoot any issues that may arise.

2.1.3.2 Hydrological/meteorological data sharing procedures

Presently, VMGD serves as the custodian of the data collected via its observation network. Notably, the VanKIRAP Project has played a pivotal role in facilitating a Memorandum of Understanding (MOU) between the DoWR and VMGD. This MOU may lay the foundation for data sharing, ensuring that essential information is exchanged efficiently between the involved parties. Such collaborative efforts are integral for enhancing the accuracy of forecasting and decision-making processes in the domain of hydrology and meteorology.

Recommendation O2: Utilise existing/develop a forum to enable coordination and partnerships accompanied by the procedures for coordination and data sharing between VMGD and DoWR.

Timeframe: Ongoing

Responsibility: VMGD, DoWR

As mentioned in Section 2.2.1 under Recommendation G2, existing forums such as TAC and the Sanma Water Advisory Committee could be utilised to enable coordination and partnerships to improve the data sharing between VMGD and DoWR. Alternatively, a new forum could be established specifically to promote collaboration and partnerships between the VMGD and DoWR. The forum needs to include representatives from both agencies, as well as other relevant stakeholders, such as disaster management authorities, NGOs, and community leaders. Regular monthly meetings should be held under the forum to discuss ongoing flood-related activities, share relevant data and research findings, and identify areas for collaboration.

2.1.3.3 Forecasting

The Sarakata River gauge was recently installed, however, its observations have not yet been harnessed to validate forecasts for high-intensity rainfall or to support the development of flood forecasting models. To optimise flood forecasting efforts, a range of valuable data and data models could be integrated into the process. One approach is to incorporate sub-daily rainfall intensity predictions generated by regional Numerical Weather Prediction (NWP) models into flood forecasting. Updating forecasts with sub-daily precipitation data would enable forecast models to deliver extended lead times and more accurate forecasts which are aligned with real-time weather conditions. Furthermore, there exists potential to refine rainfall intensity predictions by calibrating them against the data collected by the Sarakata, enhancing the accuracy and reliability of forecasts. The development of an empirical hydrological model specific to the Sarakata River upstream of Luganville would support risk informed decision-making and proactive disaster management.

Recommendation O3: Training and capacity building to support the development of flood forecasting capabilities.

Timeframe: 5 years

Primary responsibility: DoWR

Secondar responsibility: VMGD

This recommendation focuses on organising training and capacity-building initiatives aimed at facilitating the development of flood forecasting capabilities. These efforts would encompass imparting specialised knowledge, skills, and tools to individuals and teams responsible for forecasting and issuing flood warnings. Equipping the staff of DoWR and VMGD with techniques, data analysis methodologies, and the ability to interpret complex hydrological information will empower them to generate more accurate and timely flood forecasts.

2.1.3.4 Hazard thresholds

As mentioned in the Flood Mitigation Guidelines for Sarakata, Pepsi and Solwei areas (2011), data from VMGD showed that flood-prone regions like Pepsi, Sarakata, Pump Station, and Solwei receive an average annual rainfall of around 2400 mm per year. As of August 2023, flash flood warnings are issued by VMGD based on forecast daily rainfall exceeding 100 mm/day. The threshold for warnings within the Sarakata catchment is yet to be calibrated due to insufficient hydrological and meteorological data.

Recommendation O4: Refine flood hazard thresholds for the Sarakata catchment.

Timeframe: 2 years

Primary responsibility: DoWR

Secondary responsibility: VMGD, NDMO

Flood hazard thresholds which are specifically designed for the Sarakata catchment are required. The development of appropriate thresholds may involve the identification of specific flood impacts or observations which serve as triggers for subsequent actions or responses. Developing these thresholds is essential as they provide a clear and quantifiable guide for decision-making and preparedness measures related to floods. Well-defined thresholds enable authorities to act swiftly and efficiently, minimizing the potential negative consequences of floods. Furthermore, clearly defined thresholds for flood warnings provide a basis for effective communication with communities, enabling them to understand the severity of the situation and the necessary actions to be taken.

Key elements for developing flood hazard thresholds

Developing flood hazard thresholds is a comprehensive process which needs to account for various factors to determine the levels of flooding which can pose a hazard to a particular area. Some of the key elements that are typically considered when developing flood hazard thresholds are (Weeink, 2010; Upper Hutt City Council, 2022; AEM, 2023; Santos & Fragoso, 2016; Zurich Flood Resilience Alliance, 2023; Salgado & Nájera, 2022; Young, Bhattacharya, & Zevenbergen, 2021):

- Hydrological data: This includes historical and real-time data on river flows, precipitation, and groundwater levels.
- Topography and Bathymetry: The elevation and contours of the land, as well as the depth and shape of water bodies, play a crucial role in determining how floodwaters will flow and accumulate.
- Hydraulic modelling: Hydraulic models simulate the behaviour of water in different scenarios, helping to predict flood extents, depths, and velocities. These models can validate thresholds and aid in emergency planning.
- Floodplain mapping: Floodplain maps help visualise areas that are susceptible to flooding under different scenarios. These maps show the extent of flooding based on various water levels.
- Historical floods: Studying past flood occurrences provides insights into the frequency, magnitude, and impact of floods in an area. This information helps set realistic thresholds for various levels of flooding.
- Climate and weather patterns: Understanding climate trends and weather patterns helps predict potential flood-inducing conditions. Long-term climate data can be used to estimate how the frequency and intensity of flooding might change over time.
- Infrastructure and land use: Assessing the built environment, such as buildings, roads, and critical infrastructure, as well as the land use patterns in flood-prone areas, helps identify vulnerabilities and potential impacts.
- Stakeholder Input: Input from local communities, emergency responders, government agencies, and other stakeholders is crucial for understanding the local context and ensuring that the developed thresholds align with practical needs and expectations.
- Risk Assessment: A thorough risk assessment evaluates the potential consequences of different flood scenarios, considering factors such as population density, property values, and environmental impacts.
- Climate change considerations: Incorporating projections of climate change impacts, including increased precipitation, sea-level rise, and changing weather patterns, is essential for developing thresholds that account for future conditions.

- Emergency response plans: Collaboration with emergency management agencies is crucial for aligning flood hazard thresholds with response plans, ensuring timely and appropriate actions in case of flooding.

Note that it may be necessary to develop different thresholds for several distinct locations throughout the catchment depending on the information captured during risk/impact assessments.

2.1.4 Disaster risk knowledge

Risk stems from the intersection of hazards, the exposure of individuals and assets to these hazards, as well as the inherent vulnerabilities and adaptive capacities of the communities. Assessment of these risks requires a step-by-step process for data collection and analysis, consideration of the dynamics and cascading and compounding effects of hazards, in relation to the vulnerabilities arising from factors such as unplanned urban growth, shifts in rural land utilisation, environmental degradation, and the impact of climate change. The degree of risk is variable and depends upon the consequences of hazards. Consequently, a comprehensive risk assessment must encompass an evaluation of the community's ability to manage and adapt. It is also crucial to evaluate the perception of the level of risk faced by those who are vulnerable (WMO, 2023).

In-depth studies on human interactions to warnings also provide insights for improving the performance of EWS. Risk assessments can be utilised to pinpoint areas inhabited by vulnerable groups, critical infrastructure, and valuable assets. This information supports in developing evacuation strategies, including evacuation routes and designated safe zones, and alert messages to encompass potential impacts. A comprehensive understanding of all these aspects within a catchment is an indispensable precursor to the development of well-targeted and effective flood mitigation interventions and an impact based EWS (WMO, 2023).

2.1.4.1 Geospatial data management

Previous work within the Sarakata catchment has made use of spatial data including aerial imagery and LiDAR elevation data to generate flood hazard and flood risk outputs. The data utilised as inputs for these assessments and the resulting hazard and risk outputs should be managed in a suitable spatial database and made accessible to GIS users within VMGD, and distributed to other government agencies, NGOs and consultants as needed.

Recommendation R1: Establish a geospatial[5] database and data management protocol administered by VMGD.

Timeframe: 2 years

Primary responsibility: VMGD

Secondary responsibility: DoWR

This recommendation focuses on creating a geospatial database and implementing a structured data management protocol under the administration of VMGD. This involves systematically gathering and organizing geospatial data, which includes geographical information like digital elevation models, satellite imagery, and geographic coordinates for key assets and infrastructure. The data management protocol needs to outline procedures for data collection, storage, updating, quality control, and accessibility. VMGD's administration needs to ensure that the database remains

[5] According to Government of Vanuatu's National Geospatial Data Policy (2020-2030), Geospatial data is defined as any data that has a location on the Earth's surface. It combines location information (usually coordinates on the earth), attribute information (the characteristics of the object, event, or phenomena concerned), and often also temporal information (the time or life span at which the location and attributes exist).

accurate, up-to-date, and accessible to relevant stakeholders. This initiative will serve as a foundational resource for informed decision-making, risk assessment, disaster management, and urban planning, promoting overall resilience and efficient response strategies within Vanuatu. Alternatively, work undertaken by Beca, GNS Science and National Institute of Water and Atmospheric Research Ltd (NIWA) (2016) established a PostGRE/GIS database within VMGD which could serve this purpose.

2.1.4.2 Updated flood hazard/risk mapping

Flood hazard models and flood risk maps for the Sarakata catchment were prepared by NIWA, GNS Science and Beca as part of the Risk Mapping and Planning for Urban Preparedness project (2016). The existing flood hazard models are currently being updated to account for increases in projected rainfall due to climate change.

Recommendation R2: Flood hazard/risk maps should be verified/validated, based on observations and future climate projections.

Timeframe: 3 years

Primary responsibility: DoWR, VMGD

Secondary responsibility: NDMO

Flood hazard /risk models and the outputs produced by these models require validation and verification to ensure that outputs for a given input align with real-world observations. The validation process involves comparing flood hazard and risk model results with actual flood events and historical data on flood levels, extents and reported flood damages and impacts. If discrepancies are identified, model calibration needs to be undertaken to refine the accuracy of models and outputs. Changes may be required to model inputs to reflect real-world changes such as updating precipitation to account for increasing rainfall intensity due to climate change, or updating impervious coverage or land uses throughout a catchment. Alternatively, model parameters such as hydraulic roughness, or infiltration rates may simply require adjustment to achieve a better representation of a flood response within the specific catchment even when there has been no identifiable change within the catchment. The verification/validation process should be undertaken after every significant rainfall/flood within the catchment.

Recommendation R3: All model files and results should be made available to DoWR and other key stakeholders to facilitate periodic future flood model updates.

Timeframe: 3 years

Primary responsibility: DoWR

Secondary responsibility: VMGD, NDMO, and other key stakeholders

Any future flood models of the Sarakata catchment built by external contractors or consultants on behalf of DoWR, VMGD or other government agency should include all model files alongside the delivery of model results to facilitate periodic future flood model updates.

Catchments are not static, changes to infrastructure, land use and climate necessitate regular updates. Model validation and improvement (Recommendation R2) is also an ongoing process. Furthermore, flood models can be incredibly useful tools for testing and comparing alternative flood management interventions. The delivery and ownership of model files in addition to model results and flood hazard/risk maps is essential to ensure that flood models can be updated by, or at the direction of, relevant stakeholders in Vanuatu whenever required.

2.1.4.3 Flood impact assessment

Flood impact assessments explore the relationships between flood hazards and the consequences of flooding. Impact assessments are an essential aspect of flood risk knowledge as they support a better understanding of the social, economic, and environmental loss and damages propagated by flooding which can in turn support more effective flood risk reduction. In 2022, a flood impact assessment focused on displacement revealed that among the provinces in Vanuatu, Sanma has one of the highest rates of displacement due to flooding (IDMC, 2022). Figure 2.2 shows the results of the assessment grouped at district level. The assessment compared annual average displacement under current climate conditions with projected average annual displacement under both optimistic and pessimistic long-term scenarios. Assessments such as these can be a valuable step towards a deeper understanding of flood risks and the consequences of flooding leading to more effective responses which are targeted at reducing adverse impacts.

Figure 2.2: Average Annual Displacement (AAD) for Vanuatu in current climate conditions and in long-term projections under optimistic and pessimistic.

Recommendation R4: Conduct a comprehensive flood impact assessment to evaluate the potential consequences of flooding on communities, infrastructure, and the environment

Timeframe: 5 years

Primary responsibility: NDMO

Secondary responsibility: VMGD, DoWR

It is recommended to undertake a thorough flood impact assessment, which involves a systematic evaluation of the potential consequences of flooding on various aspects such as communities, infrastructure, and the environment. This assessment needs to employ methodologies to analyse the extent and severity of damages that can occur due to flooding. By quantifying potential impacts, decision-makers gain a comprehensive understanding of the risks involved and can thus make informed choices regarding flood disaster response, preparedness, and recovery strategies. This assessment may support the identification of vulnerable areas and populations as well as guide

resource allocation, policy formulation, and infrastructure planning to enhance overall flood resilience.

2.1.4.4 Risk assessment

The work undertaken by Beca, GNS Science and NIWA (2016) to develop risk maps for the Sarakata catchment provide a high-level overview of exposure to flood risk at a catchment scale. An integrated risk assessment that combines the latest information about flood-related hazards, exposure and vulnerability for the current climate and future climate change scenarios is currently underway as part of a collaboration between NIWA and the Van KIRAP project, the project will generate updated exposure data with an update to the Pacific Catastrophic Risk Assessment and Financing Initiative building database.

Recommendation R5: Develop a risk register to identify and document flood related risks, their likelihood and impact on systems of interest.

Timeframe: 2 years

Primary responsibility: Area Councils, DLA, and NDMO

A risk register is a systematic tool that can be used to identify, assess, and document flood-related risks, their potential likelihood, and the corresponding impact on systems of interest. This comprehensive register will potentially serve as a repository for recording various risks associated with flooding, ranging from infrastructure vulnerabilities to potential social and environmental impacts. Each risk needs to be evaluated in terms of its likelihood of occurrence and the severity of its potential consequences. By categorizing risks based on these parameters, decision-makers can prioritise and allocate resources more effectively to mitigate and manage the identified risks. The risk register can possibly act as a dynamic document that evolves over time, enabling DoWR and other key stakeholders to track risk trends, monitor mitigation strategies, and enhance flood resilience measures.

2.1.5 Warnings, dissemination and communication

Warnings provide a critical link between hazard detection and community safety and security. Flood warning dissemination and communication processes involve the timely and effective delivery of accurate information regarding impending floods to those at risk. Clear and accessible communication channels, including traditional media, digital platforms, and community leaders, enable the rapid dissemination of warnings. Equally important is the use of language and formats that resonate with the local population, ensuring that the messages are easily understood and actionable. Effective communication empowers individuals to make informed decisions, initiate evacuation if necessary, and take protective measures to safeguard lives and property (WMO, 2023).

2.1.5.1 Flood warning and dissemination

VMGD is responsible for issuing flood warnings, while NDMO oversees the coordination of all response efforts. The distribution of these warnings is managed through various channels such as SMS, radio, television, and social media platforms. Among these, Radio Vanuatu plays a pivotal role as a reliable means of reaching even the most remote areas across the country. In addition, during emergencies, alternative methods like word-of-mouth, traditional communication tools like Shell/Tam-tam/bells, flags, and whistles are occasionally employed for disseminating critical information.

The existing communication system for warnings in Vanuatu has specific drawbacks, particularly regarding the dissemination of warnings to all relevant parties. Despite SMS being the swiftest

communication method in the nation, there are occurrences where message transmission takes up to an hour or two. The usual warning procedure entails VMGD transmitting information to NDMO, which subsequently passes it on to the primary telecommunications operator (i.e. Digicel) for distribution. This added step within the process contributes to delays in effectively delivering warnings.

Recommendation W1: Incorporate community knowledge (including traditional knowledge) into the process of issuing flood warnings.

Timeframe: 1 year

Primary responsibility: VMGD

Secondary responsibility: DoWR, NDMO

Local communities often possess valuable insights derived from their historical experiences and deep understanding of the environment. Traditional knowledge, passed down through generations, often includes observations of nature's signals, subtle changes in weather patterns, and the behaviour of local water bodies. By incorporating this knowledge alongside scientific data and technological forecasting methods, early flood warnings can become more comprehensive and contextually relevant. Moreover, involving community members in the warning process fosters a sense of ownership and empowerment, increasing their willingness to take prompt actions during potential floods (UNDRR, 2022).

Recommendation W2: Ensure robust operational communication systems and equipment are in place.

Timeframe: 5 years

Primary responsibility: VMGD

Secondary responsibility: DoWR, NDMO, DLA, and other key stakeholders

This recommendation encourages the establishment of a communication network that encompasses various communication modes, including digital platforms, radio systems, satellite communication, and mobile apps. The communication system needs to be interoperable with the capability to function under adverse conditions to enhance the real-time sharing of critical information, updates, and alerts. Regular maintenance, training, and drills should accompany the communication system to ensure its effectiveness and readiness.

WMO checklist for an operational communication systems and equipment

- Trust between stakeholders established.
- Communication and dissemination systems tailored to the different needs of specific groups (urban and rural populations, women and men, older people and youth, people with disabilities, etc).
- Understanding of last-mile connectivity to know which population groups can be reached by different services, including mobile-cellular, satellite and radio services.
- Warning communication and dissemination systems reach the entire population, including seasonal populations and those in remote locations, through multiple communication channels (e.g., satellite and mobile-cellular networks, social media, flags, sirens, bells, public address systems, door-to-door visits, community meetings).
- Communication strategies evaluated to ensure messages are reaching the population.
- Agreements developed to utilise private sector resources where appropriate (e.g. mobile-cellular, satellite, television, radio broadcasting, amateur radio, social media) to disseminate warnings.

- Equipment maintained and upgraded to utilise new technologies (when appropriate) to ensure interoperability.
- Backup systems and processes in place in the event of failure.
- Resilience of communication channels and early warning system hardware evaluated in advance to reduce the impact of events on the infrastructure.
- Coverage of communication channels and multiple-channel systems assessed to identify gaps and possible points of failure that may increase vulnerability.

Note: Taken from the WMO's Warning Dissemination and Communication webpage (WMO, 2023)

2.1.6 Preparedness and response capabilities

The effectiveness of any FMP depends on the response shown by the people at-risk in response to any issued warning. Community members are more likely to respond to warnings when they have been educated about the risks in advance of an event and when they know what actions they can take to minimise their impacts. It is also crucial to incorporate thoroughly practiced and tested evacuation strategies within flood management plans. Individuals need to be extensively educated on secure practices that mitigate risks and safeguard their well-being. This entails awareness of available evacuation routes, safe zones, and effective measures to prevent property damage and loss.

2.1.6.1 Evacuation planning

During floods, evacuation procedures are typically improvised rather than following a predetermined plan. When alerts about heavy rainfall are received, the PDO and relevant authorities, with approval from the NDMO, make decisions to relocate communities that are at high risk of flooding. While specific evacuation routes haven't been formally designated, communities are familiar with the areas to move to during floods. Consultations have revealed that evacuation shelters are often situated at considerable distances from the affected areas, posing challenges in reaching them effectively.

Recommendation P1: Develop an evacuation plan tailored to the specific needs and vulnerabilities of communities residing near the Sarakata River.

Timeframe: 5 years

Primary responsibility: Area Councils

Secondary responsibility: PDO, DLA, and DUAP

The recommendation underscores the necessity of creating a detailed and well-structured evacuation plan that addresses the unique challenges faced by communities situated near the Sarakata River. This plan should be developed in close collaboration with the community to provide a clear and organised framework for prompt and safe evacuation in the event of flooding. The evacuation plan needs to be customised to the specific characteristics of the area, including population density, topography, transportation infrastructure, and potential flood scenarios. It ensures that people at risk are aware of the evacuation routes, assembly points, and safe shelters. The plan should also conform to the Van KIRAP Gender Equality, Disability and Social Inclusion (GEDSI) Action Plan.

2.1.6.2 Training and capacity building

Several NGOs and Community-Based Organizations have conducted awareness programs in Luganville in the past. However, a gap has been identified in the continuous provision of capacity-building initiatives for both local authorities and the community, ensuring sustained readiness for flood-related disasters. In 2021, the Luganville Community Climate Centre (CCC) was established as

part of the Van-KIRAP project. The CCC's role involves delivering Climate Information Services (CIS) to the community from the Vanuatu Meteorology and Geo-Hazards Department (VMGD). Additionally, it focuses on enhancing the adaptive capacity of communities and households to effectively utilise and apply CIS for resilience-building purposes. These community canter's offer posters and outreach materials, such as the one presented in Figure 2.3. This particular poster has been jointly developed by USAID, CARE, Red Cross, and NDMO, which is available at the Provincial Disaster Management Office.

Figure 2.3: Example of awareness material developed by NDMO for tropical cyclones (Source: NDMO).

Recommendation P2: Continued roll-out of risk-informed decision-making training to local planning authorities.

Timeframe: Ongoing

Primary responsibility: NDMO

Secondary responsibility: DLA, Area Councils, DoWR, VMGD, and DUAP

This recommendation involves equipping local planning authorities with the expertise and tools necessary for making decisions that are well-informed and considerate of potential risks. Through continued training in risk-informed decision-making, these authorities gain the ability to assess various options while considering the potential hazards, especially in scenarios involving disasters like floods. It enables local authorities to strike a balance between development aspirations and the imperative to safeguard lives, property, and the environment.

Recommendation: Continued public education and flood risk awareness raising.

Timeframe: Ongoing

Primary responsibility: NDMO

Secondary responsibility: DoWR, VMGD, and DUAP

It advocates for an ongoing effort to educate the public and raise awareness about flood risks. This ensure that individuals and communities have a clear understanding of the potential hazards posed by floods and are equipped with the knowledge and skills needed to respond effectively. For instance, people become better informed about the steps they can take to prepare for floods, the importance of early warnings, and the appropriate actions to take during floods. It creates a sense of community responsibility and ownership. When everyone understands the risks and the importance of preparedness, communities become more resilient as a whole. They can work together to develop and implement plans, share information, and support one another during challenging times. Some of the examples include: Mock drills/simulation exercises through school safety programmes, awareness raising programmes on preparedness, preparation of local language outreach material on personal disaster risk reduction strategies, and climate change adaptation.

2.2 Monitoring, evaluation, and learning (MEL) plan

2.2.1 Monitoring

Monitoring the FMP and EWS recommendations is a crucial step in ensuring their effective implementation and ongoing improvement. According to WHO, (2014), “monitoring provides information not only about what is happening and how activities are implemented but also about why things are or are not happening”. Regular monitoring serves as a critical mechanism to estimate the progress of each recommendation's execution, evaluate their impact, and identify potential areas for enhancement. This involves systematic tracking of the plan's implementation milestones, such as the establishment of communication systems, development of evacuation plans, integration of community knowledge, and other key activities. Monitoring also involves assessing the performance of the EWS in delivering timely alerts, analysing its accuracy in predicting floods, and its effectiveness in prompting appropriate responses (WMO, 2020; WHO, 2014; WMO, 2012).

The monitoring process assumes a pivotal role as a mechanism for documenting outcomes, processes, and lessons learned. It creates a repository of information that not only informs decision-making but also creates a culture of continuous learning and improvement. Indicators and targets are essential in the monitoring process as they act as a guide to measure the progress and

effectiveness of FMP and EWS implementation (USAID, 2021; WMO, 2012). Indicators presented in the Table 2.1 provide qualitative and quantifiable measurements to assess progress, effectiveness, and impact. These can be utilised to bridge the gap between recommendation and results, facilitating informed decision-making by translating complex concepts into tangible data points.

Targets, closely aligned with indicators, establish clear benchmarks for achievement. They are quantified goals that a recommendation should be achieved within certain timeframe (WHO, 2014; USAID, 2021; WMO, 2012). Targets presented in the Table 2.1 provide focus and direction for actors, especially DoWR, VMGD, and NDMO involved in flood management efforts.

Table 2.1 presents the Monitoring and Evaluation Framework for FMP and EWS which includes recommendations, timeframes, indicators, targets, frequency of evaluation, source of verification, and responsible entity. It is advisable to conduct comprehensive feasibility studies/scoping for each recommendation to ensure viability and effectiveness.

Table 2.1: Monitoring and evaluation plan for FMP and EWS

FMP and EWS theme	Recommendation	Timeframe	Indicator	Target	Source of verification	Frequency of evaluation	Responsible entity
Flood risk management governance and planning	G1: Update Sarakata flood response plan to improve clarity on roles and responsibilities.	2 years	• Clarity and Effectiveness of Roles and Responsibilities in the Updated Sarakata Flood Response Plan.	• Conduct two provincial/municipal consultative meetings/workshops every year. • Improve clarity and effectiveness of roles and responsibilities in the updated Sarakata Flood Response Plan within six months of implementation.	• Report to government.	Half-yearly	NDMO
	G2: Utilise the existing forum to improve coordination and partnerships.	Ongoing	• Enhancement of stakeholder collaboration and partnerships through existing forums.	• Increase the frequency of inter-agency collaborations and partnerships discussed and established through the existing forum by at least 50% within the first year.	• Documentation and feedback from stakeholders. • Survey results, meeting minutes, and qualitative assessments.	Yearly	NDMO
	G3: Update the Disaster Risk Management Act No. 23 of 2019.	3 years	• Level of Provincial Relevance in the Updated Disaster Risk Management Act No. 23 of 2019.	• Reflect provincial-level disaster risk management needs and context within three years.	• Documented assessments. • Report to Government.	Yearly	NDMO
	G4: Strengthened policies and institutional frameworks at the provincial level.	Ongoing	• Adequacy and implementation of strengthened policies and institutional frameworks at the provincial level.	• Adoption and effective implementation of policies and institutional frameworks at the provincial level within two years.	• Evaluation and monitoring reports from provincial authorities. • Report to government.	Yearly	DLA and DUAP
Flood risk management measures	F1: Detailed evaluation of possible options for structural flood mitigation measures within the catchment.	5 years	• Comprehensive evaluation of structural flood mitigation measures within the catchment.	• Complete a detailed evaluation report outlining the feasibility, effectiveness, and potential impacts of various structural flood mitigation options within the catchment in 5 years.	• Evaluation report.	Yearly	DoWR
	F2: Develop a catchment management plan for Sarakata.	2 years	• Completion and adoption of the Sarakata catchment management plan.	• Finalise and officially adopt the comprehensive Sarakata Catchment Management Plan within two years.	• Report to government.	Yearly	DoWR
	F3: Development of targeted policies focused on vulnerability reduction.	5 years	• Number of Targeted policies developed and implemented for vulnerability reduction.	• Develop and implement a minimum of two targeted policies focused on vulnerability reduction within the Sarakata catchment within the next three years.	• Documentation of the developed policies. • Report to government.	Yearly	NDMO
	F4: Update the Vanuatu Building Code to include consideration for climate change, disability design standards, and further detail on hazard-resilient buildings.	5 years	• Number of hazard-resilient building design standards added to the Vanuatu Building Code. • Integration of climate change, disability design standards, and hazard-resilient building details in the updated Vanuatu Building Code.	• Add a minimum of three hazard-resilient building design standards to the updated Vanuatu Building Code within three years. • Update the Vanuatu Building Code within five years.	• Report to government.	Yearly	MoIA, MIPU
	F5: Training/capacity development of local building control officers responsible for administering the building code through the building permit process.	5 years	• Enhanced competency of local building control officers through training and capacity development.	• Conduct training sessions for at least 80% of local building control officers responsible for administering the building code within three years. • Conduct training sessions for all local building control officers responsible for administering the building code within five years.	• Documentation of completed training sessions.	Yearly	PWD

FMP and EWS theme	Recommendation	Timeframe	Indicator	Target	Source of verification	Frequency of evaluation	Responsible entity
Flood risk management measures	F6: Update the Greater Luganville Development Control Plan to include conditions related to development in flood-prone areas and develop an action plan and training to support the implementation of the Control Plan for Greater Luganville.	5 years	• Incorporation of flood-related conditions in the updated greater luganville development control plan. • Completion of action plan and implementation training.	• Successfully update the Greater Luganville Development Control Plan to include specific conditions related to development in flood-prone areas within three year. • Develop and implement an action plan within four years. • Conduct training sessions for relevant stakeholders after updating the plan	• Official documentation of the updated Greater Luganville Development Control Plan. • Documentation of the developed action plan. • Records of conducted training sessions.	Yearly	DUAP
	F7: Develop risk management approaches for existing informal settlements, including incremental relocation from flood-prone settlements in consultation with the community.	5 years	• Completion of risk management approaches for informal settlements and incremental relocation plans.	• Develop risk management approaches for existing informal settlements within in five years.	• Report to government	Yearly	MoLNR
Hydrological observation, monitoring, analysis, and forecasting	O1: Continued development of monitoring instrumentation to support real-time data capture throughout the Sarakata catchment, and ongoing resourcing and capacity development for the maintenance and improvement of the existing monitoring network.	2 years	• Enhancement of real-time data capture and maintenance of monitoring network in Sarakata catchment.	• Procure and install monitoring instrumentation within a yearly cycle.	• Regular reports to government and documentation.	Yearly	DoWR
	O2: Utilise existing/develop a forum to enable coordination and partnerships accompanied by the procedures for coordination and data sharing between VMGD and DoWR.	Ongoing	• Enhancement of stakeholder collaboration and partnerships through existing forums.	• Increase the frequency of collaborations and partnerships by at least 50% within the first year.	• Documentation and feedback from stakeholders. • Survey results, meeting minutes, and qualitative assessments.	Half-yearly	VMGD
	O3: Training and capacity building to support the development of flood forecasting capabilities.	5 years	• Enhanced flood forecasting capabilities.	• Conduct comprehensive training and capacity-building programs leading to a 30% improvement in accuracy and timeliness of flood forecasts within the first year.	• Monitoring and assessment reports. • Feedback from stakeholders.	Yearly	VMGD
	O4: Develop flood hazard thresholds for the Sarakata catchment.	2 years	• Establishment of flood hazard thresholds for the Sarakata Catchment.	• Develop and finalise flood hazard thresholds within two years.	• Official documentation.	Yearly	DoWR
Disaster risk knowledge	R1: Establish a geospatial database and data management protocol.	2 years	• Implementation of geospatial database and data management protocol.	• Successfully establish and administer a geospatial database and data management protocol to support flood risk management within two years.	• Documentation showcasing the creation and administration of the geospatial database and data management protocol.	Yearly	VMGD
	R2: Flood hazard/risk maps should be periodically verified/validated, if necessary recalibrated, based on observations and future climate projections.	3 years	• Frequency of verification and recalibration of flood hazard/risk maps.	• Periodically verify and recalibrate flood hazard/risk maps based on observations and future climate projections, with updates conducted at least once every two years.	• Documentation showcasing the frequency of verification, recalibration, and updates to the flood hazard/risk maps.	Yearly	DoWR
	R3: All model files and results should be made available to DoWR and other key stakeholders to facilitate periodic future flood model updates and other actions.	3 years	• Accessibility and sharing of flood model files and results with stakeholders.	• Ensure that all flood model files and results are made accessible to DoWR and other key stakeholders within three years.	• Documentation showcasing the sharing and accessibility of flood model files and results with DoWR and other identified stakeholders.	Yearly	DoWR

FMP and EWS theme	Recommendation	Timeframe	Indicator	Target	Source of verification	Frequency of evaluation	Responsible entity
Disaster risk knowledge	R4: Conduct a comprehensive flood impact assessment to evaluate the potential consequences of flooding on communities, infrastructure, and the environment.	5 years	• Completion of comprehensive flood impact assessment.	• Conduct a comprehensive flood impact assessment within five years.	• Documentation of the completed flood impact assessment.	Yearly	NDMO
	R5: Develop a risk register to identify and document flood related risks, their likelihood and impact on systems of interest.	2 years	• Completion of flood risk register and documentation of identified risks.	• Develop a comprehensive flood risk register within two years.	• Documentation of the completed flood risk register.	Yearly	Area Councils
Warning dissemination and communication	W1: Incorporate community knowledge (including traditional knowledge) into the process of issuing flood warnings.	1 year	• Integration of community knowledge into flood warning issuance process.	• Achieve a participation rate of at least 70% of community members. • Incorporate community knowledge, including traditional knowledge, into the process of issuing flood warnings within 1 year.	• Records of community engagement sessions, meeting minutes, and documented instances of integrating traditional knowledge into flood warning decision-making.	Half-yearly	VMGD
	W2: Ensure robust operational communication systems and equipment are in place.	5 years	• Establishment of robust operational communication systems and equipment.	• Ensure that alerts and instructions reaching stakeholders in less than 15 minutes after the onset of flooding, and regular updates provided every 30 minutes thereafter within five years.	• Records of communication timestamps, alert dissemination reports, and documentation of communication protocols.	Yearly	VMGD
Preparedness and response capabilities	P1: Develop an evacuation plan tailored to the specific needs and vulnerabilities of communities residing near the Sarakata River.	5 years	• Completion and implementation of tailored evacuation plan.	• Develop and implement a tailored evacuation plan of at least three most at-risk communities within 3 years.	• Record of evacuation plans. • Records of evacuation drills, exercises, and real-life evacuation events, including incident reports, participant lists, and documented outcomes.	Yearly	Area Councils
	P2: Continued roll-out of risk-informed decision-making training to local planning authorities.	Ongoing	• Incorporation of risk-informed practices in local planning.	• Ensure that local planning authorities consistently integrate risk-informed practices into their decision-making processes and development plans within one year.	• Report to government. • Review of local development plans, policies, and decisions.	Half-yearly	NDMO
	P3: Continued public education and flood risk awareness raising.	Ongoing	• Number of public education and awareness sessions.	• Conduct a minimum of 3 public education and awareness sessions on flood risks and preparedness measures within one year.	• Records of conducted education and awareness sessions.	Half-yearly	NDMO

2.2.2 Evaluation

Evaluation serves as a systematic process aimed at assessing the effectiveness and efficiency of undertaken initiatives. It involves a comprehensive examination of the outcomes, outputs, and processes, assessing the extent to which targets have been met. Evaluations needs to address issues of relevance, effectiveness, efficiency, and sustainability of the achievement of deliverables and expected results. In particular, it should focus on (WMO, 2012):

- Unintended outcomes.
- The satisfaction of stakeholders/community members.
- External factors that have affected implementation.
- Challenges encountered during implementation.
- Corrective actions taken and eventual adjustment of strategies.
- What worked well and why.
- Lessons learned.

To generate precise and unbiased information, evaluation needs to employ rigorous research methodologies, including representative surveys and extensive quantitative analyses. Evaluations play a crucial role in addressing knowledge gaps that cannot be easily resolved through other methods, such as the analysis of monitoring data. These assessments can be targeted at specific recommendations or encompass the entire FMP & EWS itself. By examining these areas, evaluations provide valuable evidence to answer essential questions and enhance our understanding of program effectiveness and impact (USAID, 2021).

Evaluating the FMP and EWS is crucial and should occur either after a five-year period or in the aftermath of a significant flooding. This evaluation timeline allows for periodic assessments of the plan's effectiveness and its ability to respond to challenges. Additionally, conducting evaluations following major floods provides an opportunity to learn from experiences and make necessary improvements to enhance the resilience of the FMP and EWS in the face of evolving flood risks.

2.2.3 Learning

The section on learning discusses how the responsible entity will work with partners and stakeholders to learn from the project and its activities throughout implementation and act on that learning to adaptively manage the project. Learning in monitoring and evaluation is not only about measuring progress and outcomes but also about understanding why certain outcomes were achieved or not achieved. It involves identifying the underlying factors and contexts that influence program performance. By identifying both strengths and weaknesses, learning in M&E facilitates the identification of best practices and areas for improvement. This iterative learning process supports evidence-based decision-making and contributes to the overall effectiveness and impact of programs and initiatives (USAID, 2021).

2.2.4 Next steps

The proposed recommendations on the MEL Framework should be reviewed and confirmed by DoWR and VMGD, including the structure and the timeline for undertaking evaluations of the FMP and EWS. In addition, the implementation of the MEL Framework will require dedicate resourcing, such as the provision of human resources, and DoWR and VMGD should identify sources of financing for these activities.

3 Part 2: Sarakata flood response Standard Operating Procedures

3.1 Introduction

This section details the purpose and objectives of these procedures. It explains who should use these procedures and how they are structured.

3.1.1 Purpose and objectives

The purpose of this document is to inform stakeholders within the Sarakata Catchment of the roles, responsibilities, procedures, actions, decisions, and resources to enable them to prepare for, respond to and recover from floods in the catchment.

The objectives of this document are to:

- Describe the necessary response to floods in the Sarakata Catchment.
- Outline the flood response structure and arrangements (i.e. decision tree).
- Detail how flood responders are initially notified of floods.
- Describe the roles and responsibilities of stakeholders involved in flood response.
- List the actions each stakeholder should undertake before, during and after flooding.

3.1.2 Revision of document

The flood response SOP should be updated as improved equipment, data and capabilities become available. Specifically, the SOP will be updated upon receiving the provincial level SOP and after the completion of the workshop. This iterative process ensures that the SOP remains current and aligned with the latest advancements and best practices in flood response management.

Table 3.1 provides critical review points that may require an update to this document.

Table 3.1: Schedule of triggers to update Sarakata Flood Response SOP

Section	Description	Revision trigger
SOP (whole document).	Important information gained by conducting debriefing sessions at the conclusion of a flood emergency response.	The SOP may be updated with lessons learned following: • The debriefing session at the conclusion of a flood emergency response. • Flood response training exercise.

3.2 Flood stages and relevant response agencies

An overview of the flood stages agencies and response agencies are included in the sections below:

- Flood response agencies.
- Agency information and communication flows.
- Flood stages.

3.2.1 Flood response agencies

A flood response involves input from numerous agencies. VMGD is responsible for issuing flood warnings, while NDMO is responsible for coordinating flood response at the national level. The Sanma Provincial Emergency Operation Centre (PEOC)/Municipal Emergency Operation Centre (MEOC) is

activated by NDMO to oversee and manage response efforts at the provincial/municipal level. The list of national and provincial agencies with responsibilities in a flood response is given below:

- Vanuatu Meteorology and Geo-hazards Department.
- Department of Water Resources.
- National Disaster Management Office.
- Provincial Disaster Management Office.
- Provincial Disaster and Climate Change Committee/ Municipal Disaster and Climate Change Committee.
- Provincial Emergency Operations Center/ Municipal Emergency Operations Center.
- Area Council/Wards.
- Community Disaster Climate Change Committee / Chief/ Community representatives.
- Telecommunication agencies (e.g. Digicel).
- Media (TV and Radio).
- Vanuatu Police Force.
- Luganville Fire Service.
- Northern Provincial Hospital, Luganville.
- Vanuatu Red Cross (Sanma Branch).
- Community and sector working groups.
- Partner agencies/ organisations.

3.2.2 Agency information and communication flows

The agencies involved in a flood response, and the main information communication flows between agencies is shown in Figure 3.1.

3.2.3 Flood stages

Flood stages are classified as:

- Normal.
- Alert.
- Warning.
- Response.
- Stand down.
- Recovery.

The main activities involved in each stage of the flood response are detailed in Sections 3.2.3.1 to 3.2.3.6. Further detail on the key activities and responsibilities at each stage for all relevant stakeholders included in Section 3.3.

Agency-specific SOP for activation, operation and stand down should be followed.

It is important to note that a flood response will not always pass through every stage of the response as outlined below, for instance, in some cases a Warning may be triggered without any prior Alert. Or in the case of rapidly developing flash floods, a response may escalate from an Alert straight into a full-scale Response without the need to pass through the interim Warning stage.

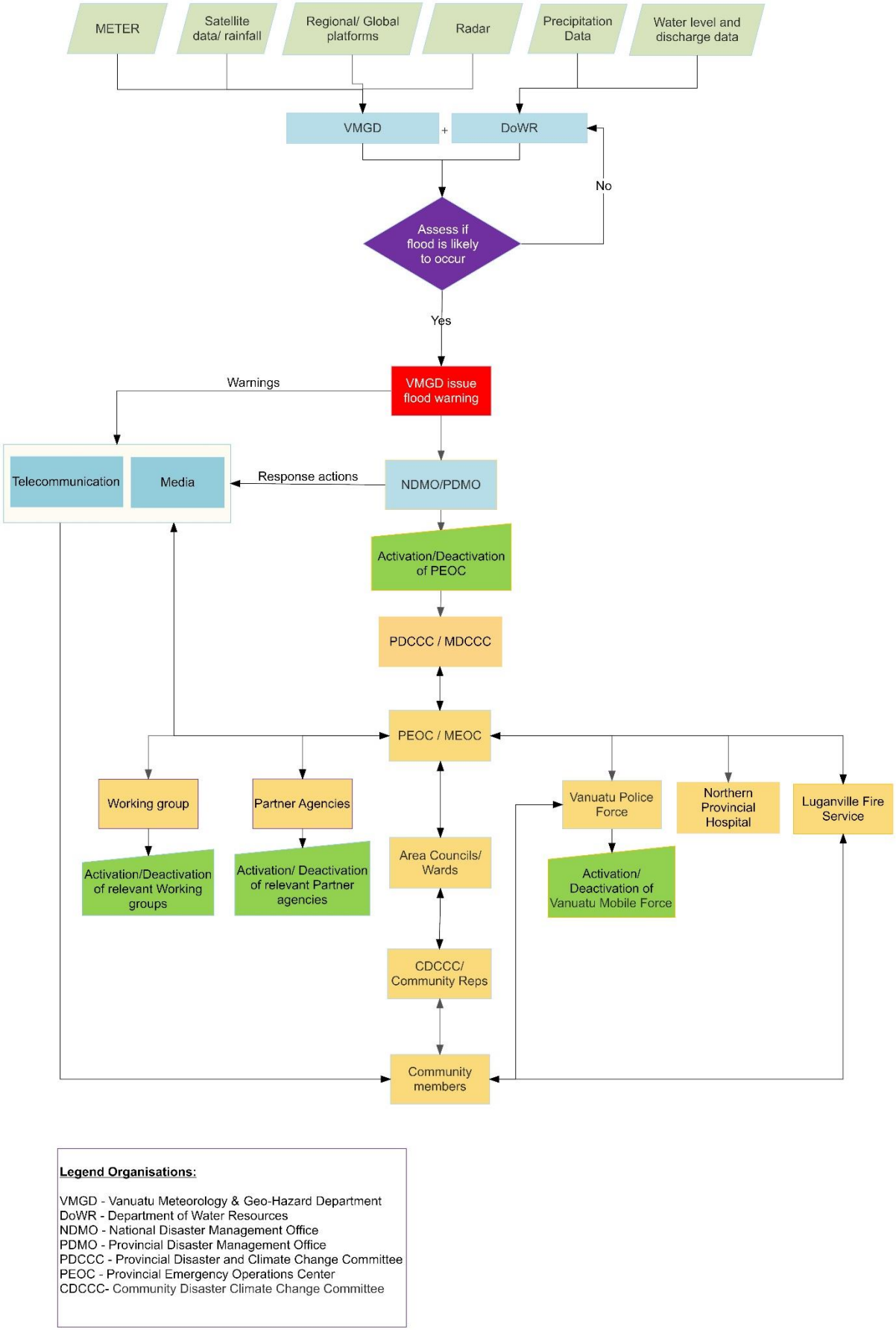


Figure 3.1: Sarakata Flood response decision tree (Source: Tonkin+Taylor).

3.2.3.1 Normal

Under Normal conditions national and local stakeholders involved in flood management within the Sarakata catchment maintain core business-as-usual activities. These activities include ongoing observation, and the continued improvement of monitoring networks and flood forecasting capabilities. Flood hazard and risk assessments are progressed and updated to improve flood knowledge and impact based early warning capabilities. Operations staff are responsible for the management and maintenance of drainage and flood protection assets within the catchment.

Proactive actions during Normal conditions (including trainings, flood simulation exercises, evacuation drills and risk communication activities) are an important part of ensuring that institutions and communities are moving towards a greater level of flood preparedness so that flood vulnerabilities are addressed to reduce the impact of future floods.

3.2.3.2 Alert

The transition from Normal conditions to the activation of a full-scale flood response passes through two intermediary stages, an Alert stage, and a Warning stage. Thresholds for the activation of each stage are triggered by weather forecast data, supplemented by real-time data gathered from the Sarakata catchment observation network, as well as direct observations from individuals on the ground in the catchment.

The issuing of an Alert is the first phase of escalation in a flood response and requires that lines of communication between key stakeholders are established and maintained. Lines of communication between local response actors and the community should also be established during the Alert phase to ensure that information on the situation is relayed to community members as soon as possible.

Agency-specific SOP for activation, operation and stand down should be followed.

3.2.3.3 Warning

The Warning phase is an escalation from the Alert phase and represents a shift from potential flooding, to expected flooding.

As in the Alert phase the ongoing monitoring of hydrological data and flood forecasts is essential. With flooding now expected, it is important during the Warning phase to begin assessing the potential impacts of flooding to enable a more targeted response.

During the Warning phase, responsibilities shift from being primarily stand-by functions, the dissemination of information and ongoing monitoring of the situation, towards active preparation in anticipation of flooding. The number of stakeholders allocated responsibilities and the resources which must be mobilised to undertake responsibilities is significantly higher than during the Alert phase.

Agency-specific SOP for activation, operation and stand down should be followed.

3.2.3.4 Response

A flood Response can be triggered by real-time rainfall and river level data captured within the Sarakata catchment, or in response to flooding otherwise confirmed within the catchment. This stage involves the full-scale deployment of emergency response teams.

Agency-specific SOP for activation, operation and stand down should be followed.

3.2.3.5 Stand down

The Stand down period is the transition between response and recovery phases of the flood response, when activities are scaled down.

3.2.3.6 Recovery

The Recovery stage bridges the gap between an emergency and a return to normal conditions. The coordination of flood recovery activities remains the responsibility of the PDCCC and the Sanma Provincial Government.

For minor floods, further recovery activities are not normally required, however, efforts should always be made to document flood extents and record flood impacts even when damage and disruption were minimal. Gathering data after every flood is important as it forms a record of the floods and informs activities such as the calibration and refinement of flood forecasting models, early warning systems and the continued development of flood response procedures.

Following a severe flood, affected individuals may require ongoing support in the form of aid distributions, temporary housing, or psycho-social support. Damaged infrastructure may require repair or upgrading to mitigate future flood impacts. In the event of a major disaster, external disaster relief funding may be required and the establishment and administration of such a fund would be the responsibility of NDMO.

Specific detail on the individual roles and responsibilities of flood response actors in the Recovery stage is not included in this flood response SOP. Each agency will need to develop its own individual policies and procedures for Recovery and return to business as usual following an emergency response.

3.3 Flood response roles and responsibilities

This section details the roles and responsibilities of agencies involved in the response to floods. Responsibilities are identified for the Alert, Warning and Response stages of the flood response. Table 3.2 presents the roles and responsibilities of flood response agencies.

Table 3.2: Flood response roles and responsibilities

Agency	Data/information needs	Responsibilities			Means of communication/ dissemination
		Alert	Warning	Response	
Vanuatu Meteorology and Geo-hazards Department	Utilise data from: • Observation stations (7). • METER, ARFOR (Area Forecast). • Radiosonde. • Weather radar. • Satellite data/rainfall. • Regional and global platforms.	• Disseminate alerts (by Weather Forecasting & Services Division (WFSD)) on adverse weather conditions at least 6-12 hours ahead of an anticipated event to the NDMO, PDMO, telecommunication agencies, media and other relevant stakeholders. • Collaborate with DoWR to evaluate the likelihood of the floods.	• Identify the potential for heavy rainfall. • Evaluate the likelihood and severity of the floods in close collaboration with DoWR. • Issue flood warnings to NDMO, PDMO, media, and other stakeholders. • Provide timely updates on weather conditions, including heavy rainfall, to the NDMO, PDMO, telecommunication agencies, media and other relevant stakeholders. • Communicate with the PDMO on any significant changes or updates in the weather forecast, ensuring that timely and accurate information is available for decision-making.	• Continue to analyse forecasts to verify predictions. • Receive feedback from PEOC regarding inundation regarding river levels. • Issue the "All Clear" notification to all concerned stakeholders when the river situation indicates that there is no longer a likelihood of further floods.	VMGD to disseminate alerts and warnings to the NDMO, PDMO, telecommunication agencies, media and other relevant stakeholders through: • Email. • SMS. • Phone. And other relevant stakeholders through: • Email. • SMS. • Phone. • Media. • Social media. • Other relevant channels.
Department of Water Resources	Utilise data from • River levels. • Flood forecast. • Risk assessment.	• Provide real-time hydrological data and flood forecasts information to VMGD to evaluate the likelihood of the floods.	• Detect rising river levels and increased flow rates and advise VMGD to issue Flood Warning to NDMO and PDMO. • Ensure a representative is available at the PEOC.	• Offer technical guidance to VMGD pertaining to data on the current situation and hydrological matters of interest.	DoWR to communicate with relevant stakeholders through: • Email. • Phone.
National Disaster Management Office	Alerts and warnings from VMGD.	• Initiate communication with the PDO in Luganville to engage in discussions regarding national arrangements. • NDMO director to provide guidance to the PDO on activating the PEOC/MEOC.	• Provide guidance and technical support to the PDO in flood management efforts. • Collaborate with PDO to assess the situation and to activate clusters.	• Provide guidance and technical support to the PDO in flood management efforts. • Pass on the “All Clear” Notification to PDO.	NDMO to communicate with PDO through: • Email. • Phone.
Provincial Disaster Officer	Alerts and warnings from VMGD or NDMO.	• Initiate communication with VMGD for updates. • Initiate communication with the PDCCC/MDCCC to engage in discussions regarding the activation of PEOC. • Disseminates warnings to the Heads of the departments to keep them updated.	• Assess the potential impact on the local community.	• Coordinates local-level response activities. • Pass on the “All Clear” Notification to PDCCC/MDCCC.	PDO to communicate with NDMO and PDCCC/MDCCC through: • Email. • Phone.

Agency	Data/information needs	Responsibilities			Means of communication/ dissemination
		Alert	Warning	Response	
Provincial Disaster and Climate Change Committee / Provincial Emergency Operations Center **Municipal Disaster Climate Change Committee / Municipal Emergency Operations Center**	Information from PDO. Internal communication tree.	• Initiate communication with VMGD for updates. • If necessary, activate PEOC/MEOC during office hours and monitor the situation with. • Utilise the internal communication tree exists to facilitate the information flow within the PDCCC, especially for the PEOC/MEOC activation/ authorisation (or guidance) of the NDMO. • Arrange individual briefing meetings with the Heads of Departments who are members of PDCCC to provide important updates, discuss the current situation, and ensure their understanding of their roles and responsibilities in the emergency response efforts. • Share the alerts with the Area Council to ensure they are aware of the current situation. • Ensure that staff members are available to staff the PEOC/MEOC.	• Activate the PEOC/MEOC on 24-hour rotation and establish an operational base for response efforts. • PDCCC/MDCCC organise coordination briefing with leaders of each working groups and PEOC/MEOC to ensure flow of information. • PDCCC/MDCCC activate their early warning communication tree and formulate messages to be shared to targeted people. • Maintain communication with VMGD for updates. • Keep NDMO informed with regular and up-to-date information regarding the ongoing situation, including relevant data, reports, and updates, to facilitate informed decision-making and effective coordination of emergency response efforts. • Review the situation and initiates the response measures. • Notify the Emergency Response Teams, including Health, Fire, and Police, to be prepared and ready for immediate response. This includes ensuring that their personnel, equipment, and resources are in a state of readiness to effectively address any emergency that may arise. • Share the alerts with the Area Council to ensure they are aware of the current situation and can take appropriate actions at the local level. • Coordinate with the Police Commanding Officer, a member from PDCCC/MDCCC, to notify the Vanuatu Police Force about the situation. Request their assistance in conducting community-wide warnings and patrols to inform the residents of the potential flooding and the importance of evacuating to safer areas. • Contact NDMO/PDO and request authority to set up evacuation centres and rationing. • Serve as the primary contact for any organization in need of emergency contacts or phone numbers. • Assume the role of the lead coordinating agency for the response efforts addressing the floods in the Sarakata catchment. • Serve as the central hub for disseminating situational information to the media and the public. • PDCCC/MDCCC establishes a communication strategy to disseminate accurate information to the affected communities, addressing the rumours and providing clear guidance on evacuation procedures, safety measures, and available support. • Keep a comprehensive emergency record of all actions taken, including updates from the VMGD indicating the potential worsening of the situation in the upcoming hours, i.e. Situation Reports (SitReps, refer to Appendix G for template). • Keep a record of the funds utilised by each agency and the overall operation to ensure transparency and accountability. • Ensure efficient coordination and management of logistics, including procurement, transportation, and distribution of	• Collaborates with relevant stakeholders to implement the response plan. • Coordinates emergency response activities, including communication, resource mobilization, and decision-making. • Communicate and coordinate with NDMO (NEOC) to request additional resources if needed for the ongoing operations. • Facilitate and coordinate all response efforts. • Provide assistance with the evacuation process and staffing of evacuation centres. • Arrange transportation to evacuate the most vulnerable individuals. • Facilitate and coordinate all relief efforts, including the distribution of relief supplies (as approved by National Disaster Committee). • Update logistic capacity. • Schedule regular PEOC/MEOC coordination meetings with the leads of each working group. • Prepare comprehensive assessment reports and Situation Reports (SITREPs) that consolidate relevant information and provide updates to all relevant stakeholders on the current situation. • Gathers information on needs and damage from Area Council in the first 24 hours. • Submit the first verbal situation report provided by Area Council to NDMO. • Organise coordination meeting with Leads of working group frequently. • Terminate PEOC/MEOC upon receiving the “All Clear” notification from VMGD. • Call for a coordination meeting to gather final response actions. • In collaboration with PDO, inform NDMO in instances where the emergency exceeds the capability and to declare a State of Emergency (SOE).	PDCCC/MDCCC to communicate with all stakeholders including, NDMO, Health, Fire, and Police, Provincial Departments, Partner agencies, and Media through: • Phone. • Email. PDCCC/MDCCC to communicate with Area Councils through: • Phone. • SMS.

Agency	Data/information needs	Responsibilities			Means of communication/ dissemination
		Alert	Warning	Response	
Provincial Disaster and Climate Change Committee / Provincial Emergency Operations Center **Municipal Disaster Climate Change Committee / Municipal Emergency Operations Center**			essential resources, to support emergency response activities effectively. • Advise the Working Group members to activate their operations and utilise the established communication tree to disseminate important information effectively and efficiently. • Coordinate with the Working groups (food security and agriculture, logistics, gender and protection, education, health and nutrition, shelter, water, and sanitation) to ensure they are informed about the situation. Liaise with each working group to facilitate their involvement and encourage them to take appropriate actions in their respective areas of expertise. • Ensure that the evacuation centre is open and accessible for those in need. • Disseminate the list of evacuation centres for each ward.		
Area Council(s)/ Ward(s)	Information from PEOC/MEOC (under PDCCC/MDCCC).	• Keep the CDCCC/ community representatives/ chiefs informed about the current situation by providing regular updates the ongoing events and developments. • Ensure that resources and personnel from the CDCCC are adequately briefed and prepared for potential activation in response to the situation.	• Keep the CDCCC chairman/ community representatives informed about the current situation by providing regular updates the ongoing events and developments. • Provide guidance to the CDCCC, community representatives, and chiefs to advise their respective communities to evacuate to safe locations. • Liaise with PDCCC/MDCCC on the type of assistance required.	• Keep the CDCCC chairman/ community representatives informed about the current situation by providing regular updates the ongoing events and developments. • Share community information, assessments, and situation reports with the PEOC/MEOC (under PDCCC/MDCCC). • Liaise with PDCCC/MDCCC on the type of assistance required during response. • Support CDCCC to mobilise community resources, such as vehicles, boats, or equipment, to assist in evacuation and rescue efforts. • Coordinate response to the floods • Wards conducts visual assessments of the affected areas and call the PDCCC/MDCCC to provide the first oral report. • Send the first community assessment to the province (on foot, by truck, boat or plane) or read it through the phone.	Area Councils to communicate with CDCCC through: • Phone. • SMS. • HF Radio. • Word of mouth (door-to-door). • Shell/Tam-tam/Bell. • Flag. • Whistle. Area Council/Wards to communicate with PDCCC/MDCCC through: • Phone (or HF Radio). • SMS.
Community Disaster Climate Change Committee / Chief / Community representatives	Information from Area Council/Wards.	• Disseminate informative messages to the community to enhance their preparedness for potential emergencies, promoting awareness and providing guidance on necessary actions to be better prepared.	• Alerts local communities and activate response networks. • Coordinate with local authorities and community leaders to disseminate evacuation instructions[6]. • Support vulnerable community members in understanding and following evacuation procedures.	• Mobilise community volunteers and resources to support evacuation efforts and provide assistance to those in need. • Mobilise community resources, such as vehicles, boats, or equipment, to assist in evacuation and rescue efforts. • Monitor the protection issues during the evacuation. • Gather community and then by visiting each affected house to fill in the first	CDCCC / Chief/ Community representatives to communicate with Community through: • Phone. • SMS. • Word of mouth (door-to-door). • Shell/Tam-tam/Bell. • Flag. • Whistle.

[6] A functional impact based early warning system will support in evacuating communities at risk earlier than the response phase.

Agency	Data/information needs	Responsibilities			Means of communication/ dissemination
		Alert	Warning	Response	
Community Disaster Climate Change Committee / Chief / Community representatives				assessment of the affected community to identify immediate needs and prioritise response efforts. • Submit the first assessment form to Area Council. • Assess damage to infrastructure, homes, and community facilities. • Identify vulnerable populations, such as children, elderly, pregnant women, and individuals with disabilities, and ensure their specific needs are addressed. • Facilitate the distribution of relief supplies, including food, water, medical assistance, and non-food items. • Maintain a register of displaced people.	CDCCC to communicate with Area Council/Wards/ PDCCC/MDCCC through: • Phone (or HF Radio). • SMS.
Telecommunication agencies (e.g., Digicel)	Alerts and warnings from VMGD and PEOC/MEOC (under PDCCC/MDCCC).	• Ensure that the current capacity is assessed and provide advice to the PDCCC/MDCCC, including the availability contingency plans. • Disseminates SMS alerts through mobile networks.	• Provide assistance to the PEOC/MEOC (under PDCCC/MDCCC) by ensuring the provision of emergency telephone communications. • Maintain communication with the PEOC/MEOC (under PDCCC/MDCCC) to assess the telecommunication requirements. • Disseminates warnings through mobile networks.	• Ensure that communications links for the PEOC/MEOC (under PDCCC/MDCCC) are maintained and operational. • Prioritise restoration of telecommunication services in the most affected areas.	Telecommunication agencies to communicate PEOC/MEOC (under PDCCC/MDCCC) through: • Email. • Phone. Telecommunication agencies to communicate community members through: • SMS.
Media (TV and Radio)	Alerts and warnings from VMGD and PEOC/MEOC (under PDCCC/MDCCC).	• Disseminates alerts to public of likely flooding areas.	• Assist in broadcasting the Flood Warning through all available stations and frequencies. • Communicate with PEOC/MEOC for further updates.	• Communicate with PEOC/MEOC for further updates.	Media to communicate PEOC/MEOC (under PDCCC/MDCCC) through: • Email. • Phone. Media to communicate community members through: • Television (TV). • Radio.

Vanuatu Police Force	Information from PEOC/MEOC (under PDCCC/MDCCC).	• Initiate and coordinate the initial dissemination efforts.
		• Ensure that all personnel are informed and equipped to monitor river levels during their patrols.
			• Function as the lead in coordinating response efforts.
			• The Police Commanding Officer will be represented on the PDCCC/MDCCC.
			• Pass on the following information to PEOC/MEOC (under PDCCC/MDCCC):
			  ○ Flood/river level observations.
			  ○ Areas at risk of flooding.
			  ○ Area that are flooding.
			  ○ Areas to be evacuated.
			  ○ Areas that are evacuated.
			• Conduct community dissemination using a mobile siren system installed in Police vehicles for emergency alerts and announcements (only if authorised by PDCCC/MDCCC).
			• Collaborate with PEOC/MEOC (under PDCCC/MDCCC) and assist in enforcing road closures and maintaining order.
				• Provide security and maintain law and order during flood response efforts (including affected areas and evacuation centres).
				• Work closely with the PEOC/MEOC and other relevant authorities to ensure compliance with road closure instructions.
				• Coordinate traffic management efforts in flood-affected areas and redirect traffic away from closed roads and implement alternative routes to ensure the smooth flow of vehicles and maintain public safety.
					Vanuatu Police Force to communicate with PEOC/MEOC (under PDCCC/MDCCC) through
					• Phone.
					• SMS.
					Vanuatu Police Force to communicate with community members through:
					• Siren system installed in Police vehicles.

Agency	Data/information needs	Responsibilities			Means of communication/ dissemination
		Alert	Warning	Response	
Vanuatu Police Force				• Assist in evacuation of affected population, search and rescue operations, and relief distribution. • Assist in coordination efforts of relevant partner agencies. • Assist in identifying the deceased people.	
Luganville Fire Service	Information from PEOC/MEOC (under PDCCC/MDCCC). Information from Vanuatu Police Force.	• Initiate and coordinate the initial dissemination efforts. • Ensure that all personnel are informed and equipped.	• Contact the Vanuatu Police Force and PEOC/MEOC (under PDCCC/MDCCC) to provide them with a briefing and specific task to be carried out. • Activate the siren only upon authorization from the PEOC/MEOC (under PDCCC/MDCCC). • Conduct community dissemination using a mobile siren system installed in fire engines for emergency alerts and announcements (only if authorised by PDCCC/MDCCC).	• Assist in evacuation of affected population and search and rescue operations. • Take necessary actions for firefighting as required.	Luganville Fire Service to communicate with Vanuatu Police Force through: • Email. • Phone. • SMS. Luganville Fire Service to communicate with community members through: • Siren system installed in Police vehicles.
Northern Provincial Hospital, Luganville	Information from PEOC/MEOC (under PDCCC/MDCCC). Information from Vanuatu Police Force and Fire Service.	• Ensure that all personnel and resources are made ready in the event of an evacuation. • Expeditiously release patients with minor injuries or outpatient cases to return to their homes.	• Advise MoH HQ of the Flood Warning • Safeguard crucial equipment and medication by transferring them to a secure and protected area. • Promptly discharge patients with moderate cases to their homes. • Coordinate the transportation of critical (severe) cases to other referral hospitals in Sanma Province for evacuation, utilizing ambulance services.	• Facilitate the evacuation of all patients. • Safely relocate all bodies in the mortuary to an alternative area. • Include medical personnel in Emergency Response Teams (ERTs) to provide medical support in response to situations that may arise at evacuation centres or remote areas. • Ensure that evacuation centres are safe by providing necessary services such as clean water and sanitation facilities, basic care, and nutrition for the evacuees.	NPH to communicate with Vanuatu Police Force through: • Email. • Phone. • SMS. NPH, Luganville to communicate with other referral hospitals through: • Phone. • Email.
Vanuatu Red Cross (Sanma Branch)	Information from PEOC/MEOC (under PDCCC/MDCCC).	• Ensure that all personnel are informed and equipped.	• Activate internal emergency response mechanisms and mobilise disaster response teams or designated personnel upon receiving the alert from the PDCCC/MDCCC. • Establish communication channels to ensure effective coordination and information sharing among staff and volunteers.	• Deploy necessary personnel and equipment to assist with evacuation, search and rescue, relief distribution, and medical assistance.	Red Cross to communicate with PEOC/MEOC (under PDCCC/MDCCC) through: • Email. • Phone.

Agency	Data/information needs	Responsibilities			Means of communication/ dissemination
		Alert	Warning	Response	
Working groups	Information from PEOC/MEOC (under PDCCC/MDCCC).	• Ensure that all personnel are informed and equipped.	• Each working group to establish communication channels to ensure effective coordination and information-sharing.	• Provides support in analysing information and reporting it in the SitRep template (refer to Appendix G). • Relevant working group to support in evacuation efforts.	Working groups to PEOC/MEOC (under PDCCC/MDCCC) • Email. • Phone. • SMS. Working groups to their relevant stakeholder: • HF Radio. • Phone. • SMS. • Email. • Other relevant communication channel.
Partner agencies/ organisation	Information from PEOC/MEOC (under PDCCC/MDCCC)	• Ensure that all personnel are informed and equipped.	• Each partner agency/organisation to establish communication channels to ensure effective coordination and information sharing.	• Provides support in analysing information and reporting it in the SitRep template (refer to Appendix G). • Relevant partner organisation to support in evacuation efforts.	Partner agencies/ organisations to PEOC/MEOC (under PDCCC/MDCCC) • Email. • Phone. • SMS. Partner agencies/ organisations to their relevant stakeholder: • HF Radio. • Phone. • SMS. • Email. • Other relevant communication channel.

3.4 Debriefing, review and revision

Important information can be gained from debriefing sessions at the conclusion of a flood emergency response. The debrief and review should be led by NDMO and should be facilitated by the individual with overall responsibility for directing the Response stage, or another suitably qualified individual with recognised authority.

The purpose of the debrief is to:

- Review the scope and effectiveness of the flood response.
- Identify strengths and weaknesses within agencies, response teams, organisational structures, systems, and processes.
- Capture detail on any problems encountered during the Response stage and suggested potential solutions.
- Gather feedback on the adequacy of the current flood response plan.

A separate and fully comprehensive debrief, involving all participating institutional and community stakeholders should be conducted at the conclusion of the response following a return to business as usual. Each group or individual participating should be given sufficient time and opportunity to provide feedback during the debrief session. It is a good idea to request that all participants provide a report on their participation in the response operation. This also provides an opportunity for additional feedback to be recorded, which may not be captured during the debrief.

The debrief should be formally structured, with an agenda provided to participants beforehand. The debrief should consider all aspects of the Response stage. For example, a suggested debrief structure, which follows the sequence of the flood response stages, could proceed as follows:

1 Welcome and introductions.
2 Flood overview.
3 Alert stage.
4 Warning stage.
5 Response stage.
6 Stand down stage.
7 Conclusion.

Recommendations and lessons learned must be documented and acted on, where necessary prompting revisions to these SOP (managed by NDMO), as well as other aspects such as institutional arrangements, systems, and processes.

Each debrief, review and revision process following floods should include the preparation of a written report capturing the key lessons learned, proposed solutions and any formal recommendations to be made to the appropriate authorities.

3.5 Post-flood community needs assessments

The purposes of an initial Community Needs Assessment is to gain a high-level understanding of the extent and magnitude of unmitigated flood damage prior to subsequent recovery interventions, and to gather information on the immediate humanitarian needs of affected communities related to food, shelter, health, water and sanitation assistance.

Trained assessment teams from both Community and Provincial Disaster and Climate Change Committee should be placed on standby during the scaling-up phase of the Response as soon as flood

warnings have been triggered. Community Needs Assessment teams operate under the direction of the Secretary General.

Should flooding eventuate and trigger the Response stage, the assessment teams should be prepared to mobilise and prepare an initial community needs assessment as soon as it is safe and practicable to do so once the "all clear" is given by the NDMO and the flood response begins to scale down and move into the early Recovery stage.

The NDMO has developed guidelines[7] [8] for the implementation of initial Community Needs Assessments, which capture information on the physical impacts of a disaster and the immediate needs of affected communities. The guidelines include requirements which must be met before Community Needs Assessments can commence, including requirements related to:

- Approval of questionnaires.
- Gender balance of assessment teams.
- Participation of local enumerators.
- Processes for data collection, analysis, and reporting.

The NDMO has also developed a standard first community assessment form[9], however, alternative assessment forms can be utilised provided they are pre-approved by the NDMO or relevant cluster.

3.6 Training and exercise programmes

Training exercises and simulations are essential for stress testing emergency response plans, and for developing the skills of individuals and teams involved in any Response. The focus of an exercise should be practical learning in a controlled environment outside of a real emergency, followed by a structured debrief and review exercise (see section 3.4). A training and exercise schedule is outlined in Table 3.3

Table 3.3: Training and exercise schedule

Training activity	Description	Timing / frequency
Initial SOP training	Facilitated workshop and desk-top exercise to develop a common understanding of flood response protocols and policies which is agreed by all stakeholders involved in the response.	Completion of SOP (July 2023).
Initial SOP simulation exercise	Simulation exercise to test the functions of each agency involved in the response throughout its different stages, before, during and after a flood emergency.	Completion of SOP (July 2023).
Annual flood response training	Ongoing training will assist relevant agencies with flood preparedness and flood response within the Sarakata catchment. These exercises can also inform refinement of the SOP and drive ongoing collaboration between stakeholders at National, Provincial and Community levels.	Annual training / simulation exercise.

[7] ndmo-draft-assessment-guidelines-december-2016.pdf
[8] Vanuatu National Disaster Management Office (NDMO) - Downloads - Post-Disaster Needs Assessment (gov.vu)

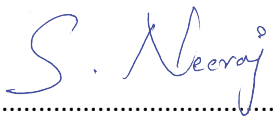
[9] First-Community-Assessment-Form--Bislama--July-2016 (2).pdf

4 Applicability

This report has been prepared for the exclusive use of our client SPREP, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor International Ltd
Environmental and Engineering Consultants

Report prepared by:



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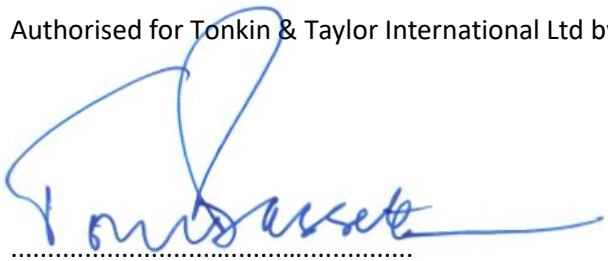
Dr Neeraj Shankar
DISASTER MANAGEMENT CONSULTANT

Authorised for Tonkin & Taylor International Ltd by:



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Tom Bassett
PROJECT DIRECTOR

With specialist input from

- **Jordan Curtis**, WATER RESOURCE ENGINEER
- **Dr Katherine Cowper-Heays,** WATER AND CLIMATE RESILIENCE CONSULTANT
- **Benjamin Sims,** DISASTER RISK REDUCTION CONSULTANT

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Appendix A Approach for Flood risk management and early warning system

The recommendations presented in this report are organised around the six themes of flood management and early warning systems shown in Figure Appendix A.1: .

Figure Appendix A.1: Six themes of flood management and early warning systems.

The relationship between the six themes and the underlying frameworks (Figure Appendix A.2 and Figure Appendix A.3) which informed the approach taken for this project is shown in Figure Appendix A.2 .

Appendix A Table 1: Relationships betw3een six themes of flood management and early warning systems and reference frameworks

Six themes of flood management and early warning systems	Twelve Benchmarks of Urban Flood Risk Management in the Pacific (UFCOP, 2017)	People-Centred Multi-Hazard Early Warning Systems (WMO, 2022)
1 Flood risk management, governance, and planning	Benchmark 11: Flood risk management governance. Benchmark 12: Flood risk management process rollout.	1 Institutional arrangement.
2 Flood risk management measures	Benchmark 5: Flood risk management measures. Benchmark 6: Flood modification measures. Benchmark 7: Risk-informed land use planning and development controls.	
3 Hydrological observation, monitoring, analysis, and forecasting	Benchmark 1: Hydrological data collection/storage/reliability.	2 Earth data observation. 3 Data and information collection. 4 Hazard detection.
4 Disaster risk knowledge	Benchmark 2: Hazard assessment (mapping). Benchmark 3: Exposure and vulnerability assessment (mapping). Benchmark 4: Risk assessment.	5 Hazard assessment. 6 Impact based forecasting/warning.
5 Warning dissemination and communication	Benchmark 8: Flash flood warning systems.	7 Warnings and other infrastructure products. 8 Dissemination and notification methods. 09 Risk communication.
6 Preparedness and response capabilities	Benchmark 9: Emergency management planning and capability. Benchmark 10: Community preparedness.	10 Community connection and response.

Benchmark	Description	Limitations
1. Hydrological data collection/storage/ reliability	Assesses the overall quality of hydrological data for flood modeling, including network coverage, frequency of readings, quality of ratings, length/ completeness/ standardization/accessibility	Gives only a rough average across different submeasures
2. Hazard assessment (mapping)	Assesses the quality of available flood hazard mapping (including climate change projections)	Does not capture the quality of the flood model or topographic surface that controls the outputs
3. Exposure and vulnerability assessment (mapping)	Assesses the spatial resolution and type of information (including urban growth projections) available to assess building and household exposure and vulnerability	Does not capture completeness, quality (e.g., whether floor heights are surveyed), or currency of data
4. Risk assessment	Assesses the completeness of risk assessments in terms of both financial damage and risk to life, and for multiple design events up to the probable maximum flood	
5. Flood risk management measures	Assesses the degree to which the full suite of FRM measures (structural and nonstructural) is utilized and integrated	
6. Flood modification measures	Assesses the quality of cost-benefit, environmental, and social impact assessments and community engagement as part of project evaluation	
7. Risk-informed land use planning and development controls	Assesses the type of planning controls, and the basis of the flood planning area/level, used to manage flood risk	Effectiveness depends on implementation, which is difficult for informal settlements
8. Flash flood warning systems	Assesses the precision of flood warnings and dissemination methods, recognizing the limits for flash flood catchments	
9. Emergency management planning/capability	Assesses the degree to which national and local emergency service organizations have planned for, are resourced for, and have trained for flood operations	Does not take into account nongovernmental organization (NGO) plans and capability
10. Community preparedness	Assesses the degree to which governments have invested in promoting community awareness and readiness to respond to flooding	Investments in community education may not necessarily translate to better behaviors
11. FRM governance	Assesses the overall quality of governance structures for FRM	Gives only a rough average across different submeasures
12. FRM process roll out	Assesses the degree to which the FRM process has been rolled out across a jurisdiction (country)	

Figure Appendix A.2: 12 Benchmarks of Urban Flood Risk Management in the Pacific (UFCOP, 2017).

Figure Appendix A.3: Multi-Hazard Early Warning System (WMO, 2022).

Appendix B List of stakeholders consulted

Name	Organisation
Alice Iarem Sanga	NDMO
Anneth Karlyp	MoET
Brooks Rakau	DoWR (Acting Director)
Elfrida Hinge	VBTC
Erickson Sammy	DoWR
Fred R Jockley	VMGD
George Marcel	SPAC
Jerry Timothy	VMGD
John Ailiv	PHA-Health
John Ruben	VMGD
Jonah Taviti	DoWR
Kensley Micah	NDMO (PDO)
McCarthney Agy	DoWR
Michelle Jonas Trief	DoLA
Moirah Matou	VMGD
Montin Romone	VMGD (Director)
Philip Meto	NDMO
Raviky Talae	DoWR

Appendix C Online workshop

On 16th June 2023, an online consultative workshop was conducted with stakeholders at the national level.

Appendix D In-country stakeholder workshop

On July 27th, 2023, a stakeholder workshop was conducted in Santo, Vanuatu, with the purpose of presenting and evaluating the Sarakata River Catchment Flood Management Plan (FMP), Early Warning Systems (EWS), decision tree, and the introduction of the Standard Operating Procedures (SOP) for flood response within the Sarakata River catchment area.

D1 Workshop agenda

Workshop Agenda	
Actual Time	**Description**
30 mins	Opening, welcome, and introductions
90 mins	Presentation and group activity on FMP and EWS • Theme 1: Flood risk management governance and planning • Theme 2: Flood risk management measures • Theme 3: Hydrological observation, monitoring, analysis & forecasting
15 mins	Morning tea
90 mins	Presentation and group activity on FMP and EWS • Theme 4: Disaster risk knowledge • Theme 5: Warnings, dissemination and communication • Theme 6: Preparedness and response capabilities
45 mins	Decision Tree and Standard Operating Procedures (SOP)

D2 Workshop photos

Appendix E Sarakata flood mitigation and early warning system gap analysis report

Sarakata Flood Mitigation and Early Warning System Gap analysis report

Prepared for
Secretariat of the Pacific Regional Environment Programme

Prepared by
Tonkin & Taylor International Ltd

Date
May 2023

Job Number
1020851 v1

Tonkin+Taylor

Document control

Title: Sarakata Flood Mitigation and Early Warning System					
Date	**Version**	**Description**	**Prepared by:**	**Reviewed by:**	**Authorised by:**
24/03/23	Draft	Gap Analysis Draft	NESH	KGH	TB
5/05/23	1	Gap Analysis Report Final	NESH	KGH	TB

Distribution:

Secretariat of the Pacific Regional Environment Programme	1 electronic copy
Tonkin & Taylor International Ltd (FILE)	1 electronic copy

Table of contents

Executive summary

The Secretariat of the Pacific Environment Programme (SPREP) is implementing the Climate Information Services for Resilient Development in Vanuatu (CISRD), or Vanuatu Klaemet Infomesen blong redy, adapt mo protekt (Van-KIRAP) Project. As the first part of this project, Tonkin & Taylor International Ltd (T+TI) has been engaged to provide technical expertise on the Van KIRAP Project and the Department of Water Resources to review and update existing flood mitigation guidelines for the Sarakata catchment in Espiritu Santo Island, and to support the development of flood early warning systems in Sarakata.

This report provides a review of the existing Flood Mitigation Guidelines for Sarakata, Pepsi and Solwei Areas (2011) including the evaluation and identification of gaps in terms of early warning systems and long-term climate change considerations. The review has identified the gaps across governance, institutional arrangements, observations, risk knowledge, warning dissemination, and preparedness and response. The following recommendations are provided to address the identified gaps and to inform the development of updated flood mitigation guidelines:

- Strengthened governance and institutional arrangements, relating to:
  - Strengthened policies and institutional frameworks at the provincial level including clear roles and responsibilities.
  - Clear standard operating procedures for flood early warning system management.
  - Development of forums to enable coordination and partnerships.
  - Update and finalise the Sarakata Flood Management Plan, including establishment of a monitoring and evaluation plan to ensure effective and coordinated governance of flood disaster risk reduction and to foster sustainable development.
- Strengthened observation, monitoring, analysis, and forecasting, relating to:
  - Additional observational equipment and supporting services and capacity.
  - Inclusion of empirical models or probabilistic modelling to inform hazard and risk assessments.
- Strengthened disaster risk knowledge, relating to:
  - Adoption of hazard thresholds.
  - Updating and strengthening risk assessment and risk management practices.
- Strengthened warning dissemination and communication, relating to:
  - Community-focussed warning and dissemination.
  - Community-specific evacuation plans.
- Strengthened preparedness and response, relating to:
  - Training and capacity building.
  - Community-based disaster risk management.
  - Grass-roots level involvement.

This report will inform the development of a new flood management plan (FMP) and early warning system (EWS) for the Sarakata-Luganville catchment using the existing flood mitigation guidelines, the Sanma Province Disaster Response Plan and other relevant policies and plans.

1 Introduction

The Secretariat of the Pacific Environment Programme (SPREP) is implementing the Climate Information Services for Resilient Development in Vanuatu (CISRD), or Vanuatu Klaemet Infomesen blong redy, adapt mo protekt (Van KIRAP) Project. T+TI has been engaged to provide technical expertise on the Van KIRAP Project for the Department of Water Resources (DoWR) to review and update existing flood mitigation guidelines for the Sarakata catchment in Espiritu Santo Island (Department of Water Resources, 2011), and to support the development of flood early warning systems in Sarakata.

The specific objectives of the consultancy services are:

i Review of the Flood Mitigation Guidelines for Sarakata, Pepsi and Solwei Areas (2011) including the evaluation and identification of gaps in terms of early warning systems and long-term climate change considerations.

ii Development of a new flood management plan (FMP) and early warning system (EWS) for the Sarakata-Luganville catchment using the existing flood mitigation guidelines, the Sanma Province Disaster Response Plan and other relevant policies and plans.

iii Development of scenarios and simulations of the Sarakata-Luganville FMP and EWS in partnership with national and provincial stakeholders.

iv Institutionalise the new Sarakata-Luganville FMP and EWS into the DoWR and with external stakeholders through drafting a Memorandum of Understanding (MoU) and completion of a training workshop.

This report presents the findings of Objective i. It provides a summary of the review of the existing guidelines and includes an evaluation and identification of gaps in the current status of early warning systems and long-term climate change considerations.

Objectives ii to iv will be addressed in subsequent reports.

1.1 Methodology

The Flood Mitigation Guidelines for Sarakata, Pepsi and Solwei Areas (2011) and other more recent documentation relevant to early warning systems and hazard management within Luganville and the Sarakata Catchment were reviewed with reference to two different frameworks:

- Early warning system elements consider the WMO multi-hazard early warning framework and people-centric early warning guidelines (Figure 1.1)
- Flood management activities are reviewed with reference to the benchmarks outlined in the Urban Floods Community of Practice (UFCOP) Urban Flood Risk Management in the Pacific (Yeo, Esler, Taaffe, Jordy, & Bonte-Grapentin, 2017).

Supplementary data obtained through discussions with key stakeholders and responses from key stakeholders to a survey have informed which of the actions recommended in the Sarakata Catchment flood mitigation guidelines have been implemented and to develop an understanding of the remaining gaps.

Section 2 presents the gap analysis by evaluating the elements of the multi-hazard early warning framework. The flood-specific benchmarks identified in the UFCOP Urban Flood Risk Management are incorporated into each element of the gap analysis.

Section 2.5.3 presents a list of recommendations to be considered in the flood mitigation guidelines to be developed under Objective ii of this project.

Figure 1.1: Ten steps of the impact-based early warning system (Fakhruddin, 2018)

Benchmark	Description	Limitations
1. Hydrological data collection/storage/ reliability	Assesses the overall quality of hydrological data for flood modeling, including network coverage, frequency of readings, quality of ratings, length/ completeness/ standardization/accessibility	Gives only a rough average across different submeasures
2. Hazard assessment (mapping)	Assesses the quality of available flood hazard mapping (including climate change projections)	Does not capture the quality of the flood model or topographic surface that controls the outputs
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4. Risk assessment	Assesses the completeness of risk assessments in terms of both financial damage and risk to life, and for multiple design events up to the probable maximum flood	
5. Flood risk management measures	Assesses the degree to which the full suite of FRM measures (structural and nonstructural) is utilized and integrated	
6. Flood modification measures	Assesses the quality of cost-benefit, environmental, and social impact assessments and community engagement as part of project evaluation	
7. Risk-informed land use planning and development controls	Assesses the type of planning controls, and the basis of the flood planning area/level, used to manage flood risk	Effectiveness depends on implementation, which is difficult for informal settlements
8. Flash flood warning systems	Assesses the precision of flood warnings and dissemination methods, recognizing the limits for flash flood catchments	
9. Emergency management planning/capability	Assesses the degree to which national and local emergency service organizations have planned for, are resourced for, and have trained for flood operations	Does not take into account nongovernmental organization (NGO) plans and capability
10. Community preparedness	Assesses the degree to which governments have invested in promoting community awareness and readiness to respond to flooding	Investments in community education may not necessarily translate to better behaviors
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12. FRM process roll out	Assesses the degree to which the FRM process has been rolled out across a jurisdiction (country)	

Figure 1.2: 12 Benchmarks of Urban Flood Risk Management in the Pacific (UNFCOP, 2017)

1.2 Luganville context

Luganville is the second most densely populated urban centre in Vanuatu after Port Vila[1]. The total population of Luganville is 17,719 (2020 estimate), with an average annual growth rate (2.7% pa) slightly higher than the national average (2.3% pa). As the only urban centre on Espiritu Santo Island, Luganville serves as the island's primary economic hub, with economic activity centred around retail, wholesale, banking, hospitality, and tourism sectors. Luganville has one of country's busiest ports, with much of Vanuatu's copra and cacao shipments passing through it. The town is also served by the Santo-Pekoa international airport.

Many of the fastest growing neighbourhoods in Luganville are informal settlements, including several located within flood-prone areas alongside the Sarakata River. Informal settlements are frequently situated on land with disputed tenure arrangements, making enforcement of land use controls and other regulation challenging (Beca, GNS Science and NIWA, 2015).

[1] 2020 National Population and Housing Census, VNSO

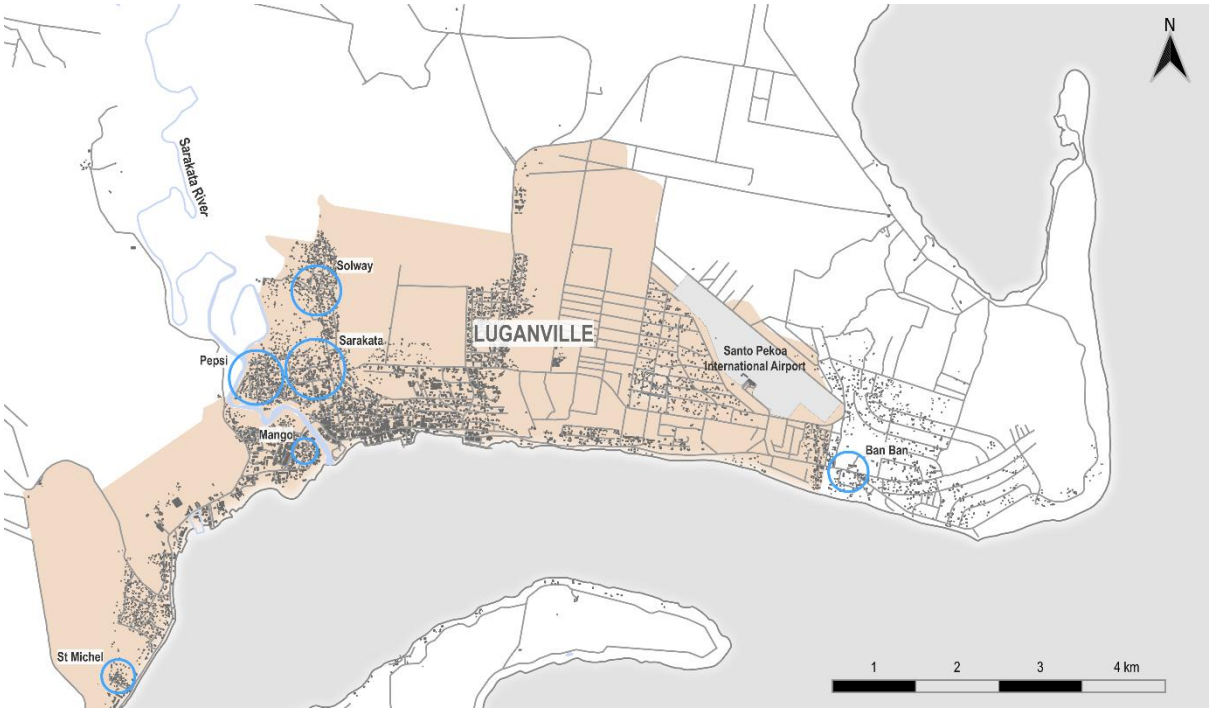

Figure 1.3: Map of Luganville showing locations of informal settlements (blue circles)

Land along the Sarakata River margins is vulnerable to fluvial flooding, particularly the numerous informal settlements established within the flood plains of the river. Elsewhere in the catchment, pluvial flooding is exacerbated by shallow groundwater and inadequate surface water drainage (Department of Water Resources, 2011). During heavy rainfall saturated subsoils prevent infiltration leading to high volumes of runoff and frequent flooding. Natural stream networks throughout the lower Sarakata catchment have reportedly been modified, and in some instances filled, to accommodate agriculture and construction activities. Urban drainage networks throughout the catchment are reportedly in poor condition with many networks no longer maintained or functioning.

Flooding in Luganville and throughout the wider Sarakata catchment is a frequent problem. In recent years excessive rainfall has generated serious flooding and forced evacuations[2]. Climate change impacts are projected to increase the magnitude of extreme rainfall events, both those rainfall events associated with tropical cyclones and non-tropical cyclone events, contributing to increased flooding impacts in future (Anil Deo, et al., 2021)[3].

2 Gap analysis

2.1 Governance and planning

Governance plays a crucial role in flood disaster management and preparedness. Effective governance involves the coordination and collaboration of multiple stakeholders, including

[2] Three families evacuated in Luganville due to flooding | News | dailypost.vu
Cyclone Harold updates: Storm makes landfall on Vanuatu's Santo | RNZ News

[3] Australia-Pacific Climate Partnership (2021). 'NextGen' Projections for the Western Tropical Pacific: Current and Future Climate for Vanuatu. Technical Report, Australian Aid, CSIRO, SPREP. Retrieved from https://www.rccap.org/uploads/files/2c538622-72fe-4f3d-a927-7b3a7149e73f/Vanuatu%20Country%20Report%20Final.pdf

government agencies, non-governmental organisations, and community members, to ensure a comprehensive and timely response to floods. This can involve implementing flood preparedness measures, such as early warning systems, evacuation plans, and infrastructure improvements, as well as providing immediate relief and long-term recovery support to affected communities. Good governance also ensures transparency, accountability, and the involvement of all stakeholders in decision-making processes, to build trust and promote a culture of resilience in the face of future flood events.

The institutional arrangement of Sarakata describes the way relevant organisations and community operates, manages, delegates, or undertakes their policies or institutional mandate. Establishing roles and responsibilities, identifying key decision-makers and stakeholders, and ensuring accountability and transparency in decision-making processes are essential components of effective institutional arrangements. By implementing strong institutional arrangements, disaster management efforts can be coordinated, efficient, and well-resourced, reducing the impact of floods on communities and infrastructure. In addition, institutional arrangements can also promote a culture of preparedness in the face of future flood events.

2.1.1 Review of flood risk management governance

There is a range of existing plans and policies to manage flood risk, including Vanuatu's Climate Change and Disaster Risk Reduction (CCDRR) Policy (2016-2030). The vision of CCDRR is to enable Vanuatu to be a "*nation whose communities, environment and economy are resilient to the impacts of climate change and disaster risks*".

The Vanuatu National Sustainable Development Plan (NSDP) for the period 2016 to 2030 serves as the country's highest-level policy framework, through which Ni-Vanuatu resoundingly called for a balance between the social, environmental, and economic pillars of sustainable development, with cultural heritage as the foundation of an inclusive society. In addition, there are other relevant policies and plans that have been developed to address the climate change and disaster risks identified for Vanuatu. Below is a summary of these policies and other policies and plans that assist in managing flood risk.

Table 2.1: Policies and plans

Policies and plans	Objectives
CCDRR Policy (2016-2030).	This national scale policy identifies a vision to enable Vanuatu to be a "*nation whose communities, environment and economy are resilient to the impacts of climate change and disaster risks*"
Vanuatu National Sustainable Development Plan (NSDP, 2016-2030)	This Plan is the country's highest-level policy framework, which highlights the importance of a balance between the social, environmental, and economic pillars of sustainable development, with cultural heritage as the foundation of an inclusive society.
National Water Strategy 2018-2030 (NWS)	The NWS encompasses priority areas identified to ensure safe, sufficient, accessible, affordable, and reliable access to water sustainably. Identifies the need for effective planning and coordination among key water sector stakeholders where Vanuatu's vulnerability to various disaster risks is anticipated to increase with climate change.
Provincial Disaster and Climate Response Guideline (PDCRP)	This guideline intends to guide the Provincial Governments and the National Disaster Management Office to develop Provincial Disaster and Climate Response plans with the support of the DRM stakeholders such as the Vanuatu Humanitarian Team who involve Non-Government Organisations and Vanuatu Red Cross Society.
Department of Water (DoWR) Standard Operating Procedures	This SOP addresses the timing for DoWR partner agencies which have key responsibilities for disaster response in close coordination with the DoW.
National Gender Equality Policy 2020-2030 (NGEP)	The NGEP provides a unifying strategic framework for government, civil society, and development partners to coordinate actions to advance gender equality and the wellbeing of women and girls. It acknowledges that climate change and disaster risks have different impacts on women and men, that gender differences should be considered when planning and managing climate and disaster risks, including gender-specific needs and priorities to cope and adapt to climate change impacts.
Sanma Gender Equality Action Plan 2020-2024	This Action Plan provides a clear plan of action for government, civil society, private sector, and development partners to coordinate actions to advance gender equality and the well-being of women and girls in Sanma Province in line with the NGEP.
Vanuatu Meteorology and Geo-hazards Department (VMGD) Strategic Plan 2014-2023	The VMGD Strategic Plan seeks to strengthen capacity and delivery of its services focusing on the areas of weather services, climate services, climate services, climate change services, geo-hazard services, observations monitoring, research, administration, and finance.
Vanuatu Klaemet Infomesen Blong Redy, Adapt Mo Protekt (Van KIRAP) Water and Climate Information Services (CIS): policy review, action, and communication plan. Apia, Samoa	This plan aims to increase the ability of decision makers, development partners, communities, and individuals across five target sectors (agriculture, fisheries, infrastructure, tourism and water) to plan for and respond to the long- and short-term impacts of climate change.
Vanuatu Strategic Roadmap for Emergency Management 2021-2023 (SREM)	The SREM is designed to operationalise the objectives of the Disaster Risk Management Act (2019) guide a stronger and more coordinated approach to disaster and emergency management in Vanuatu.

2.1.2 Existing institutional arrangements for flood management

At the national level, DoWR is responsible for monitoring surface and ground water levels, whereas VMGD is responsible for assessing climate change risk, forecasting heavy rainfall, and for the development and management of early warning systems. The local flood response is conducted by the Sanma Provincial Emergency Operation Centre (PEOC) in coordination with NDMO. Inter-agency coordination is a key requirement for delivering effective flood management outcomes. A list of national and provincial institutions related to floods is summarised in Table 2.2.

Table 2.2: Institutions relevant to Sarakata catchment flood management and related EWS .

Institution	Responsibility
NDMO	NDMO coordinates preparation and responses to emergencies and disasters across Vanuatu.
Provincial Disaster and Climate Change Committee (PDCCC)	The PDCCC comprises of key provincial authorities and officers, including the Red Cross, Sanma Provincial health department, and education department. The PDCCC is responsible for disaster preparedness and response, including mainstreaming disaster preparedness in the 5-year provincial development plan.
Sanma PEOC	The PEOC was established in 2018 and is the main body of the emergency, response and early recovery coordination system. The PEOC roles are executed by the PDCCC under direct leadership of the Secretary General of the province. PEOC has the appropriate technology to send and receive real-time disaster information along with three or more National Disaster Management Officers[4]. During an emergency, PECO acts as a communication channel between provincial and national officers and supports them in better decision-making during emergencies.
VMGD	VMGD ensures that the meteorological and geophysical data and knowledge are effectively applied to Vanuatu's national goals. One of the objectives is to contribute to achieving national sustainable development. It has six Technical Divisions responsible to provide the required services and products (Observation, Forecasting, Climate, IT and Engineering, Administration and Geohazards Divisions). VMGD provides regional and national atmospheric forecasts, marine forecasts, tidal information, tropical cyclone warnings and outlooks, tsunami information and warnings, climatological information.
Vanuatu Humanitarian Team	The Vanuatu Humanitarian Team is a collaboration between Vanuatu NGOs, Red Cross, United Nations and government agencies The Vanuatu Humanitarian Team supports NDMO during response and recovery activities.
DoWR	DoWR sits under the Ministry of Land and Natural Resources and is mandated to regulate and coordinate the water-related activities (surface and ground water) at all levels of governance in Vanuatu. DoWR has responsibilities for developing flood policy and legislation, monitoring and evaluation, and maintaining water quality. It also has a Project and Operations Unit to deliver on the Department's mission to "*develop and manage the nation's water resources for the social and economic wellbeing of the people of Vanuatu*".
Department of Energy (DoE)	DoE is responsible for development of energy policies, legislation and regulations to guide the development of energy services and improve

[4] https://www.spc.int/updates/news/2018/07/vanuatu-officially-opens-two-provincial-emergency-operations-centres-in

Institution	Responsibility
	service delivery; identification, implementation, management and evaluation of energy projects, monitoring and facilitating energy activities; providing awareness and training activities.
Department of Local Authorities	The Department of Local Authorities is responsible for overseeing local government, which comprises six provincial, three municipal and 72 area councils. It leads and supports planning processes that draw on community-driven vulnerability and risk assessment processes.
Department of Women's Affairs	The Department of Women's Affairs has a primary role in capacity development and institutional strengthening activities related to the mainstreaming of gender equity, disability, and social inclusion considerations into climate change adaptation, mitigation, and disaster risk reduction activities.
Vanuatu's National Cluster System	Vanuatu's National Cluster System was established following the Tropical Cyclone Pam in 2015, to ensure humanitarian organisations and government agencies develop and implement disaster preparedness and response activities in the country. It comprises Education Cluster, Emergency Telecommunications Cluster (ETC), Food Security and Agriculture Cluster (FSAC), Gender and Protection Cluster (G&P), Health and Nutrition Cluster, Logistics Cluster (VLC), Shelter Cluster, and Water Sanitation and Hygiene Cluster (WASH). The clusters are led by a government agency and co-led by a humanitarian partner. There is an Inter-Cluster which acts as a coordinating mechanism for the eight technical clusters. Relevant clusters will be activated based on need during disasters.
Luganville Municipal Council	Luganville Municipal Council is responsible for disseminating flood warnings to the communities, conduct awareness programmes, ensure households do not access the flood affected roads, and support in recovery related activities following the floods[5].
Luganville Community Climate Center	Luganville Community Climate Center acts as a hub for receiving Climate Information Services (CIS) from the VMGD and further dissemination of CIS to 'last mile' communities.
Vanuatu Red Cross Society (VRCS)	VRCS assists communities in Vanuatu in disaster preparedness activities such as "*community risk assessments, awareness sessions, first aid trainings, the development of mitigation and response plans, the improvement of early warning systems and the establishment of Community Disaster and Climate Change Committees*"[6]. VRCS has established emergency operation centres in Sanma, Malampa, and Penama Branches to coordinate the operations in the field, which can be activated during emergencies[7]. Also, Emergency Response Teams (ERT) are available across the different branches of VRCS, including Sanma, to conduct disaster response operations.

2.1.3 Review of flood management planning measures

The existing Flood mitigation guidelines for Sarakata, Pepsi and Solwei areas (Department of Water Resources, 2011) have been reviewed in relation to their governance and planning mechanisms. The objective of this document is to provide guidelines that are designed in such a way to help decision-

[5] As per the draft Flood Mitigation Guidelines for Sarakata, Pepsi, and Solwei Areas
[6] https://vanuaturedcross.squarespace.com/disaster-management
[7] Vanuatu Red Cross Society – 2020 Annual Report

makers identify their needs and provide a range of mitigation options to flood-related disasters. The guidelines are developed to provide an introduction to the communities and various mitigation measures from the impacts associated with floods.

Measures identified in the guidelines include recommended flood management actions as part of a broader integrated water resources management approach:

- Structural flood modification measures.
- Catchment management.
- Exposure and vulnerability reduction.
- Risk informed land use planning.

These areas of flood risk management are discussed below.

2.1.3.1 Structural flood modification measures

The Sarakata catchment flood mitigation guidelines acknowledge the limitations of structural approaches to flood management. Structural approaches include the high cost to construct and maintain largescale infrastructure, and the potential for these to generate misconceptions around the level of protection and residual risk associated with physical flood protection. However, structural flood management measures are necessary in certain circumstances, such as to enable development in certain locations, or to protect existing development in exposed locations (Kundzewicz, 2002). The guidelines (Department of Water Resources, 2011) recommend that any structural flood mitigation measures must be supported with in-depth hydrological and hydraulic studies.

While the guidelines mention trenches to lower elevated groundwater levels, and the restoration of natural channels to improve conveyance, they do not provide a more detailed assessment or further recommendations regarding either option.

Few structural flood management measures have been constructed in the Sarakata catchment. Existing measures include the hydropower dam situated in the catchment, bridge widening works, and river widening (as identified through Survey and the Urban Floods Community of Practice's review of flood risk management in the Pacific (Yeo, Esler, Taaffe, Jordy, & Bonte-Grapentin, 2017, p. 45)).

There is little information available about the extent or functionality of the existing drainage infrastructure in either Luganville or the wider Sarakata catchment. The Sarakata catchment flood mitigation guidelines note that "most of the stormwater drains around the Sarakata area are no longer functioning due to being blocked or damaged" (Department of Water Resources, 2011, p. 9).

2.1.3.2 Catchment Management

The Sarakata catchment flood mitigation guidelines emphasise the importance of catchment management and the potentially adverse impacts of human activities and land-use changes on catchment hydrology and the severity of flood impacts. The guidelines advocate the development of a catchment management plan which includes afforestation.

The guidelines recommend that a multi-stakeholder participatory approach is adopted for the catchment planning process, with input from community groups, provincial advisory committees, and provincial and national government agencies. DoWR is suggested as the lead agency for catchment planning, however, this initiative has not been implemented.

2.1.3.3 Exposure and vulnerability reduction measures

The Sarakata catchment flood mitigation guidelines emphasize the socio-economic aspects which contribute to the heightened vulnerability of marginalised groups. The guidelines suggest that targeted policy focused on poverty reduction through the promotion of diverse income-generating activities is essential for reducing vulnerability to natural hazards, however, no specific policies or programmes are proposed.

The flood guidelines also highlight the importance of an effective building code as a measure for reducing the level to which buildings are exposed to flood hazards, and the vulnerability of structures within flood prone areas. Locally appropriate guidelines and codes for the design and construction of hazard resilient housing are essential in areas where total retreat from flood plains is not practical. The Vanuatu Building Code, originally drafted in 1990 and revised in 2000, was gazetted in 2017 (Pacific Region Infrastructure Facility, 2021) following review of Vanuatu's existing land use planning framework (Beca, GNS Science and NIWA, 2016b). That review also recommended the development and dissemination of new guides in simpler formats which address construction techniques and retrofitting of existing structures for greater resilience to hazards. The Building Code includes requirements for site drainage and flood protection. The code stipulates that 'the land immediately surrounding a building should be free of standing water within one hour of a storm with a 5-year return period', and also requires that 'no flood water resulting from a storm with a 30-year return period should enter a building' (Government of Vanuatu, 2000). Enforcing these regulations would limit the flood exposure of new buildings in more frequent flood events (less than a 30-year return period). The Code states that rainfall intensities may be ascertained from the Vanuatu Meteorological and Geo-hazards Department.

2.1.3.4 Risk informed land use planning

The Sarakata catchment flood mitigation guidelines state that non-structural measures should be the primary approach to flood management in the catchment and suggest that appropriate planning and land use controls are central to this objective (Department of Water Resources, 2011).

The existing land use planning framework in Vanuatu consists of National Legislation (primarily the Physical Planning Act and Land Leases Act), National policy documents including the Land Use Planning and Zoning Policy, and local zoning plans (Beca, GNS Science and NIWA, 2016b).

A Zoning and Development Control Plan for the Luganville Physical Planning Area was approved by the Luganville Municipal Council and Sanma Provincial Government Council in 2018. Zoning plans in Vanuatu are only prepared for public land, the Luganville Zoning and Development Control Plan is applicable only to the urban area within the Luganville Physical Planning Area (Ministry of Lands and Natural Resources, 2023). Consequently, flood prone areas outside of the Luganville Municipal boundary are not included in the Luganville Zoning Plan and land use is ultimately controlled by customary landowners. Vanuatu's existing land use planning processes include applications to register leases, planning permits for subdivisions and foreshore development and environmental impact assessment processes (Beca, GNS Science and NIWA, 2016b).

2.1.4 Gaps identified relating to flood risk management governance and planning

The following gaps were identified in the review of relevant policies and plans (also drawn from the Urban Risk Management Strategy review (Beca, GNS Science and NIWA, 2016b):

- At national level, the plans and policies lack emphasis on the coordination at local level.
- The plans available at provincial level lack details, especially, the roles and responsibilities.
- The DoWR SOP lacks a level of detail that would make it useful (i.e. the roles and responsibilities are not clear).

- Currently, there is no finalised comprehensive flood management plan in place to ensure effective and coordinated governance of flood disaster risk reduction and to foster sustainable development. For instance, poor coordination between non-governmental organisations and community-based organisations created many bottlenecks during Tropical Cyclone Harold response operations. The roles and responsibilities of the agencies mentioned in the draft Flood Mitigation Guidelines for Sarakata, Pepsi, and Solwei Areas lack detail, and do not include all the necessary and relevant stakeholders. The strengthening of response and recovery mechanisms was a key objective of Vanuatu's recovery strategy following the compound disasters of Tropical Cyclone Harold and COVID-19 (Government of Vanuatu, 2020).
- The Flood Management Guidelines include a range of recommendations, many of which have not been actioned. The roles and responsibilities identified are not clear.
- Land use zoning currently allows for areas exposed to high potential hazard risks be revised to avoid future intensification and instead be considered for alternative land uses.
- The Sarakata River riparian reserve area within the Luganville Zoning and Development Plan is not aligned with the flood hazard mapping undertaken by NIWA (2015).
- Informal settlements in areas within the flood plain of the Sarakata River do not have any formal lease agreements, making the enforcement of planning controls extremely difficult. Previous government efforts to relocate residents from flood prone settlements have been unsuccessful.

2.2 Observation, monitoring, analysis, and forecasting

A suitable data observation system is critical for detecting hazards to inform the early warning notification. The performance of the whole system is limited by the accuracy and timeliness of the data.

A multi-hazard data observation network is multi-faceted and would typically comprise local hydro-met stations, local seismic networks, local tide gauge networks, Doppler radars, Automatic Weather Stations, and upper air observations. Each of these observation sites must be monitored at an appropriate interval relative to the warning time required for the hazard. Whole of life maintenance and running costs of the monitoring equipment must be considered at the inception of the system.

Coordination on regional and global hazards such as weather systems, climate and earthquakes are managed through international agencies such as the WMO. Data used for hazard forecasting are typically high density, and need to be continuously updated which requires a lot of resources. For some countries lacking resources this can be difficult, and results in out-of-date information being used for forecasts and warnings. For warnings to be useful across multiple areas and provinces, they should be based on Common Alerting Protocols (CAP) to allow for interoperability with other systems[8].

A poor communication system can increase disaster risk.

2.2.1 Observation network

A river gauging station (river monitoring system) was installed on the Sarakata River in September 2022 (Figure 2.1), at a location approximately 10 km upstream of the Luganville Municipal Boundary. The gauge reports the river level, river discharge, rate of rise, rainfall total, rainfall intensities and other parameters at five-minute intervals and transmits data via the cellular network, with satellite

[8] Lendholt, M.; Hammitzsch, M.-Generic Information Logistics for Early Warning Systems

redundancy in the event of a cell network failure. Data from the station are transmitted to both VMGD and a publicly accessible online platform[9].

There are also six ground water monitoring stations to support planning and decision-making by provincial water advisory committees, Luganville Municipal Council, and the Sanma Provincial government.

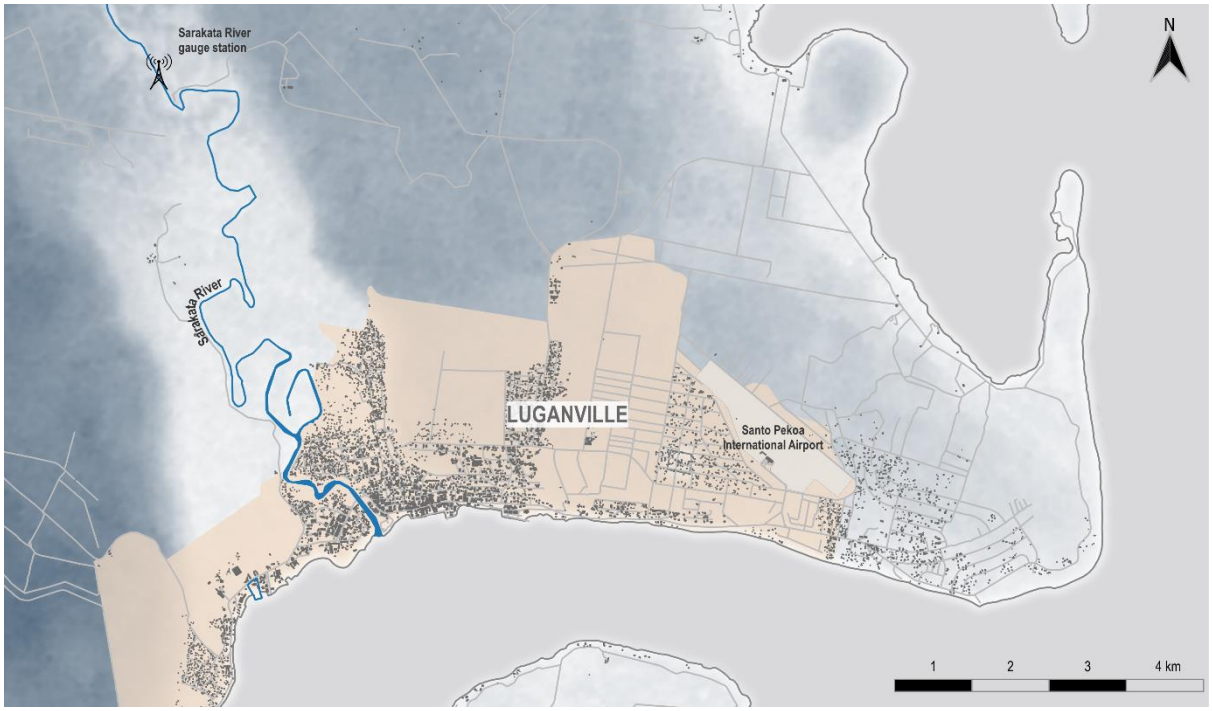

Figure 2.1: Sarakata river gauge station location

As of December 2022, river gauging of the Sarakata River at the gauge station was yet to be completed. River gauging (established from river cross sections and velocity measurements) would enable the river gauge station to deliver near real time river discharge data[10]. NIWA personnel were also reportedly investigating options to expand the observation network in the Sarakata Catchment through the installation of an automatic rainfall gauge further up the catchment[11]. This would enable a more detailed understanding of the relationships between rainfall in the Sarakata Catchment and runoff in the river.

The only long-term rainfall datasets available on Espiritu Santo Island is from the Pekoa Airport gauging station which lies outside of the Sarakata catchment, approximately 6 km east of the Sarakata River. Daily rainfall data from the Pekoa Gauge is available from 1960.

A flow gauge on the Sarakata River and a rain gauge within the Sarakata catchment were operated by the French Hydrology Agency (ORSTOM) between 1982 and 1985. The data were published at the time and used to develop flow duration curves for the Sarakata River (SMEC, 2014).

Since the late 1990s there have been two donor-funded initiatives to establish hydro-meteorological monitoring stations within the Sarakata catchment, upstream of the hydroelectric power plant. However, neither of these initiatives has been sustained and hydrology data from these stations were unavailable at the time of writing.

[9]Sarakata River Gauge online portal accessible at: https://bit.ly/3fRFuT1
[10] Campbell Scientific meeting with T+T December 1 2022
[11] SPREP meeting with T+T December 1 2022

2.2.2 Data and information collection

VMGD currently hosts all the collected river and rainfall data, and holds the historical data captured through the observation network. Gauged data is streamed to VMGD and is available through the online portal. Options for sharing of data with DoWR are being investigated.

2.2.3 Gaps identified relating to observation, monitoring and analysis

The following gaps have been identified relating to observation, monitoring and analysis to inform a strong flood early warning system:

- Improved instrumentation required to support real-time data capture to provide accurate warnings. An additional upper catchment flow gauge and a rainfall gauge would support this.
- Established procedures for coordination and data sharing between VMGD and DoWR.
- Current lack of capacity and training to support the necessary flood forecasting capability.

2.3 Disaster risk knowledge

Hazard assessment, exposure and vulnerability assessments, and risk assessments are important for establishing an effective flood management plan.

Risk assessments involve identifying hazards, evaluating exposure to those hazards, identifying vulnerability, and responding to risk via prevention or mitigation. This process assists decision makers to identify the potential locations that are most at risk and helps to determine relevant mitigation/management measures such as identifying low risk areas to be designated as evacuation zones.

Conducting risk assessments requires specific expertise and experience to cover its various aspects.

2.3.1 Flood hazard assessments

The Sarakata Catchment flood mitigation guidelines (Department of Water Resources, 2011) affirm that a comprehensive understanding of flood hazards and flood risk within a catchment is a necessary precursor to the development of a catchment flood management plan and supporting policy.

Hydrodynamic flood models and hazard maps have been developed for Luganville and the Sarakata catchment (NIWA, 2015). The flood hazard detailed in the modelling and data report was mapped for the Mele catchment in Port Vila and the Sarakata River catchment.

Hydrological investigations derived rainfall estimates for 10%, 2% and 1% annual exceedance probability (AEP) events. Climate change impacts were not included in the development of these. A storm tide with a one-year return period and peak of 1.7m above mean sea level were selected for the downstream boundary condition of the Sarakata River model. The timing of the tidal peak was aligned with the peak of the modelled flood hydrograph. Roughness heights for different land uses were developed based on aerial imagery, lidar datasets and ground inspection.

The results of the model simulations (Figure 2.2) suggest that in a 1% AEP flood event, large sections the Luganville town centre east of the Sarakata River, will be completely inundated, with modelled depths and velocities indicating high damage potential and a threat to life across much of the town centre. The modelling and data report (NIWA, 2015) noted that localised filling of floodplains to form bridge embankments exacerbated flooding upstream of bridges at several locations in the catchment.

Work is currently underway by NIWA to incorporate climate change projections into an updated flood model as part of an Asian Development Bank funded multi-hazard disaster risk assessment. However, the results of this assessment are not available at the time of writing this review.

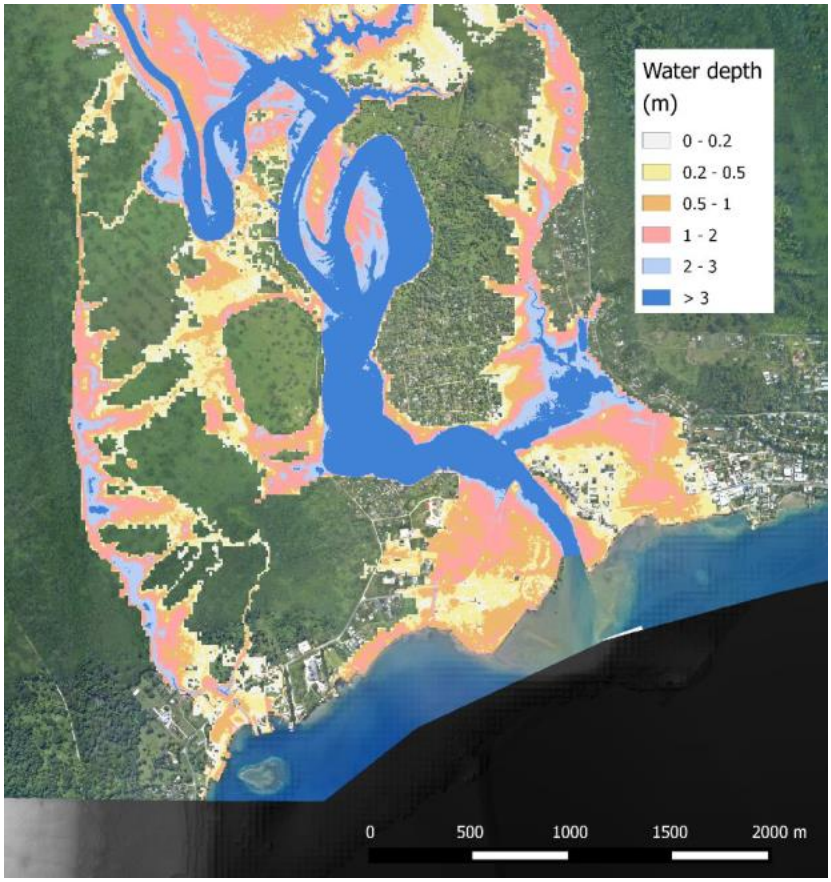

Figure 2.2: Maximum water depths in Sarakata River Catchment during 1% AEP flood event (NIWA, 2015)

2.3.2 Risk assessment

The Vanuatu Urban Risk Management Strategy was developed in 2016 (Beca, GNS Science and NIWA, 2016a) to respond to the hazards, risks and urban growth trends for Luganville and the greater Port Vila urban areas. This strategy involved hazard and risk mapping for the Sarakata River catchment, which determined that most of Luganville is at high risk from coastal, river flood, seismic and/or wind hazards.

The assessment determined that at a 1% annual exceedance probability (AEP), some 730 buildings are prone to flooding from the Sarakata River and are exposed to moderate to very significant levels of potential damage (Beca, GNS Science and NIWA, 2016b). The potential risk from river flooding at a 1% AEP is shown in Figure 2.3, and the full breakdown of flood-prone buildings is shown in Figure 2.4. This study also modelled the riverine flooding risk to Luganville at 2% and 10% AEP-flows.

The Urban Risk Management Strategy also considered the potential damage to buildings resulting from flood events. Damage functions were developed based on floods in Samoa in 2012, and the damage descriptors for different flood depths/velocities are provided in Figure 2.5 (Beca, GNS Science and NIWA, 2016a).

The potential risks and damages depicted in Figure 2.3 are based on a simulated spread of typical buildings and inferred construction styles. It is noted in the assessment report that these should be treated with caution and are intended to assist planners and other stakeholders in making strategic-

level planning decisions and not for work requiring detailed site-assessment of risk (Beca, GNS Science and NIWA, 2016a).

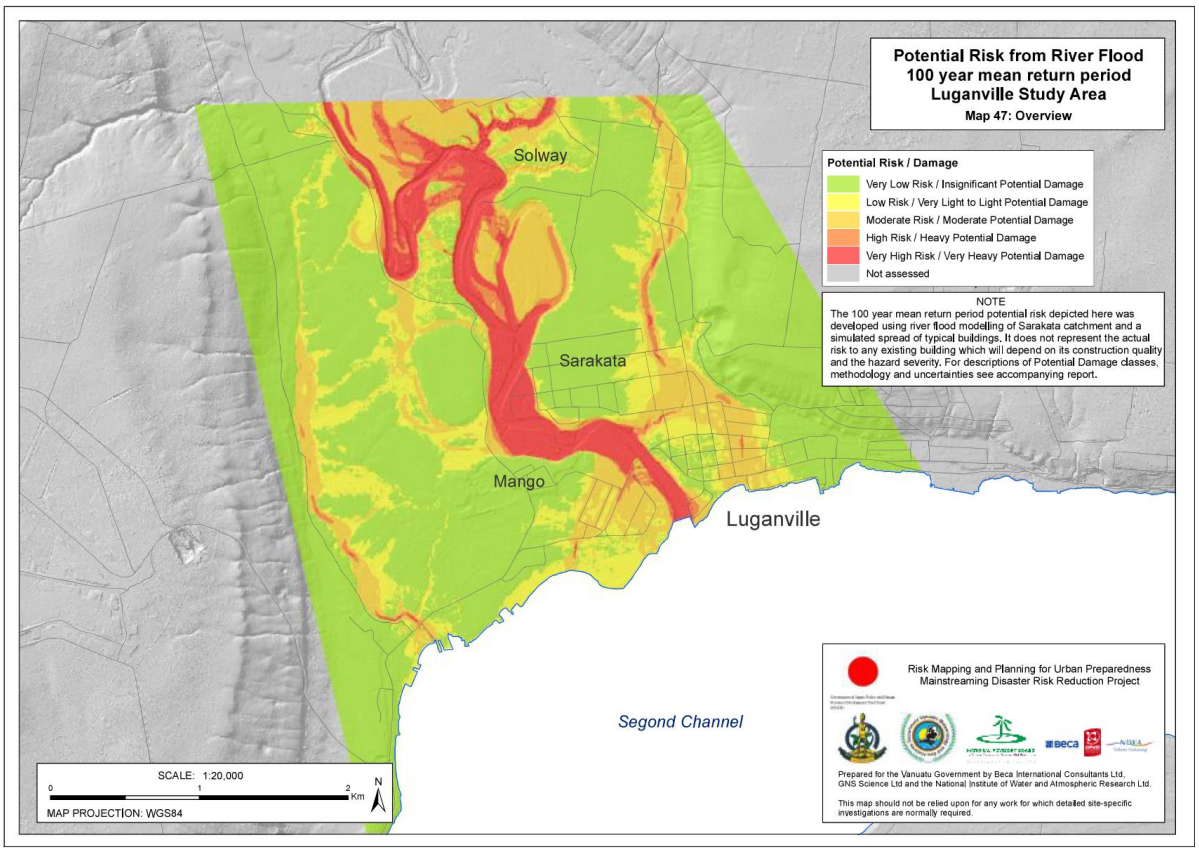

Figure 2.3: Combined maximum potential risk for Luganville for the 100 year mean return period (Beca, GNS Science and NIWA, 2016b)

	Unknown	None	Insignificant	Very Light - Light	Moderate	Heavy	Very Heavy
Seismic	0	0	0	0	5066 (98%)	79 (2%)	0
River Flood	2353*	0	1588 (57%)	476 (17%)	608 (22%)	44 (<2%)	76 (3%)
Wind	0	0	0	0	0	5145 (100%)	0
Coastal Inundation	0	4825 (92%)	53 (1%)	163 (3%)	144 (3%)	50(1%)	10 (< 1%)

* Buildings falling outside of the flood modelling area.

Figure 2.4: Assessment of potential damage to existing buildings within the Luganville study area (Beca, GNS Science and NIWA, 2016a, p. 45).

POTENTIAL RISK		VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
POTENTIAL DAMAGE		INSIGNIFICANT	VERY LIGHT - LIGHT	MODERATE	HEAVY	VERY HEAVY
Description of potential damage		No damage to very minor damage to weak structures	Buildings of poor construction slightly damaged.	Buildings of poor construction damaged, many heavily damaged, some collapse. A few buildings of average construction damaged some with partial collapse. Some buildings of good construction damaged.	Many buildings of poor construction destroyed. Buildings of average construction heavily damaged, some collapse. Buildings of good construction damaged some with partial collapse.	Most buildings of poor construction destroyed. Many buildings of average construction destroyed. Buildings of good construction heavily damaged, some collapse.
Water Depth Velocity		< 0.2 m	0.2 - 0.6 m < 0.5 m/s	0.6 - 1.3 m 0.5 - 1.5 m/s	1.3 - 2.0 m 1.5 – 3.0 m/s	> 2.0 m > 3.0 m/s
Damage State*	Class 1	DS0-DS1	DS1-DS2	DS2-DS3	DS3-DS4	DS4-DS5
	Class 2	DS0-DS1	DS1-DS2	DS2-DS3	DS3-DS4	DS5
	Class 3	DS0-DS1	DS1-DS3	DS3	DS4-DS5	DS5
	Class 4	DS0-DS1	DS1-DS3	DS3-DS4	DS4-DS5	DS5

Figure 2.5: Potential damage descriptors for flooding, which is applied to the greater Port Vila Urban Area and Luganville (Beca, GNS Science and NIWA, 2016b)

The assessment by Beca, GNS Science and NIWA (2016a) evaluated the potential risk to people from flooding by overlaying flood risk data with geolocated 2009 census data to estimate the number of people exposed to flood hazards. This analysis suggested that 25% of the population of Luganville (1,811) occupy houses which are exposed to a moderate, high, or very high flood risk. It is stated in the assessment that flood damage in the "Moderate", "Heavy" or "Very Heavy" ranges could lead to deaths without evacuation, and that people would likely be swept away by flood waters at higher velocities (Beca, GNS Science and NIWA, 2016a).

2.3.3 Gaps identified relating to disaster risk knowledge

Flood hazard mapping is available for the Sarakata catchment, with a range of limitations identified for that information. A review of the flood hazard mapping and other relevant information has identified the following gaps that are relevant to incorporation of disaster risk knowledge into the flood early warning system:

- Flood hazard modelling requires updating to include for climate change (this is currently underway).
- Risk to people and informal settlements included in the previous flood risk assessment for Luganville relied on a simulated spread of buildings and inferred construction styles, and on census data from 2009 (work is underway to develop updated exposure data with an update to the Pacific Catastrophic Risk Assessment and Financing Initiative building database.
- Assessment of risks to people and health associated with frequent flood events has not been evaluated.
- Hazard detection has not been fully integrated with land use planning and controls.

- An integrated risk assessment that combines the latest information about flood-related hazards, exposure and vulnerability for the current climate and future climate change scenarios (this is currently underway as part of a collaboration between NIWA and the Van KIRAP project).

2.4 Warning dissemination and communication

Early warning systems (EWS) are a major component in disaster risk reduction through emphasis on disaster preparedness. These need to be end-to-end systems that work together to create a single, cohesive, and robust system. The failure of any individual component will lead to the overall failure of the entire EWS and likely increase negative impacts on lives and livelihoods. Therefore, it is essential that the responsibility for the dissemination of the warnings and the responses necessary to avoid potential harm or loss lies with government and local community decision makers. Generally, warnings of potential hazards are issued via weather watches, advisories, and statements mostly in deterministic forms. These are required to be updated at a frequency, which is appropriate to the warning lead-time relevant to the hazard.

An important element of EWS is the incorporation of impact-based warnings. Communities not only need scientific hazard information, but also information about how to ensure their safety and protect their property (WMO, 2011). There is often a significant disconnection between the forecasts and warnings and an understanding of their potential impacts. However, this information is vital for producing accurate warning information which includes the likely impact associated with the forecast. This enables users to interpret the hazard warning in a meaningful way that relates to their needs. Impact-based forecasting is informed through hazard assessment, vulnerability assessment, risk assessment, impact assessment, and studies of risk perception. Warning advisors must work with local communities and sectors to ensure they understand the likely impacts through local knowledge from past events to ensure they appropriately incorporate impact information into their warnings.

2.4.1 Early warning and other information products, dissemination and notification methods

Flash flood warnings are currently issued by VMGD. These are triggered when rainfall is forecast to be greater than 100 mm rainfall/day. VMGD issues these warnings to local authorities, government offices, community disaster climate change committees, church leaders, women in community and NDMO. Wider dissemination of warnings is managed through NDMO via SMS, radio, TV, and social media. Radio Vanuatu has been identified as the only medium which can be accessed by the entire population of the country, regardless of remoteness, and therefore it is considered a key factor in information and communication sharing. Fiji Met Service is the regional centre for cyclone warnings, which are provided for Vanuatu. Uptake of warnings generally has been effective, particularly as a result of improvements in warnings following Cyclone Harold. Ten tsunami sirens are in place around Luganville urban and semi-urban areas[12].

A dashboard for the new river monitoring system was developed by VMGD for public to access the information online. It is estimated to benefit around 17,700 residents of Luganville. Data collected from this gauge can be used to verify the warnings.

VIKAP-2 project is underway to install VHF radio for improved communication to provinces and meteorological stations for use during Tropical Cyclones, severe weather or when other communications are down.

[12]VMGD meeting with T+T December 2022

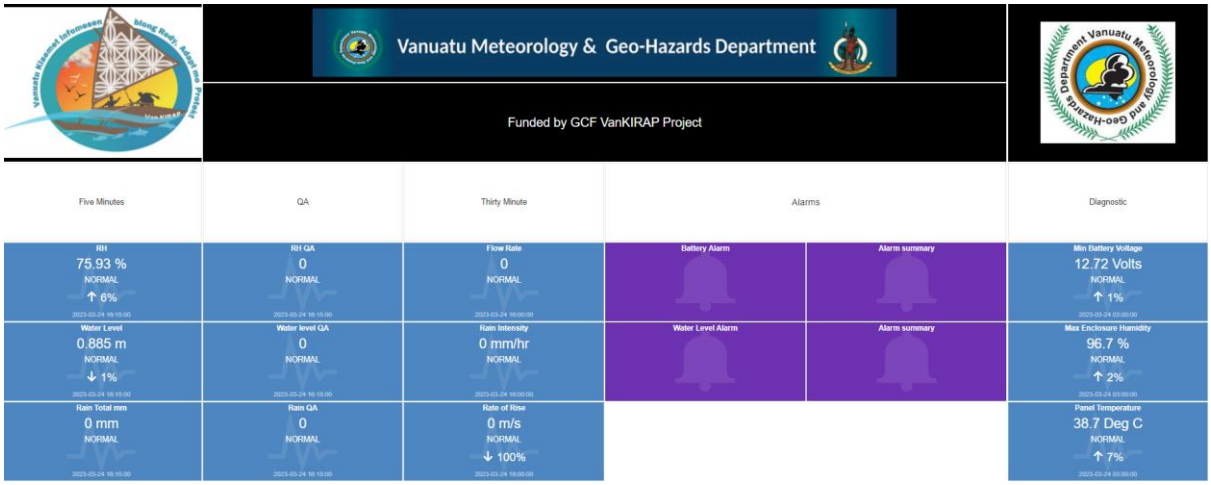

Figure 2.6: Public dashboard for new river monitoring system installed in September 2022 (Source: VMGD[13])

2.4.2 Risk communication

Risk communication systems must be well established, ensuring all stakeholders are effectively notified, including government, public, local community, community leaders and tourists. Channels of communication and procedures for monitoring the warning must be clearly understood by all parties and systems regularly checked.

Early warning functions need to be linked to risk assessment and preparedness programmes within a coherent disaster-management strategy. Communication from scientists is important for informing members of the public of potential hazards, so that individuals can assess their own level of safety and take preparation measures. A top-down approach is not appropriate or sufficient for an EWS. Communities should be involved in the risk mapping and analysis process to ensure their perspectives are included when decisions are being made.

2.4.3 Gaps identified relating to warning dissemination and communication

Gaps identified in flood warning dissemination and communication include:

- Flash flood warnings are based on basic metrics (100 mm/day rainfall depth), the basis of which is not confirmed.
- Absence of a flood management plan that clearly identifies roles and responsibilities and standard operating procedures.
- A lack of co-ordination of flood warnings and procedures with established early warning procedures for other multi hazard warnings, e.g. cyclones.
- A lack of integration with training and awareness programmes to include flood warnings into other existing hazard awareness and response programmes.
- A lack of evacuation plans for areas that are at-risk.

2.5 Preparedness and response capabilities

The ultimate test of any flood management plan depends on the response shown by the people at-risk. This is the result of a chain of preparedness, that is integrated across government, private sector, NGOs and communities. Community members are more likely to respond to warnings when they have been educated about the risks in advance of an event, and when they know what actions, they can take to minimise their impacts. It is critically important to work with the community to

[13] https://bit.ly/3fRFuT1

understand local knowledge, raise public awareness, tailor warnings to ensure accurate community interpretation of the key messages, and to ensure appropriate response plans and safe evacuation procedures are adequately resourced. Community connection and response and community preparedness are two essential elements under the community capacity.

2.5.1 Emergency management facilities, planning, and capabilities

The Sarakata catchment is serviced by one of the country's four Provincial Emergency Operations Centres (PEOC). The Santo (Samna) is operated by NDMO and is linked to the National Emergency Operations Centre (NEOC) in Port Vila. Incident organisational structure of PEOCs are guided by ToRs, and are activated in line with standard operating procedures with functions of agencies pre-agreed. Standard Provincial Disaster and Climate Change Plans are drafted for the Samna province.

In addition to activation through the NEOC, the VRCS can activate EOCs at national and at local level. For example, in response to TC Harold, the VRCS set up operations centres in Santo, Malekula and Pentecost to coordinate activities in the field. The establishment of these centres follows existing Standard Operating Procedures (SoPs) of the VRCS (NDMO, 2020).

At a national scale, relief items are stored by NDMO in shipping containers (three in number). Locally, a warehouse was constructed in Sanma (Logistics Cluster, 2023) in 2017 which is managed by Vanuatu Red Cross. Medical storage facilities are limited, with the country's only dedicated medical storage facility located in the Port Vila region, managed by the Ministry of Health. In addition, there is a lack of cold chain options for relief supplies, where electricity and refrigeration are generally unavailable and generators may be needed in emergency situations to cool sensitive supplies (e.g. vaccines) (Logistics Cluster, 2023). Transportation of relief items to Samna can be problematic due to the status of the roads, limited aircraft availability, and limited shipping infrastructure.

Communications in support of emergency operations can be challenging, particularly as telecommunications infrastructure is vulnerable to damage from Tropical Cyclones, and not all responders have access to adequate devices. The VRCS media and communications team has established a coordination network across its branches. This intended to support its multi-hazard contingency plan, and to deliver public, operational, and internal information, as well as reporting and institutional communication. Hospitals and airports on the island are reported to possess high frequency (HF) radios. Customs operates through very high frequency (VHF) channel. The Office of the Government Chief Information Officer (OGCIO), World Vision and the Red Cross work with satellite phones (Logistics Cluster, 2023).

The NDMO Strategic Plan 2016-2020 identifies the need to strengthen linkages between National and Provincial levels to reduce by-passing of PDCCC and stated an objective to strengthen the Incident Command System within the EOC by establishing a clearer command structure for response. Also, the NDMO Strategic Plan 2016-2020 highlights the need for provincial EOCs and Provincial Disaster Committees to work more consistently with the NEOC.

In 2015 a risk-informed decision-making training course was delivered to urban planners and engineers in Vanuatu, including members of the Sanma provincial disaster management office, to strengthen existing land use planning and disaster risk reduction processes through the integration of hazard information and risk-based decision-making (Secretariat of the Pacific Community, 2015). Following the training it was recommended that additional training to a broader group of planning officers from local authorities and municipal councils was necessary to further develop the capacity of town planning departments and to better integrate the management of flooding and other hazards into the planning process (Yeo, Esler, Taaffe, Jordy, & Bonte-Grapentin, 2017).

2.5.2 Community connection and response

In 2019, the NDMO became the leader of the Communication and Community Engagement Sub-Cluster, supported by VRCS. The role of this sub-cluster is to strengthen communication with communities during disasters and ensure a timely and effective communication with the affected communities.

As mentioned in Section 2.2, Luganville Community Climate Centre was established to provide Climate Information Services (CIS) from the VMGD to the community. They are also responsible for building adaptive capacity of communities and households in the uptake of, use and translation of CIS into actions to build resilience. Posters and outreach materials are available in these centres. However, only two posters have been published to date: one describing six steps for communication with communities and one drawing attention to communication (both in Bislama). More than 20 information fact sheets are being developed as part of the Van KIRAP project with the objective of documenting how CIS can inform climate change resilience.

The SREM developed for 2021-2023 does not account for provincial and community engagement, but since it is a developing document, future iterations might appropriately include references to a comprehensive programme for volunteer engagement, an important aspect currently lacking at country level.

2.5.3 Gaps identified relating to preparedness and response capabilities

Gaps identified in flood warning dissemination and communication include:

- Unclear uptake on the recommendations for continuation or expansion of risk-informed decision-making training for flood management.
- Underutilisation of community connection and outreach through the Luganville Community Climate Centre.
- No inclusion of provincial and community engagement in the SREM (2021-2023).

3 Recommendations

3.1 Governance and institutional arrangements

Key recommendations relating to governance and institutional arrangements are:

- Strengthened policies and institutional frameworks at the provincial level including clear roles and responsibilities.
- Clear standard operating procedures for flood early warning system management.
- Development of forums to enable coordination and partnerships.
- Update and finalise the Sarakata flood management plan.

3.1.1 Policy and institutional framework

Effective implementation of the flood management plan, hazard forecasting, and warning dissemination requires a strong policy and institutional framework. Creating an enabling environment by developing a simple and well understood law, or a policy, or an institutional framework for implementing the FMP and forecast services is necessary.

Inter-agency coordination is a key requirement for delivering effective flood management outcomes, where a critical element of this is clear identification of roles and responsibilities.

3.1.2 Standard Operating Procedure

A standard operating procedure (SOP) is a set of detailed step-by step instructions developed by an organisation to manage complex tasks and routine operations. To support the development of protocols and SOPs, case studies of past high impact flooding events with sufficiently documented impacts, response, forecast and warning information and available hydrometeorological data analysis are essential. SOPs could assist in establishing a chain of command, the production of uniform and reliable results, improved efficiency, and assist with the definition of clear roles and responsibilities. Therefore, creation of SOPs for hazard prediction and early warnings in Sarakata Catchment is important.

3.1.3 Coordination and partnerships

Providing platforms such as workshops or conferences for stakeholders to engage can improve their partnership. This could also be in the form of regular (e.g. three-monthly meetings) of the relevant public and private organisations, plus an online Community of Practice for daily/weekly interactions. Creating partnerships between the public organisations and private telecommunication enterprises can enhance the information dissemination channels.

3.1.4 Update and finalise the Sarakata Flood Management Plan

The updated FMP should be designed to ensure effective and coordinated governance of flood disaster risk reduction and foster sustainable development. The plan should address unclear coordination between NGOs and community-based organisations and should include consideration of the gaps identified in Section 2.1.4. The Plan should also include annual monitoring and evaluation to assess the effectiveness and efficiency of actions undertaken, leading to continuous improvement.

Effective flood management also requires incorporation of flood management measures. These can be broadly categorised into three categories:

- those measures which change the nature of the flood hazard itself.

- those measures which alter the exposure and vulnerability of people and property within flood affected areas.
- those measures aimed at influencing the behaviours and responses of individuals and communities impacted by flooding (Yeo, Esler, Taaffe, Jordy, & Bonte-Grapentin, 2017).

A further distinction can be made between structural and non-structural flood management measures. Structural measures are those which employ engineered physical infrastructure to reduce or otherwise manage flood hazards. In contrast, non-structural approaches make use of non-engineered and distributed measures to reduce losses associated with flooding. Non-structural flood management measures include legislative and regulatory responses, flood insurance and financial aid, early warning systems and catchment management.

It is recommended that elements of all three categories of flood protection measures, that utilise both structural and non-structural solutions are incorporated into the updated FMP. Examples of these types of measures are outlined in Table 3.1 (adapted from Yeo, Esler, Taaffe, Jordy, and Bonte-Grapentin, 2017), which when applied comprehensively can accommodate uncertainty and proactively manage residual risk.

Table 3.1: Common flood management measures

Modify flood hazard	Modify exposure and vulnerability	Modify human responses
Non-structural • Source control through catchment management, afforestation, enhanced infiltration • Stream restoration, maintenance of riparian margins **Structural** • Construction of flood barriers, levees, and embankments, dikes, and diversions • Flood detention basins, dams, and wetlands • Enhanced flood plain storage, polders and washlands • Enhanced channel capacity, dredging, debris management.	**Non-structural** • Legislation and land use planning, zoning regulations • Development controls, building codes • Stimulation of permanent relocation • Development of safe evacuation routes and flood refuges **Structural** • Distributed small-scale structural measures – raised building foundations, waterproofing of buildings, localised drainage and flood protections	**Non-structural** • Flood forecasting and early warning systems • Flood preparedness and awareness raising. Improving information and education on floods and flood response • Flood insurance schemes and risk financing • Post disaster assistance and financial aid • Community self-protection and emergency response teams • Post-flood recovery plans

Following updating of the FMP (as above), a separate exercise will be to develop flood management options, and to specify planning zones based on actual and/or residual flood risk.

3.2 Observation monitoring, analysis, and forecasting

Key recommendations relating to observation, monitoring, analysis, and forecasting are:

- Additional observational equipment and supporting services and capacity.

- Inclusion of empirical models or probabilistic modelling to inform hazard and risk assessments.

3.2.1 Additional observational equipment

There are limited hydrological monitoring and meteorological data available in the Sarakata catchment.

Data gathered from the Sarakata flow gauge (installed in 2022) is an important first step in improving the observational network. Data from this gauge may be used to validate the existing flash flood warnings and floodplain mapping. Additional flow and rainfall gauges are necessary to strengthen the observational equipment network needed to support flood monitoring and forecasting. Increased instrumentation also requires procedures for coordination and data sharing between VMGD and DoWR, and improved capacity and training to support the necessary flood forecasting capability.

Further detail relating to these requirements could be included as part of the development of the VMGD strategic plan, specifically addressing the requirements for flood-related meteorological services for the Sarakata catchment.

3.2.2 Empirical models or probabilistic modelling

Vulnerability, exposure and hazard-based data assist in informed decision-making for developing policies and plans, then selecting and implementing appropriate flood mitigation measures.

To augment low data availability, empirical models or probabilistic modelling could be developed using global, regional, and local hydrometeorological, geo and socioeconomic databases. These could be calibrated with historical losses to support an evaluation of the impacts of hazards on infrastructure, ecosystems, people and society that are typically too complex to model accurately. The risk assessment or loss modelling would help assess future disaster loss and damage assessment to people, infrastructure and natural resources. At the same time, an indirect loss data collection process could be introduced for risk and impact assessment.

3.3 Disaster risk knowledge

Key recommendations relating to disaster risk knowledge are:

- Adoption of hazard thresholds.
- Updating and strengthening risk assessment and risk management practices.

3.3.1 Hazards threshold

Defining hazard thresholds is essential for FMP to ensure flood risk is communicated accurately to the communities. A proper hazard threshold for each vulnerable area should be well articulated in the SOPs. Table 3.2 presents definitions and thresholds of indicators and risk scenario classifications.

Table 3.2: Example of definitions and thresholds of indicators to monitor flood risk

Key Monitoring Indicators	Definition	Thresholds	Normal	Alert	Alarm	Emergency	Warning Source
Rainfall/ Precipitation	Percentage of long-term mean (monthly)	Percentage increase above average in mm (based on thresholds)	No change	Any increase	20% to 60% increase	Greater than 60% increase	VMGD
River levels/ flooding	Monitoring river level for flooding or high-risk levels	River level above critical levels or flooding	Minimal risk level compared to long term mean flow of the river	Low risk level	Moderate risk level	Greater than High risk level but less than Bank full	DOWR

3.3.2 Risk assessment and risk management

Existing flood hazard mapping of the Sarakata Catchment is being updated to include the effects of climate change. Once available, these maps should be used to update the risk assessment for the catchment, including assessing the risk to buildings, infrastructure, people and informal settlements. This risk assessment should feed into local planning measures.

Furthermore, creation of a risk register can be a useful tool in risk reduction by identifying and documenting risks, their likelihood and impact on the systems of interest (e.g. a community, a business, a sector). Risk is typically placed in a register in the form of a matrix consisting of risk scores (likelihood versus consequences or using hazard, exposure, and vulnerability assessment). A risk register should also outline proactive actions to mitigate the risks with assigned responsibilities, thus ensuring good risk governance. Ideally, risk registers highlight systemic risk and cascading effects. Outlining risks in a public risk register enables effective risk communication.

3.4 Warning dissemination and communication

Key recommendations relating to warning dissemination and communication are:

- Community-focussed warning and dissemination.
- Community-specific evacuation plans.

3.4.1 Community-focussed warning and dissemination

As identified in Section 3.1.4, an updated Flood Management Plan will support the development of clear roles and responsibilities as well as improved training and awareness programs. For flood management to be effective, warnings must be implemented within the local context through a combination of technological and non-technological solutions designed with the community, and understanding how it best receives warning information. Warnings should be tailored to the provincial context, and be readily accessible (i.e. information available via community notice boards) Currently, flash flood warnings are based on basic metrics (100 mm/day rainfall depth), the basis of which is not confirmed and should be validated and refined as observational data become available. Community knowledge of the river flood response to previous events may be an alternative when technology fails (i.e. Observations or Traditional Knowledge).

Communications systems relay information on observed hazards to other specialists and link the technical community to the body of officials, politicians, government agencies, other organisations, or community leaders, which are responsible for determining the relevance of hazard data to populations at-risk.

Communication problems, due to equipment and human failure, are the most significant causes of poor warning dissemination. Redundancy in the systems provides alternative means of communication in the event of failure. Inclusion of flood warnings into the established warnings, procedures, and training and awareness initiatives developed for other hazards may provide a greater reach to the community and provide necessary redundancy.

3.4.2 Community-specific evacuation plans

Working with community leaders to develop evacuation plans for areas that are at risk is an important component of ensuring flood warnings are effectively acted upon.

3.5 Preparedness and response capabilities

Key recommendations relating to preparedness and response are:

- Training and capacity building.
- Community-based disaster risk management.
- Grass-roots level involvement.

3.5.1 Training and capacity building programs

As identified in the FMP, continued roll-out of risk informed decision making training to planning officers from local authorities is necessary to further develop the capacity of town planning departments and to integrate better the management of flooding and other hazards into the planning process (Department of Water Resources, 2011).

Conducting training and mock drill/simulation exercises through school safety programmes or awareness raising programmes on preparedness could be beneficial for improving community's knowledge on floods.

Educating communities on flood risk reduction/mitigation measures might save lives and protect assets during flooding. Outreach material on forecasting, disaster risk reduction, and climate change adaptation could guide the communities on flood response procedures. It would also assist the communities in taking informed decisions.

3.5.2 Community-based disaster risk management

Ensuring the direct involvement of the community through community-based disaster risk management (CBDRM) will be a crucial part of strengthening flood risk management in the settlements alongside the Sarakata River. The assessment of flood risks outlined in Section 3.3.2 should incorporate principles of CBDRM to identify and engage vulnerable groups to ensure that their specific needs and capacities are understood. This will ensure that flood management policies and interventions align with the needs and capabilities of the community.

3.5.3 Grassroots level involvement

For an effective implementation of FMP, Luganville Municipal Council should actively involve the communities at-risk, facilitate public education and awareness of risks, and disseminate effectively messages and warnings to ensure they are prepared for future events. It should encourage communities to participate in design and implementation of disaster risk reduction programmes. Effective functioning of the Luganville Community Climate Centre is also crucial to implement this recommendation.

4 Applicability

This report has been prepared for the exclusive use of our client Secretariat of the Pacific Regional Environment Programme, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

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Appendix F Guidance on Memorandum of Understanding

To institutionalise the FMP and EWS, the development of an Memorandum of Understanding (MoU) between DoWR and relevant parties, including VMGD, NDMO, DoCC, NGOs, private sector, and communities, is needed. DoWR needs to coordinate this process and secure approval from parties.

The purpose of the MOU is to provide documentation that demonstrates relevant stakeholders have been consulted, coordinated, and agree to the roles and responsibilities outlined in the FMP, EWS and SOP. Specific guidance and advice are provided below on development of the MoU.

- **Purpose and objectives:** The MoU should clearly outline its purpose and objectives, which, in this case, is to secure the stated intent of parties to work together and cooperate on the implementation of the FMP, EWS and SOP. The parties participating in the MOU should be listed.
- **Definitions:** The technical terms used within the MoU should be defined, as this helps to avoid confusion and uncertainty among parties.
- **Roles and responsibilities of parties:** The MoU should state that all signatory parties agree to the allocation of roles and responsibilities that are outlined herewith in the FMP, EWS, and SOP, and in subsequent iterations of these documents.
- **Alignment with existing agreements and processes:** The MoU should also state that existing agreements and institutional processes, such as existing sectoral plans and frameworks, must be updated to align with these roles and responsibilities, and that parties must secure the financing required to execute the MoU.
- **Responsibility for compliance:** The MoU should state which agencies are responsible for ensuring compliance, and how compliance will be delivered. This should be aligned with the monitoring, evaluation and learning plan outlined within this document.
- **Legal nature of the agreement:** Advice should be sought from the Vanuatu State Law Office on whether MoU is binding or non-binding for parties. The legal structure of the agreement may also affect the enforceability of the roles and responsibilities, and procedures for compliance among parties.
- **Use of templates:** DoWR should ensure that the development of this MoU utilises existing templates to reduce administrative burden.
- **Nature of signatory parties:** Too many parties may result in difficulties securing consensus. The MoU should only be signed by relevant parties, and representatives of parties if possible, e.g. VANGO to represent the interests of NGOs, VCCI to represent the interests of the private sector, community organisations to represent the interests of community members.
- **Signing by parties:** Based on advice by the Vanuatu State Law Office, the MoU should only be signed by individuals that have the required delegation of authority, such as departmental heads or designees, based on government policy and legislation. Furthermore, the MoU may need to be submitted to an appropriate governing body for consideration. The MoU should be promulgated to all parties after signing.
- **Process for updating MoU:** Information should be provided on the process for updating and agreeing amendments to the MoU.

Appendix G SitRep Template

S SITUATION	M MISSION	E EXECUTION	A ADMINISTRATION	C COMMUNICATIONS	S SAFETY
	INCIDENT:			From:	
	LOCATION:			To:	

Situation overview	
Objectives	
Strategies	
Administration & Communications	

Safety Considerations	
Critical Issues	

Time of Briefing:	**Briefing to by:** Carol Rovo	**Person's Names:**

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