ADAPTATION FUND

PROPOSAL COVER PAGE

1. Type of project: Single-Country ☒ Regional ☐
2. Countries: Fiji
3. Project/Programme Category: Regular
4. Project/Programme Stage: Concept
5. Requested financing amount (in U.S. Dollars Equivalent): 5,560,000
6. Letter/s of Endorsement (LOE) signed:
   LOEs should be signed by the Designated Authority (DA). The signatory DA must be on file with the Adaptation Fund. To find the DA currently on file check this page: https://www.adaptation-fund.org/apply-funding/designated-authorities

   Yes ☒ No ☐

7. Write the date of endorsement for each LOE for the project.

   a) Country: Fiji Date signed: 01/09/2023

8. Title of Project/Programme: Enhancing Climate Adaptation through scaling up Fiji's coastal inundation forecasting early warning system
9. Implementing Entity: World Meteorological Organization (WMO)
10. Executing Entities: Fiji Meteorological Service (FMS)
11. Is this a new submission or a resubmission: New: ☒ Resubmission: ☐
12. If a resubmission, please select the last submission date: n/a

CONCEPT NOTE PROPOSAL FOR SINGLE COUNTRY

PART I: PROJECT/PROGRAMME INFORMATION

Title of Project/Programme: Enhancing Climate Adaptation through scaling up Fiji's coastal inundation forecasting early warning system

Country: Fiji

Thematic Focal Area: Disaster risk reduction and early warning systems

Type of Implementing Entity: Multilateral Implementing Entity

Implementing Entity: World Meteorological Organization (WMO)

Executing Entities: Fiji Meteorological Service (FMS)

Amount of Financing Requested: 5,560,000 (in U.S Dollars Equivalent)

Project / Programme Background and Context:

Summary

Fiji faces an increased dire risk of coastal inundation from enhanced intensity of tropical cyclones, sea level rise and other meteorological, climatological, and hydrological hazards associated with the impacts of climate change. With 91% of its population living by the coast, coastal inundation threatens Fiji's livelihoods and economy. Coastal inundation forecasting early warning systems (EWS) enables communities-at-risk and industries by the coast to prepare for and respond to natural hazards. For EWS to properly operate, it needs an end-to-end system from the operational end to interactions with the stakeholders. Through the Coastal Inundation Forecasting Demonstration Project (CIFDP), the Fiji Meteorological Service (FMS) successfully implemented a coastal inundation forecasting EWS, but budget limitations meant that forecasts were not possible for all of Fiji, nor work on social elements. Scaling up CIFDP, this project will enhance the early warning systems and replicate the forecasting system to the remaining key coastal areas in Fiji. This project seeks to implement innovative technical and social solutions to climate adaptation, adopting regionally new technologies and socially inclusive approaches to build resilience of communities-at-risk.

This project will directly benefit all coastal communities in the two most populated islands of Viti Levu and Vanua Levu. It will also strengthen partnerships between non-profit organizations (NGOs), government institutions and FMS to coordinate information and warnings. In addition, it will build the capacity of Fiji to integrate science into climate strategies and policy with constructed databases. As co-benefits, this project will generate enhanced forecasting products for neighboring Pacific countries through the Regionalized Specialized Meteorological Service (RSMC) in Nadi.

Introduction

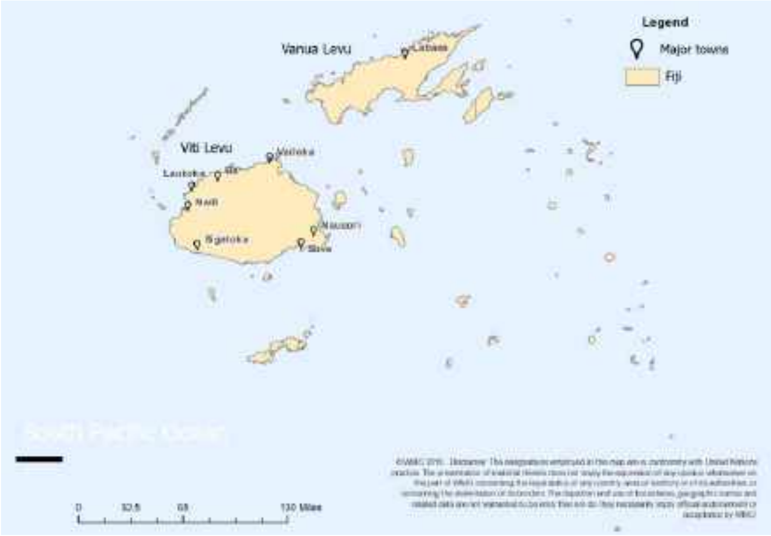


Figure 1 Map of Fiji and its major towns

Fiji, comprised of more than 332 islands, is located in the South Pacific Ocean (Figure 1). As an Island State, the average distance from any Province to the nearest coast is 7km, where the whole country faces an increased dire risk of coastal inundation from enhanced intensity of tropical cyclones, sea level rise and other meteorological, climatological and hydrological hazards associated with the impacts of climate change.

Since 1970, the Fiji Meteorological Service (FMS), the Executing Entity for this project, has been authorized by the Parliament of Fiji as the sole official authority to give forecasts and early warnings for meteorologically related hazards. FMS extensively coordinates and collaborates with other Government Ministries including the National Disaster Management Office (NDMO), to ensure efficient response of the community to natural hazards.

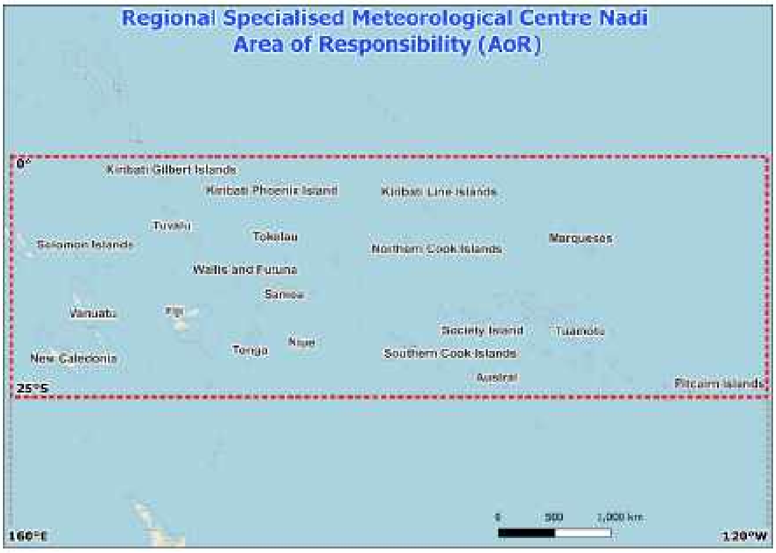


Figure 2: Regional Specialized Meteorological Centre Nadi Area of Responsibility

In addition to Fiji's role in giving accurate and timely forecasts and warnings over its sovereign territory, Fiji, through its National Weather Forecasting Centre-Nadi, is designated as the Regional Specialized Meteorological Centre (RSMC) for Tropical Cyclone over the World Meteorological Organization (WMO) South-West Pacific region (Figure 2). Since its designation as an RSMCin 1997, Fiji has been providing tropical cyclone bulletins, alerts and warnings for its region. Given the lack of equipment and available resources at their meteorological agencies, most of the countries in the region rely solely upon warnings from Fiji (RSMC-Nadi) to disseminate daily forecasts and warnings for tropical cyclones and to prepare for natural hazards. These additional responsibilities of FMS demonstrate the crucial role FMS plays nationally and regionally to respond to meteorological hazards. It is expected that the project will generate co-benefits to strengthening delivery of early warning systems in other Pacific countries as the enhanced coastal inundation forecasting Early Warning Systems (EWS) capacity of FMS will also improve the products generated at RSMC-Nadi.

Socio-Economic context

Population

Of the 332 islands in Fiji, 110 islands are populated. Viti Levu and Vanua Levu are the two largest islands with the biggest populations[1] with 87% of the total population residingl on the two islands. The districts (Tikina) listed in Table 1 with the largest population are in Viti Levu and Vanua Levu, concentrated along the coasts (Figure 3). In Fiji, 27% of the population live within 1km of the coastline, 76% with 5km and 91% live within 10km of the coast[2]. Thus, the vast majority of the population of Fiji is vulnerable to natural hazards from extreme weather events affecting the coasts. Concentration of population by the coast is one of the determining factors to site selection for the project as further delineated in the Section of **Selection process for Project site**.

[1] Fiji: Climate Vulnerability Assessment
[2] https://journals.plos.org/plosone/article/figure?id=10.1371/journal.pone.0223249.t002

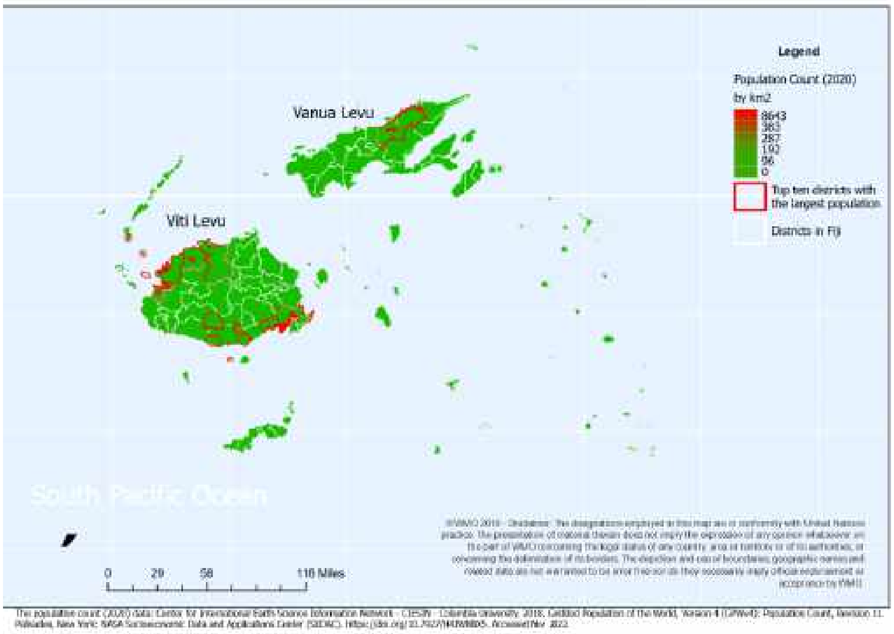


Figure 3 Population Count (2020) in Fiji

Table 1 Districts (Tikina) with the largest population

Districts (Tikina) with the largest population
Naitasiri
Vuda
Suva
Nadi
Ba
Labasa
Bau
Tavua
Serua
Lami

Economy and labor force

Fiji's services sector, which includes the tourism sector, makes up 56% of its annual GDP and 44% of the population is employed in the services sector[3]. In 2017, the tourism industry alone made up about 34% of Fiji's Gross Domestic Product (GDP). COVID has detrimentally affected Fiji's economy where, in 2020, Fiji experienced a reduction of 15% in real GDP due to lockdowns which completely halted tourism for an extended period. Nonetheless, Fiji's economy has been forecasted to see an upward trend, as Fiji has now opened its borders again. With the upswing in the tourism industry, the role of FMS is again highlighted in the provision of impact-based early warnings to the Tourism industry, including to the small and medium-sized enterprises (SMEs) in the industry. EWS is one of the most effective and primary climate adaptation activities which supports the tourism sector and other related sectors on the coasts. Coastal inundation forecasting EWS creates an enabling environment for businesses to enhance their adaptation and resilience to the adverse effects of climate change.

Climate impacts in Fiji

Temperature

Fiji has experienced a significant increase of mean air temperature over the past decades. With the temperature rising, there is increased risk of water borne diseases; it also exposes Fiji's susceptibility to viral diseases. There is a significant rise in anomaly of projected mean temperature since the early 2000s (Figure 4). Furthermore, with sea surface temperature (SST) also rising in the South-west Pacific Ocean according to the State of the Climate in the South-West Pacific 2021 [4], Fiji is likely to experience increased intensity of tropical cyclones. Higher temperature (sea surface) contributes to sea level rise leading to higher frequency and intensity of coastal inundations. In addition, the rise in sea surface temperature will affect coastal ecosystems, including bleaching of coral reefs and more severe algae blooms. Aside from the tourism sector, the main livelihood of Fiji includes an artisanal fishery. However, with the change in movement of fish stocks due to changing SST, artisanal fishermen in Fiji face threats to their livelihoods.

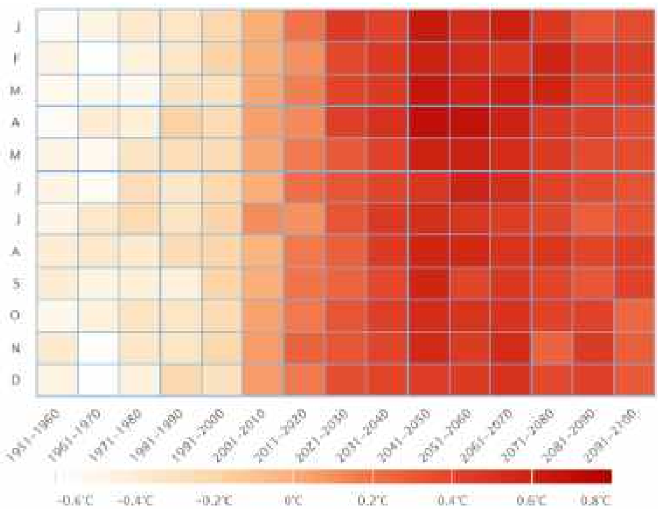


Figure 4: Projected Mean-Temperature Anomaly Fiji

[3] https://data.worldbank.org/indicator/NV.SRV.TOTL.ZS?locations=FJ
[4] https://library.wmo.int/doc_num.php?explnum_id=11387

Sea Level Rise

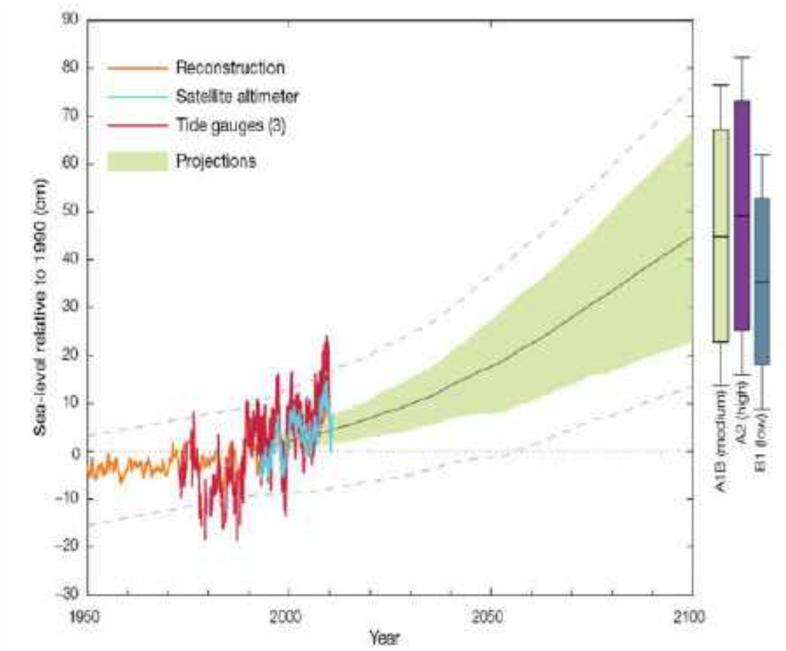


Figure 5: Observed and Projected Relative Sea-Level Change Near Fiji

Since 1993, Fiji has recorded a 6 millimeter (0.2 inches) increase in its sea level per year, larger than the global average (0.14 inches). The rapid rise in sea level and the resulting saltwater intrusion that stems from the increased ferocity of coastal inundation have made portions of the island nation uninhabitable [5]. By 2100, it has been projected that Fiji will experience nearly 40 cm of sea level rise when looking at a medium level scenario (Figure 5). As the majority of islands in Fiji are low-lying, such rise of sea level will detrimentally affect the coastal zones. As a result, by 2100 it has been projected that all of the provinces in the two biggest islands will experience permanent inundation of buildings (Figure 6). As stated above, as most of the population live near the coasts, there will be significant loss of livelihood on the islands, as in severe areas of inundation, relocation of communities needs to take place.

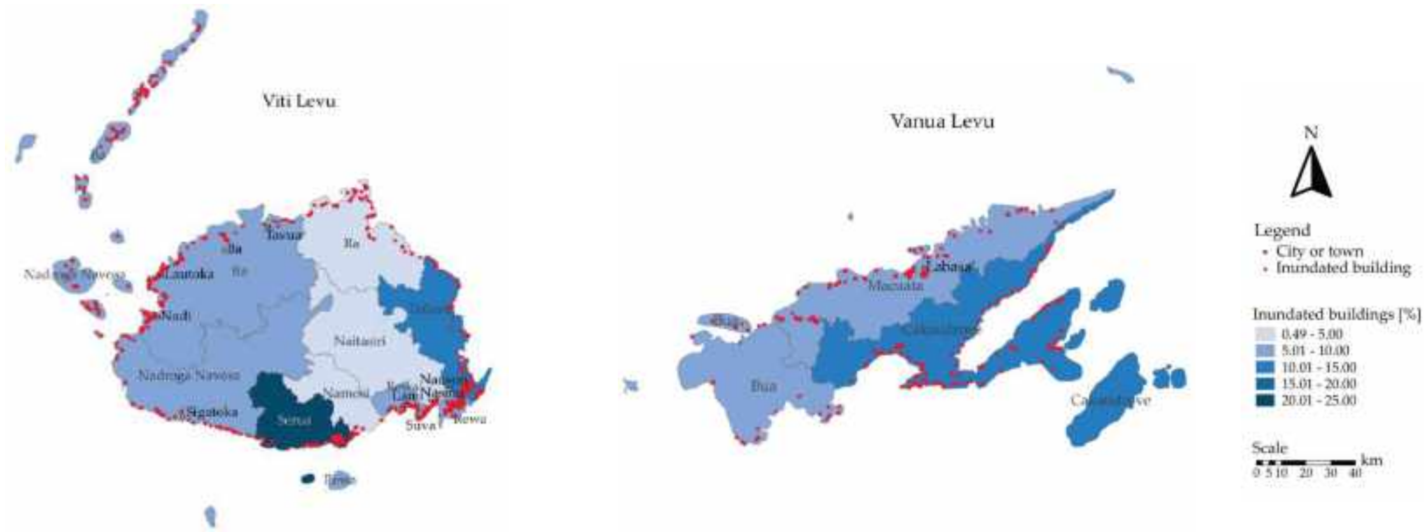


Figure 6:Distribution of permanently inundated buildings in Vanua Levu and Viti Levu in 2100. Each province is colored according to the percentage of inundated buildings compared to the total existing ones.

Ocean Acidification

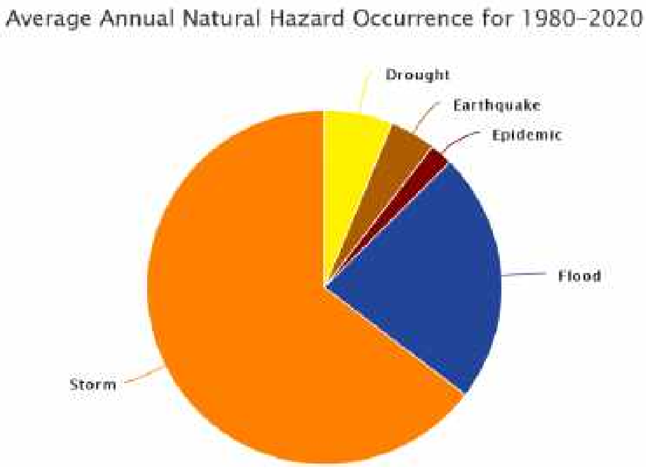
Ocean acidification is a grave threat from climate change faced in the Pacific as coral reefs become more brittle leading to dissolution as a result of their high sensitivity to pH levels . Coral reefs serve as a first line of natural barrier against waves and storms, protecting the coastal communities from coastal inundation; however, if the coral reefs diminish, coasts would be exposed to the direct forces of meteorological hazards endangering the communities and infrastructure at the coasts. According to Secretariat of the Pacific Regional Environment

[5]Merschroth S, Miatto A, Weyand S, Tanikawa H, Schebek L. Lost Material Stock in Buildings due to Sea Level Rise from Global Warming: The Case of Fiji Islands. Sustainability. 2020; 12(3):834. https://doi.org/10.3390/su12030834

Programme (SPREP), a decrease of 30% in the pH of the tropical Pacific Ocean has been observed since the 19th century and at this rate, by the end of this century, another 150% drop of pH is expected. This means that the rate of decrease seen over the last 200 years is expected to occur every 20~50 years. Under future projections, ocean acidification will ultimately cause net dissolution of coral reefs. In one study, it has been estimated coral reefs will cross a tipping point to a net dissolution by 2030[6].

The decreasing pH level, coupled with increasing sea surface temperature and sea-level rise poses a major threat to the livelihood of Fijians who rely on the ocean for daily sustenance. In addition to loss of the protection from coral reefs, the coupled impacts of climate change increase the risk of coral bleaching and loss of marine diversity, forcing Fijians to seek alternative livelihoods,

Extreme Weather Events



According to 2021World Risk Index, Fiji is ranked as the 14th most hazardous country, based on its high exposure to natural hazards and relatively low coping capacity[7]. Moreover, Fiji is estimated to have a 70% chance of suffering a significant occurrence of natural hazards each year as revealed from a study done by the International Monetary Fund (IMF)[8]. Since 1980, Fiji has experienced more than 51 natural disasters, 65% due to meteorological hazards (Figure 7). For Fiji, extreme weather events are the single biggest risk and cause of damage[9]. In particular, tropical cyclones are the single most significant natural hazards for Fiji, and Fiji on average, experiences one tropical cyclone per year.

Figure 7: Average Annual Natural Hazard Occurrence for 1980-2020

Coastal Inundation

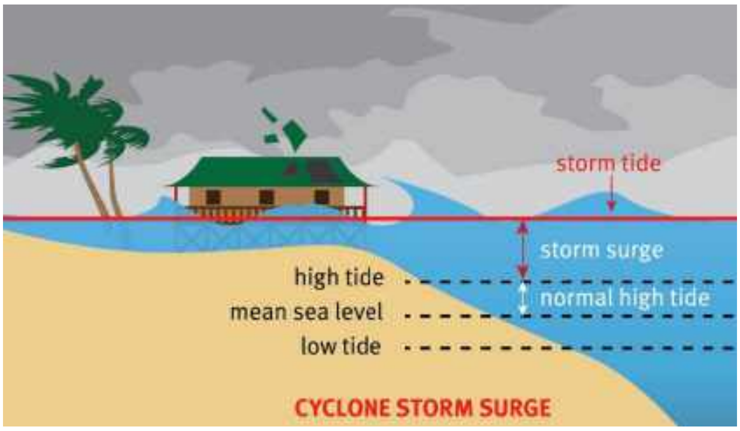


Figure 8: A schematic of storm surge

About 91% of Fiji's population live within 10km of the coast. With most of the islands in Fiji having a volcanic origin, they are mountainous and rugged. As such, most of the highways which join different sides of the islands run parallel to and close to the coast. Thus, inundation along the coasts heavily affects the livelihood and well-being of the population as it damages infrastructure and properties in addition to causing loss of life. Coastal inundation also disrupts coastal ecosystems. From frequent and widespread coastal inundation, there is increased risk of saltwater intrusions, contaminating freshwater aquifers, and affecting the municipal and agricultural water supplies, soil and natural ecosystems. It affects the livelihoods of the coastal populations leading to relocation of communities. Over the past years, coastal inundation in Fiji is increasing in frequency and severity as a result of stronger tropical cyclones which lead to higher storm

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[6] Wolfe, K., Roff, G. Global predictions of coral reef dissolution in the Anthropocene. Commun Earth Environ 3, 42 (2022). https://doi.org/10.1038/s43247-022-00363-3

[7] https://reliefweb.int/sites/reliefweb.int/files/resources/2021-world-risk-report.pdf

[8] https://www.imf.org/en/Publications/WP/Issues/2018/05/10/The-Economic-Impact-of-Natural-Disasters-in-Pacific-Island-Countries-Adaptation-and-45826

[9] https://climateknowledgeportal.worldbank.org/country/fiji/vulnerability#:~:text=Fiji%20is%20also%20particularly%20exposed,scale%20events%20that%20go%20unreported.

surges. Storm surges are created when high winds, for example from tropical cyclones, push water towards the coast, leading to coastal inundation. . Storm surge, often combined with high tides and waves, causes water to overtop low-lying land and coastal berms and overflow seawalls built around the coasts leading to coastal inundation (Figure 8)[10]. Storm surges have been historically the leading cause of casualties from tropical cyclones globally, with on average 8000 deaths every year. Figure 9 shows an image of impacts of coastal inundation from Cyclone

Figure 9: Impacts on Kia Island, Fiji from Tropical Cyclone Yasa, 2020

Swells are another cause of coastal inundation. Swells are long wavelength waves that are produced from distant storms. For instance, a neighboring island or a country may be experiencing storms and the high waves that are generated from the storms can travel thousands of kilometers to Fiji leading to coastal inundation. During the non-tropical cyclone (TC) months of May to October, swells are generated by deep low-pressure systems near New Zealand. These low-pressure systems generate waves that travel thousands of kilometers and cause coastal inundation in Fiji and other islands in the Pacific. Due to sea level rise, the frequency of swells causing coastal inundation in Fiji and other low-lying islands is increasing.

Another cause of coastal inundation is riverine flooding, where the river flows into the ocean, and some distance upstream. High river discharge, a result of heavy precipitation over both short and medium durations, may be effectively “blocked” by high water levels at the coast, from a combination of high tides, waves and storm surge, causing the river to overflow its banks upstream of the coast, as experienced during the severe flood event of 2012 which devastated the Western parts of Fiji. Being in the tropics, Fiji experiences variable precipitation due to its convective nature which makes it more challenging to accurately forecast the rainfall and consequently the resulting of river flow/runoff. This is exacerbated by intensification of hydrological cycles from climate change. Pluvial floods and flash floods which are triggered by intense precipitation events are likely to become more frequent. A complex mixture of natural phenomena enhanced by climate change is causing more severe inundation, particularly along coastal areas near the mouths of major rivers.

With climate change leading to a combination of higher storm surge plus waves induced from stronger cyclones, increased sea level rise and more frequent riverine flooding by the coasts from heavier precipitation and extreme weather, coastal inundation is occurring more frequently and severely.

Vulnerability to climate change

Economic Vulnerability

Tropical cyclones pose the major economic threat to Fiji, costing on average around 5% of GDP every year[11]. In 2016, Severe Tropical Cyclone Winston hit Fiji and caused approximately 0.9 billion USD damage which

[10] Laurens M Bouwer and Sebastiaan N Jonkman 2018 Environ. Res. Lett. 13 014008
[11] https://climateknowledgeportal.worldbank.org/country/fiji/vulnerability#:~:text=Fiji%20is%20also%20particularly%20exposed,scale%20events%20that%20go%20unreported.

amounts to around one-third of its total GDP[12]. Excluding the agricultural asset losses from tropical cyclones and floods, the biggest asset losses come from the transport sector and buildings. The Transport sector is of major economic significance in Fiji where it contributes 12% to its annual GDP and constitutes 30% of annual Fiji government spending[13]. The damage to the transport sector can greatly compromise the tourism sector and disrupt overall economic flow including for the agricultural sector. Sector specific forecasting EWS products, one of the outputs from the project, can secure safety on roads, aviation, and marine routes in addition to enhancing effective mobility and minimizing disruptions in the transportation sector in the event of tropical cyclones and floods. It has been estimated that the economic loss from tropical cyclones and floods is going to increase as a result of continuous coastal development and urbanization. By 2050, the magnitude of GDP lost from these two natural hazards will increase by up to 50%, which is around 6.5% of the GDP. In a climate vulnerability assessment undertaken by the World Bank, climate modeling indicates that revenues from tourism, one of the primary economic forces in Fiji, would drop by 18% just from the projected increase in temperature by 2030, not accounting for enhanced perception of risk as a holiday destination from enhanced intensity of natural hazards. Thus, effective preparation for and response to natural hazards, especially for coastal hazards, can mitigate the adverse effects of core economic forces in Fiji.

Livelihood *and Health*

HAZARD	AVERAGE NUMBER OF PEOPLE FALLING INTO POVERTY EVERY YEAR (and percent of total population)			PEOPLE FALLING INTO POVERTY FOR THE 100-YEAR EVENT (and percent of total population)		
	2017	2050	2100	2017	2050	2100
Tropical cyclones	7,300 (0.9%)	7,300 (0.9%)	7,300 (0.9%)	48,000 (5.7%)	48,000 (5.7%)	48,000 (5.7%)
Fluvial floods	11,400 (1.4%)	16,000 (1.9%)	17,900 (2.1%)	105,000 (12.5%)	125,000 (14.8%)	132,300 (15.7%)
Pluvial floods	7,000 (0.8%)	9,100 (1.1%)	11,000 (1.3%)	66,000 (7.8%)	89,500 (10.6%)	107,500 (12.8%)
TOTAL	**25,700 (3.1%)**	**32,400 (3.8%)**	**36,200 (4.3%)**			

Source: World Bank team, based on asset loss estimates from PCRAFI for tropical cyclones and SSBN for floods.

Note: There is an uncertain overlap between tropical cyclones and floods, making it difficult to disaggregate the various hazards. However, sensitivity analyses have shown that this overlap does not affect results significantly. Tropical cyclone losses are presented as constant, as there's is a large uncertainty in future cyclone behaviour, frequency and intensity. These numbers also assume a stable population.

Figure 10 Effect of climate change on natural disasters' impact on poverty

Communities at risk from natural hazards include women, people living with disabilities, the elderly and those who live under the poverty line, unable to recover from repercussions of the natural hazard events. In Fiji, around 10% of the population reside in informal settlements that are particularly exposed to effects of natural hazards. Surveys in Fiji have found that, in the last decade, the informal settlements have been expanding, and in an effort to increase resilience of these communities, Fiji has been working with UN Habitat through Adaptation Fund Investment. According to a Climate Vulnerability Assessment undertaken by the World Bank in 2017, an average of 25,700 people fall into poverty every year because of losses from tropical cyclones and floods, the biggest drivers of natural hazards in Fiji. A 100-year return period tropical cyclone would push about 5% of the population into poverty, demonstrating the magnitude of vulnerability that Fiji faces from climate change (Figure 10). In addition to the acute risks from natural hazards, effects of climate change such sea-level rise, ocean acidification and intensified and more frequent natural hazards also threaten the livelihood of those relying on subsistence farming and artisanal fishing. More than one-third of Fiji households relies on agriculture as a form of income, where agriculture makes up about 8% of the total GDP (2015 GDP). However, as a result of coastal erosion, saltwater intrusion, riverine flooding and coastal inundation, the agriculture sector in Fiji is gravely threatened by climate change. Furthermore, projected increases in temperature and flood can heighten the risk of spread of vector-borne, water-borne diseases and other non-communicable disease such as respiratory diseases, leading to further stress in Fiji health care system.

[12] https://www.humanitarianresponse.info/sites/www.humanitarianresponse.info/files/documents/files/fiji_lessons_learned_workshop_report_external.pdf

[13] https://www.gfdrr.org/sites/default/files/publication/Making%20Fiji%20Climate%20Resilient%20-%20Full%20Report_0.pdf

Relocation of communities

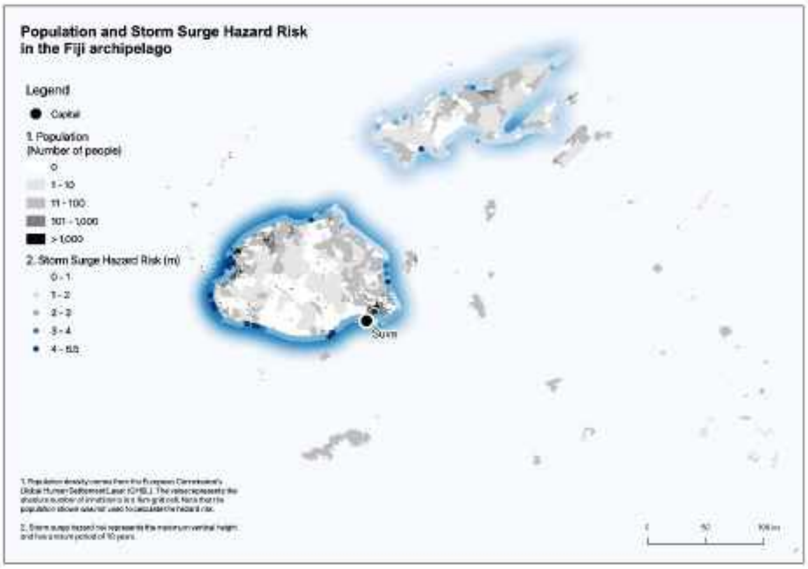

Figure 11 Population and storm surge hazard risk in the Fiji archipelago.

From the adverse effects of climate change including intensified storm surge and sea level rise, communities heavily affected by coastal inundation have been relocated to other parts of the islands. According to the Internal Displacement Monitoring Centre, in the next 20 years about 35,000 people will be displaced because of storm surges in Fiji with 58% probability (Figure 11). Furthermore, as a result of cyclonic winds, 2,076 people are estimated to be displaced every year. A number of relocations in Fiji have already happened including for the islands of Viti Levu and Vanua Levu. The resettlement process has not been easy for Fiji as the communities need to leave their livelihoods and traditions behind and move to another community that is further inland. In the relocation process, a number of unintended consequences have also occurred, including the rise in crime as villagers have easier access to alcohol shops and recreational centres. Some have moved back to their home villages as many relied on fishing for their livelihood. In response to this situation, the Fiji Ministry of Waterways is working with the Secretariat of Pacific Community (SPC) to build nature-based sea walls for 16 coastal communities. The synergies and complementarity with this project are further delineated below in Section F.

Recommendations and Lessons Learnt from the CIFDP -Fiji

In 2012, Fiji requested assistance from the WMO, as FMS lacked high-resolution forecast models and observational data. At the time, Fiji relied on coarse global models (eg.,. numerical weather prediction) and a sparse observational network to prepare for severe and extreme weather events. In addition, in the 2013 stakeholder workshop, the capacity of end users and coastal communities was appraised to be insufficient to ensure optimal use of forecast and warning information to manage hazard risks. Considering such gaps, FMS sought to improve their forecasting ability and capacity with the theory of change in mind on rendering its meteorological products impact-based and operationalizing a multi-hazard early warning system (MHEWS). Recognizing the critical role of FMS to both Fiji and the region, and the visible effects of climate change on its coastal communities, WMO with Fiji, received funding from the Republic of Korea (the Korea Meteorological Agency (KMA) and The Korea International Cooperation Agency (KOICA)) totaling $1.4 M USD to implement the Coastal Inundation Forecasting Demonstration Project-Fiji (CIFDP-F).

The Coastal Inundation Forecasting Initiative (CIFI) is a forecast and warning systems approach developed through CIFDP. This approach was also implemented concurrently in Bangladesh, Indonesia and the Caribbean. The objective of the Demonstration Project in Fiji was to enable efficient early warning systems to protect coastal communities and support sustainable development. The CIFDP-Fiji was successfully demonstrated and completed in 2020 as delineated in the Final Report. The Final Report from CIFDP-Fiji articulates many positive outcomes from the project, including the capacity of FMS staff to operate high resolution models, and the national forecasters having access to the infrastructure and equipment to forecast accurately.

The Final Report also contains a number of recommendations for Fiji, including exploring opportunities for additional funding to scale up the project to rest of Fiji:

To promote effective response actions at the grass-roots level stakeholders recommended that simple tailored warning messages should be co-designed with the support of the community and local champions. Stronger partnerships with NGOs at a national level would be helpful.

- To purchase equipment, particularly ocean buoys, for data collection
- To replace the non-working river level gauges and relocation of measuring equipment to a more sustainable location.

- To replicate the flood forecast warning system to other river basins of Viti Levu and other populated basins.
- To measure flood flows in Fiji rivers, especially for the Nadi basin (only river level data is currently available).
- To extend the wave model to include all of Fiji.
- To convert all the products into impact products

The demonstration projects in other parts of world have also yielded positive outcomes, validating the effectiveness of this approach and leading to what is now known as the WMO Coastal Inundation Forecasting Initiative (CIFI). The CIFI's innovative approach empowers countries in forecasting coastal adaptation. Building upon the lessons and recommendations from the Demonstration projects, especially the pilot project in Fiji, this project further expands upon the CIFDP and focuses on building resilience of end users and industries by the coast to fully realize MHEWS. The lessons from the CIFDP in Fiji include:

- While mitigation and good preparation were a goal, focus and resources were concentrated on response, rescue and recover as staff and resources are constrained and limited at times of hazardous events.
- There is still a need for resources to support community education programs and community emergency management planning that will focus more on preparation and mitigation and build community resilience.
- By the end of the CIFDP- Fiji, although significant technical and scientific advances have been made as outcomes of the CIFDP including improvement in coastal inundation forecasting and warning capabilities, the information is not generally accessible to the user community, primarily because of limited data sharing arrangements.
- Stakeholders consider it essential that validated and quality checked information be easily accessible for end users.
- FMS needs to both understand and address the needs of specific user communities, including social groups with identified special needs based on gender, ethnicity and language, disability and a range of other characteristics.
- FMS should work in partnership with several community engagement platforms, such as women's information networks and persons living with disabilities to better support developing user-specific warnings services.
- An important gap and obstacle to implement the coastal inundation forecasting EWSwas the lack of adequate bathymetry data, and issues with sharing that data when available.
    - This also applies to the Digital Elevation Model (DEM) data, especially for the coastal regions.
- This baseline data is critical to being able to predict where the water will go, and therefore which areas will be inundated and to what depth.
- Regular planned re-evaluation of the system (criteria, ensemble, setting up goals for intended key achievements, end users) need to be set in place to assess the impact and effectiveness, and propose modifications to the coastal inundation forecasting EWS.

The above recommendations and lessons from CIFDP are integrated and are at the core of the project, while further considering the evolving needs of the country. This project reinforces the message from the UN Secretary General's announcement in March 2022 on World Meteorological Day on *Early Warnings For All* where every person, community and nation has access to effective early warning systems within the next five years. To incorporate impact-based forecasting and fully implement MHEWS into operations, the full value chain from the underlying data that goes into forecasting models, equipment to collect data, and the capacity of staff and end users to interpret the data, need to go hand in hand in order for a paradigm shift to occur in building resilience of high-risk communities. Subsequently, this project looks at the full value chain to build the resilience of Fiji to coastal and marine hazards. Furthermore, CIFI has been demonstrated to be replicable and through this project, the system will be scaled up to demonstrate that every person and community in Fiji is covered under an early warnings system.

Selection process for Project site

For Component 1, the project intervention site will be the sites covered under CIFDP, as this Component asseses the achievements of the demonstration project. For Component 2, for some output, there will be expansion of sites. Storm surge forecasting under CIFDP covered the whole of Fiji; thus, in this project, rather than expanding the sites scope, investment from Adaptation Fund (AF) will enable upgrading of the storm surge forecasting to be impact-based and probabilistic based on ensembles. For the inundation mapping based on the storm surge model, Viti Levu was covered under CIFDP. With the expansion of scope in DEM data, the islands of Vanua Levu, Kadavu and Taveuni are the primary targets of the expansion of the storm surge inundation mapping (Figure 12). However, as DEM and bathymetry data are costly, it may not be feasible to collect data for all islands in Fiji and thus the focus is on hotspot areas around major towns. For swell forecasting and riverine flood guidance, the sites will be expanded (Figure 13 and Figure 14). As described in the Project / Programme Background and Context: section, 87% of the population live on the two main islands, explaining the rationale behind the selected the sites. For swell forecasting, swell mostly occurs in the selected sites thus restricting the scope to the two main islands. For Components 4,5, and 6, the target will be all coastal communities and industries by the coast in Fiji.

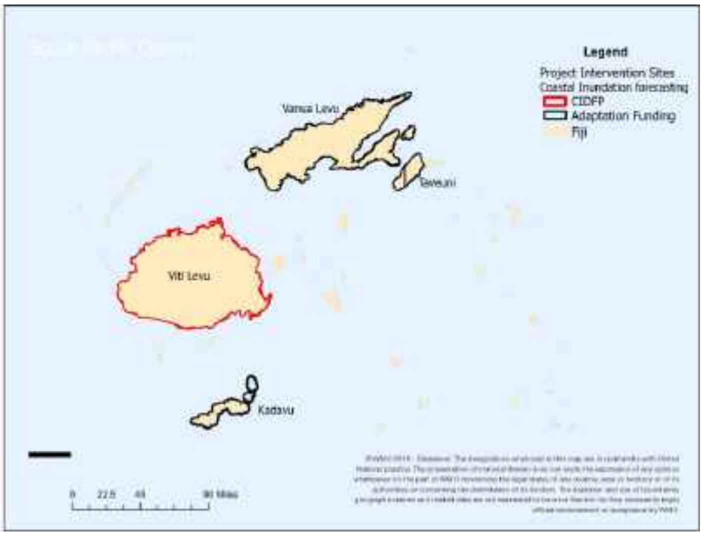

Figure 12 Selected coastal areas for expansion of coastal inundation forecasting

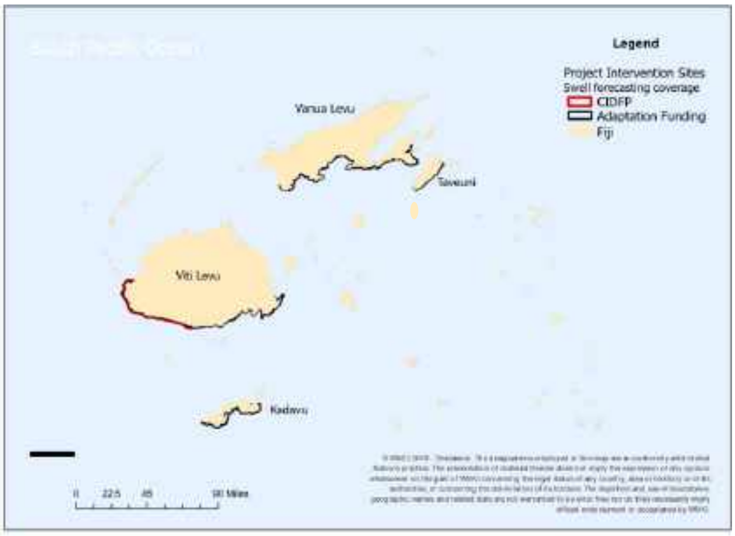

Figure 13 Selected coastal areas for expansion of swell inundation forecasting

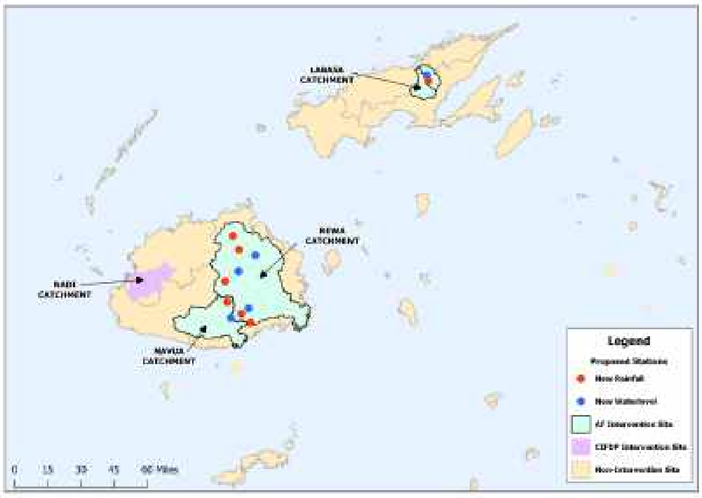

Figure 14 Selected River basins for installation of river level gauges and expansion of CIASS

Problems to be addressed in the project

The main challenges faced by FMS (or Fiji) is that MHEWS for coastal inundation is not horizontally integrated at national policy and at operational levels, and not practiced at the community level. Fiji is experiencing an increase in frequency and intensity of coastal inundation as a result of extreme weather events associated with adverse effects of climate change. This project aims to induce transformational change in the approach to MHEWS for coastal inundation by addressing the following gaps faced by Fiji:

- Fiji lacks basic parameters of data for a robust observation network. Because there is a lack of marine and coastal observational data, for instance DEM, bathymetry, sea surface temperature and wave height data, it is difficult for gather evidence and quantify adverse effects of climate change.
- Fiji does not have a centralized database to provide a measure of the impacts of meteorological hazards, including coastal/marine events. The data is currently scattered across government agencies and is not in machine-readable formats. As the data is not stored in one place and there is no single repository for data, FMS does not have access to information when approached by other agencies and stakeholders regarding the impact of meteorological hazards.
- Vulnerable coastal communities still rely very much on traditional knowledge of weather prediction. Furthermore, there is a lack of public awareness at the community level on how products and warnings issued by FMS should be interpreted and actioned.
- FMS capacity and technology for forecasting coastal inundation has substantially improved as an outcome of the CIFDP. However, for the products to reach the community and reach the last mile, the information that is disseminated needs to be transformed into user friendly products that are impact-based. There also needs to be regular evaluation and monitoring of its products to ensure information from FMS is reaching and meeting the needs of vulnerable coastal communities
- Capacity development of forecasters at FMS is required to maintain and upgrade the system.

Project/Programme Objectives:

Goal: The overall goal of this project is to enhance Fiji's capacity to prepare for and respond to natural hazards induced from climate change, through scaling up its coastal inundation forecasting early warning system. The project will strengthen capacity of forecasting competencies at an institutional level. Furthermore, the project will build resilience of communities-a-risk and industries by the coasts.

The goal of this project will be achieved through the following objectives:

- Enhance forecasting models and extend coastal inundation models to other key parts of Fiji ensuring early warnings for all major towns/villages.
- Integrate impact-based forecasting and multi-hazard early warning systems into the operations of FMS
- Streamline forecasting systems into a single interoperable system
- Create hazard risk mapping of coastal areas on central forecast geo-server
- Enhance public awareness on coastal inundation forecasting EWS, impact-based forecasting products and hazard risk maps.
- Build a data archive of meteorological hazards for coastal/marine events and their impacts
- Strengthen sectoral partnerships between government agencies, industries and NGOs.

Project/Programme Components and Financing:

Project/Programme Components	Expected Concrete Outputs	Expected Outcomes	Amount (US in Millions)

1. Identifying and assessing institutional and community capacity, state of infrastructure, communication platforms for coastal inundation adaptation requirements	1.1 Comprehensive assessment of the extent and level achieved, sustained and expanded from CIFDP since 2019	A coherent and comprehensive mapping to scale up and execute the technical and social innovation recommended from CIFDP-F	0.20
2. Expanding the forecast systems from CIFDP-F to other key parts of Fiji and upgrading the forecasting systems	2.1 A streamlined and enhanced multi-hazard early warning system (MHEWS) for coastal inundation that is impact-based, expanded to cover additional key coastal inundation-prone areas of Fiji	Enhanced capacity of Fiji Meteorological Service to provide more accurate and user-friendly forecast to communities- at risk	3.35
3. Assessing and mapping the risk of coastal inundation hazards	3.1 Hazard risk maps highlighting high risk areas for inundation from swell, storm surge and river flooding adapted for use in impact-based forecasting (IBF) 3.2 Communities at risk and government institutions have access and are trained to interpret the hazard risk map	- Enhanced preparation for coastal hazards - Hazards risk information made available for climate resilience, urban and coastal planning	0.15
4. Establishing a data archive of meteorological hazards for coastal/marine events and their impacts	4.1 Centralized catalogue of meteorological events including marine/ coastal hazards, and related impacts 4.2 Database of meteorological and oceanographic observations 4.3 FMS staff trained to monitor and manage the event catalogue and metocean database	- Historical impact data is made available for research and formulation of science-backed climate policy -Trained staff from FMS on the monitoring and management of the event catalogue and metocean database	0.30
5. Enhancing and streamlining communication with stakeholders and communities-at-risk	5.1 End-users including the social groups with special needs have access to tailor-made products and channels to give feedback on the products 5.2 Sector-specific MHEWS forecast products are developed and used by various end users including the industries 5.3 Public awareness of coastal inundation is enhanced	Improved and effective response to early warning system by the public and industries along the coast	0.50
6. Strengthening cross-sectoral partnerships with institutions and NGOs	6.1 Strengthened partnerships with government agencies and NGOs 6.2 Arrangement of data sharing system between sectors	Improved coordination and efficient usage of resources and sharing of information for building coastal	0.20

		adaptation	
7. Project/Programme Execution cost			0.45
8. Total Project/Programme Cost			5.15
9. Project/Programme Cycle Management Fee charged by the Implementing Entity (if applicable)			0.41
Amount of Financing Requested			5.56

Projected Calendar:

Milestones	Expected Dates
Start of Project/Programme Implementation	June 2024
Mid-term Review (if planned)	October 2026
Project/Programme Closing	June 2029
Terminal Evaluation	November 2029

PART II: PROJECT / PROGRAMME JUSTIFICATION

A. Describe the project/programme components, particularly focusing on the concrete adaptation activities of the project, and how these activities contribute to climate resilience. For the case of a programme, show how the combination of individual projects will contribute to the overall increase in resilience.

This project promotes innovative technical and social solutions to climate adaptation, adopting regionally new technologies and socially inclusive approaches to build resilience of communities-at risk. The World Meteorological Organization (WMO), in its Multi-Hazard Early Warning Systems: A Checklist, notes that effective “end-to-end” and “people-centered” early warning systems may include four interrelated key elements

(1) disaster risk knowledge based on the systematic collection of data and disaster risk assessments;
(2) detection, monitoring, analysis and forecasting of the hazards and possible consequences;
(3) dissemination and communication, by an official source, of authoritative, timely, accurate and actionable warnings and associated information on likelihood and impact; and
(4) preparedness at all levels to respond to the warnings received.

These four interrelated components need to be coordinated within and across sectors and multiple levels for the system to work effectively and to include a feedback mechanism for continuous improvement. Failure in one component or a lack of coordination across them could lead to the failure of the whole system. This project and its outputs and outcomes will be designed and implemented as described in the following sections, to address each of the four elements in the checklist. The project will also benefit from guidance provided by the WMO Guide on Implementation of a Coastal Inundation Forecasting- Early Warning System. To achieve its objective, the project will include six components, the details of which are provided below.

Component 1. Identifying and assessing institutional and community capacity, state of infrastructure, communication platforms for coastal inundation adaptation requirements

Output 1.1 Comprehensive assessment of the extent and level achieved, sustained and expanded from CIFDP since 2019

One of the major challenges of EWS is the establishment of clear institutional arrangements, capabilities and capacities at national and local levels that support the sustained development of public and institutional response capability. Public understanding of and trust in the system comes with knowledge and awareness on the part of the end users of the system and convincing performance on the part of the public service provider.

There are several technical requirements on a national level towards the development and implementation of an effective, sustainable, and operational EWS. Such requirements include observations of the necessary hydrometeorological variables, historical and additional data and metadata (including access to national and regional products), data management, existing capabilities in terms of coastal hazards forecasting, forecasting product generation, warning policies and practices including dissemination. Another major consideration is the capacity to undertake the additional responsibilities of this new, or enhanced service.

Technical assessment seeks to identify the strengths, weaknesses and gaps of the current practices of all agencies involved in coastal inundation forecasting and warning and provides an overview of what needs to be improved with respect to EWS development, implementation and sustainability. This approach is illustrated for severe weather through the Severe Weather Forecasting Demonstration Project (SWFDP) (WMO, 2016) and the ocean (storm surge in particular) and marine services requirements (WMO-No 1076, WMO-No 471 and WMO-No. 558, 2012), as well as the hydrological requirements (listed in the WMO Assessment Guidelines for the E2E EWS for Flood Forecasting), along with the experience of the CIFDP sub-projects.

On a national scale it is necessary to understand the agencies which are responsible for coastal hazards risk knowledge, their monitoring, forecasting, warning, communication and dissemination, as well as preparedness and response. As coastal hazards are of mixed nature, all the hazards and functions listed should be mapped against the relevant institutions with respect to ocean, marine (i.e. coastal waters), hydrological and meteorological phenomena, as well as bathymetric and topographic information.

The availability and conditions of infrastructure at the forecast centre where the EWS will be operating, is vital in terms of the EWS robust operations in 24/7 mode. Building conditions in terms of resilience to natural hazards and for forecasters' safety and minimum comfort are required. Technical aspects, including computing power, electricity and communications are vital. Advanced generation Desk-Top Computers are generally required with periphery devices in order to have access to products (e.g., numerical weather prediction (NWP) and satellite) from the Internet of Global Telecommunication System / the WMO Information System. Electricity and communications back-up technologies should be in place to provide the robust operation of EWS.

The EWS is designed to be operated jointly by marine meteorologists and hydrologists for the essential product "content" and emergency communication specialists for dissemination and community action. Thus, comprehensive knowledge and expertise is necessary for the system operators.

Activity 1.1.1 Conduct evaluation and assessment of institutional capacity

The CIFDP-F project completed in 2019 introduced a new capability in Fiji for forecasting and warnings of coastal inundation from multiple hazards, including storm surge, waves, tides and river floods. This was a major achievement. It is now essential to assess the capacity and capability of all institutions involved in the coastal inundation forecasting and warning process, including their observing and telecommunications networks, computing resources, level of staff capability and capacity, dissemination platforms. Some of these capabilities may have continued to develop since the Demonstration Project ended, due to running the system operationally; others may be in need of upgrading. The enhancement of the CIF system and its expansion to all of the Fijian islands will necessarily be captured in a gap analysis as part of the assessment.

At the outset of the Demonstration Project in Fiji, one of the key tasks was to prepare a National Capacity Assessment (NCA), identifying the technical and institutional gaps in capability for forecasting and warning for coastal inundation events. Many of these gaps were addressed with the implementation of the Demonstration Project, but some were identified as requiring additional effort during the final stakeholders' workshop in November 2019. The independent assessment of the CIFDP carried out for WMO also identified some remaining gaps, particularly related to the "last mile" of communication of warnings, and in training provided across the end-to-end value chain. Also, the Demonstration Project focused only on the main island of Viti Levu, so assessment of the capacity and capability to extend to the rest of Fiji must also be carried out. This assessment evaluates the effectiveness of the CIFDP-F at addressing the previously identified gaps and maps the remaining gaps as well as those arising from the scaling up of the project functionally and geographically.

A particular need in this gap analysis is to address the effectiveness of the communications platforms for dissemination of forecast and warning information to the affected population, with a particular focus on particularly vulnerable groups. Fiji participants from a recent Marine Services Course noted a lack of suitable platforms to communicate with the end users.

Activity 1.1.2 Conduct survey of communities-at-risk and stakeholders to evaluate correct usage of information and early warning

One of the key elements of the proposed expanded EWS is the so-called “last mile” of warning communication. While there was some outreach to communities-at-risk in CIFDP-F, through meetings in local villages, coastal inundation videos and other stakeholder meetings, this is an area where significant benefits can be realized in terms of adaptation strategy. Surveys to assess the current understanding of EWS products will help to define the strategy to improve; this can be done in some cases in conjunction with meetings in various communities to extend outreach.

Activity 1.1.3 Assess policy framework and ensure it supports the existing and planned technical requirements of coastal inundation.

It is important to ensure that the implementation of enhanced and expanded forecast and warning programs, with their various associated data collection, data sharing and communication is consistent with the legal framework of Standard Operating Procedures (SOP) in the Fiji government. Examples of potential concerns include, for example, sharing of critical bathymetry data, which may be considered sensitive for national security or of commercial value, and responsibility for emergency response. Free and open data sharing is crucial to EWS development. Furthermore, this project will work with the CommonSensing Platform, an ongoing innovative project in Fiji, in deriving satellite imagery and elevation models to formulate evidence-based strategies for disaster risk reduction for riverine flooding. Thus, in its assessment, the project will examine how data related activities will leverage and complement the ongoing work taking place in Fiji. This output will include the assessment of any government policies which might impact the planned implementation of the project in Fiji, including recruitment of staff, funding of the meteorological service, communications, particularly with disadvantaged groups. Other policies which might affect the implementation the project could include restrictions on locations for deployment of instrumentation such as buoys and river gauges, and access to forecast and warning information on government servers via the internet.

Local workshops will be planned and facilitated to appraise existing communication platforms. This will be a key element to assess the effectiveness and gaps from the outcomes of the CIFDP-F in terms of communications platforms to ensure the EWS messaging is effectively delivered to all at-risk communities in Fiji, in particular to disadvantaged groups who may not have access to the same level of communications services.

Component 2. Expanding the forecast systems from CIFDP-F to other key parts of Fiji and upgrading the forecasting systems

Output 2.1 A streamlined and enhanced multi-hazard early warning system (MHEWS) for coastal inundation that is impact-based, expanded to cover additional key coastal inundation-prone areas of Fiji

The objective of this output is to streamline and enhance the coastal inundation forecasting system that was developed as part of the Demonstration Project. This is the largest component in terms of magnitude of requested funding and is primarily concerned with the technical aspects of the EWS. This system provided forecasts and warnings of coastal inundation for storm surge, waves, tide and riverine flooding, separately or in combination. The focus of the Demonstration Project was the main island of Viti Levu, which contains the major population centre Suva, and the international airport at Nadi. The riverine flood forecasting was confined to the Nadi River basin, which flows out to the northwest shelf of Viti Levu, past the airport and the town itself. The plan is to extend the enhanced impact-based coastal inundation forecasts and warnings to the main populated islands of Fiji. This activity will demonstrate the scalability and replicability of the EWS, which can then be applied to other South Pacific islands. The following five activities will contribute to the upgraded and expanded service.

Activity 2.1.1 Collect, update and incorporate bathymetric and digital elevation model (DEM) data for hazard risk assessment, in forecast models, and mapping of the forecast inundation extent in coastal areas.

A critical element of impact-based forecasting for coastal inundation is the topographic profile of the various islands. This is in large part what determines where the flood waters go, and to what depth. Only with that information will FMS be able to inform the population of the impacts of the flooding event, e.g., whether evacuation will be necessary, whether mitigative actions may be required to prevent property damage. Topographic data are also used for hazard maps (see Component 3), which are key to risk assessment and planning, e.g., urban planning. Identification of flood-prone areas can inform adaptation or mitigation options. Currently, high quality topographic information, sometimes referred to as Digital Elevation Model (DEM) data, is inadequate for most of Fiji, only being available for the Nadi River Basin and parts of the Coral Coast from CIFDP-F. The project will collect additional DEM data for key coastal areas of Fiji using LiDAR surveys and conventional ground-based measurements, i.e. using GPS. Satellite-based measurements will be investigated for use in Fiji, such as the TanDEM-X product from the German Space Agency, which was used successfully in the CIFDP project on Hispaniola. The DEM data will be incorporated into a common Geoserver system, which serves the integrated MHEWS for Fiji. A geoserver already forms the DEM base for the Flood Forecast Guidance System in Fiji, and will be the common system for displaying storm surge and wave inundation forecast information; this will also be the base for hazard mapping in Component 3. Ideally, DEM data would be on the order of metres horizontal resolution and centimetres vertically; realistically, the resolution of collected data would be about 10m horizontal and 1 m vertical resolution, which is in line with similar coastal inundation projects carried out in Caribbean and in the North Indian Ocean. Most areas currently have insufficient coverage and granularity of DEM data for Fiji, so the key target areas on the coasts where the DEM will be enhanced will be identified based on exposure, population and potential impact of inundation.

A second critical element is bathymetric data in Fijian waters, particularly within a few kilometres of the coast. Accurate bathymetry is essential for modelling of storm surges, as the slope of the ocean bottom is a key factor in the height of the resultant storm surge (and also tsunamis). Wave forecasting for shallow waters also relies on accurate bathymetry, particularly shoreward of the fringing reefs such as along the Coral Coast on the south coast of Viti Levu. The magnitude of the coastal inundation on the south coasts of many Fijian islands is related to the bathymetry of the reefs and the lagoons between the reef and the shoreline, so this particular bathymetric data is especially important. Bathymetry data were enhanced (i.e., higher resolution) along the south coast of Viti Levu during the Demonstration Project, but much more coverage for high resolution data is required for the other target areas of Fiji. Target areas where bathymetry must be enhanced will be identified. This will be obtained for key areas by conventional depth measurements, i.e., manually from boats; new satellite techniques using radar altimeters will also be investigated. The updated bathymetry data will be incorporated into wave and storm surge models as appropriate.

Activity 2.1.2 Procure, install and replace river level gauges, tide gauges and ocean buoys in other major river basins and coasts

Both ocean and hydrological data are the life blood of coastal early warning forecast and warning systems. If the water level is high at the coast, whether due to abnormally high tides or storm surge, the outflow from high river levels may be blocked from flowing into the ocean and back up in the river estuary causing serious flooding upstream from the coast.

Water level, and ideally flow measurements, in rivers are the key to hydrological models, and in particular to decision-tree systems such as the Coastal Inundation Alert Support System – CIASS system implemented during the Demonstration Project. The CIASS system uses water level measurements and precipitation at a number of locations in a river basin to predict the level and timing of any potential flooding further downstream. The data are telemetered every 10 minutes to the CIASS system, so the FMS forecasters can quickly respond to any changes in the river levels or precipitation amounts, and revise forecasts and warnings in a timely manner. The telemetering system, whether by radio or satellite link, must be robust under heavy weather systems such as tropical cyclones in order to keep the data flowing to the CIASS system. Outages in the telemetering system were a significant source of concern during the Demonstration Project and must be addressed in the current project. Through the CIFDP-F Project, new water level instruments were installed only in the Nadi River, whereas similar instruments in other rivers in Fiji were installed many years earlier with a lot of gaps between them. Additional river level measurements are required in major river basins in Fiji in populated areas. For expansion of this project, additional water level gauges will be required in two other major rivers in Viti Levu: Rewa, Navua and on one major river in Vanua Levu: Labasa, as indicated from *Selection process for Project site* Section.

Ocean buoys may measure a variety of meteorological and oceanographic parameters – wind, waves, sea surface and air temperature, sea level pressure. In the Demonstration Project buoys measuring only waves and sea surface temperature were deployed along the south coast of Viti Levu. These wave data are very important for verification of the wave forecasts, and for guidance to the forecasters as a storm, or long-distance swell, approaches. Verification is a critical component of forecasting activities, in order to improve models and forecasting procedures, and to build confidence in the forecast output. During the passage of Severe Tropical Cyclone Harold in 2019, observation from one of the wave buoys deployed during the CIFDP-F project verified the forecasted wave heights. Using such information enabled FMS to provide early warning on coastal inundation to the coastal village in Kadavu. By the time the waves inundated their coastline at night, houses nearest to the shoreline were already evacuated. The historical record of wave measurements is also used for climate monitoring and risk assessment. Wave buoys, measuring also sea surface temperature, and possibly air pressure, will be deployed in other key Fijian waters, in consultation with the Fiji Navy, Maritime Safety Authority of Fiji, Fiji Ports Authority, private shipping and fishing companies and others including the traditional resource owners. Unfortunately, the buoys are often subject to vandalism, so locations must be selected with that in mind, and some degree of redundancy is desirable when it comes to costing, for spares. The video produced in the Demonstration Project highlighting the importance of the buoys to timely EWS was presented to key coastal communities such as fishers in an effort to reduce the amount of vandalism; these types of activities will continue to be a key outreach activity under Component 5 of this project.

Measurement of the ocean still water level along the coast is also important. In addition to any direct coastal inundation caused from the still water levels, high water levels at the coast (for instance from sea surface height anomalies associated with El Niño–Southern Oscillation) may act as a barrier to the river outflow, causing the river to overflow its banks. Knowledge of the still water levels is key to coastal inundation, since the waves and surge are added onto the still water level; impacts are likely to be more damaging with a storm at high tide. Therefore, the still water level is directly input to the coastal inundation forecast. As with the wave data, the still water data also has an important function in verifying the water level forecasts, e.g. from storm surge models. There are few still water level gauges in the Fijian islands presently. Additional ocean still water level gauges will be deployed at key locations to be determined but should include locations near the mouths of the 3 additional rivers to be included in the CIASS extension.

Caution must be exercised in the procurement of this instrumentation since its life cycle management including repair and replacement may become unsustainable for the ongoing budget of FMS. Such consideration will be taken into account for this Activity.

Activity 2.1.3 Install additional computational and internet bandwidth capacity for extending the coastal inundation forecast system to include all of Fiji.

A wave model for a domain covering all of the Fijian islands requires very high spatial resolution, in order to properly define the water/land boundaries, and variations in water depth when it is less than about 100m. To run a sophisticated high-resolution model, incorporating the new high-resolution bathymetry obtained in Activity 2.1.1, requires a considerable amount of computing power. The project will ensure that sufficient computer capacity is available to run such a model. Moreover, to run the coastal inundation models developed for the Coral Coast from long period swell requires large computing capability in the development of the forecast algorithm, less in the operational running. This swell inundation component of the EWS will be extended farther west along the south coast of Viti Levu, to the corner where the coast turns to the north, and to the south coast of Vanua Levu.

Additional computer capacity will also be required to run the storm surge model for all of Fijian waters (see Activity 2.1.4) or extending beyond to other islands in the Southwest Pacific for which the RSMC-Nadi provides guidance on tropical storms. In addition to increased computer capacity, it is also very important to have sufficient communication bandwidth to import data and products, including gridded fields of various forecast parameters from global centres, satellite data and in situ observations, including the ocean buoys, still water level measurements and telemetered river level and precipitation measurements. This will also be required for dissemination of, for example, high resolution graphical products such as forecast inundation maps.

Dedicated High Performance Computing (HPC) servers will be acquired for the numerical forecasting process, also using the geoserver display package, and accessing the static (bathymetry, topography) and real time (in situ observations, numerical weather prediction digital guidance products, satellite data) products. Windows-based workstations will also be required for some tasks. High-capacity telecommunications networks will also be acquired and implemented.

Activity 2.1.4 Replicate coastal inundation forecast and warning systems from CIFDP-F to other parts of Fiji

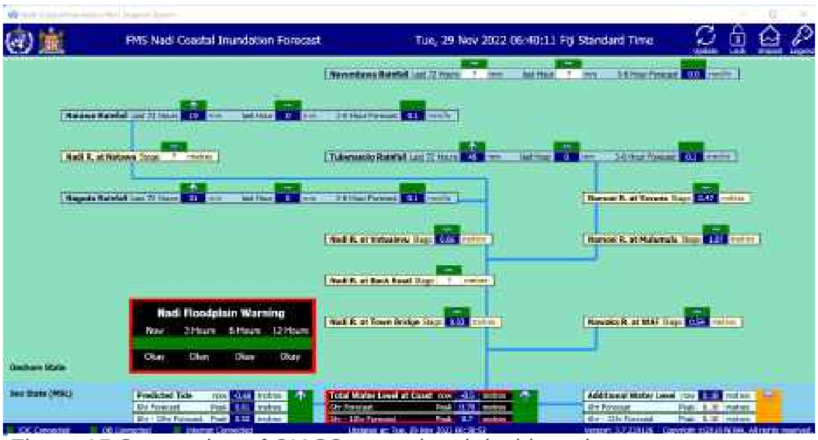

Figure 15 Screenshot of CIASS operational dashboard

During the Demonstration Project, a riverine flood forecasting decision-tree system was implemented for the Nadi River (Coastal Inundation Alert Support System – CIASS). This took real-time measurements of river level and precipitation at the observing stations in the Nadi River basin and produced impact-based flood warnings for various locations in the basin, including Nadi town. At the conclusion of that project, interest was expressed by the Fiji Meteorological Service and other stakeholders in replicating the CIASS system in other major rivers on Viti Levu. This project will implement the CIASS system on two other major rivers on Viti Levu: Rewa, Navua, and on one major river in Vanua Levu: Labasa, as indicated in the Selection process for Project site Section. This will include an assessment of the adequacy of the existing river level measurements on these rivers and their tributaries, and adding additional gauges as required (see Activity 1.1.1 and Activity 2.1.2). The first task will be assessment of suitable sites for deployment of river level and precipitation gauges, taking into account any considerations of representativeness of the measurement for flood forecasting purposes. Actual deployment of numerous river level and precipitation gauges per river will follow the assessment. Each river will the need to be “calibrated”, with respect to transit times between various gauge locations and forecast sites. This information is what is required to be imported into the replication of the CIASS system for each river. Testing of the final system is the last step, and of course requires actual flooding events to occur to validate the forecast and warning system. Training on the system will be updated and refreshed, noting that the forecast system is not completely new, mostly the additional locations.

The second of the three forecast and warning components of CIFDP-F involved the implementation of the Japan Meteorological Agency (JMA) storm surge model for all of Fiji. This allowed FMS to run the storm surge model in-house, using input guidance from the RSMC-Nadi for Tropical Cyclones The storm surge forecast allowed FMS to provide inundation forecasts, including maps of inundation extent, for Viti Levu under CIFDP. With the additional DEM data acquired, the islands of Vanua Levu, Kadavu and Taveuni are the primary targets of the expansion of the storm surge inundation mapping. The use of forecast ensembles will be enhanced, increasing from the current 3-member ensemble; the use of ensembles will allow probabilistic forecast information to be provided (probabilistic forecasting contains a set of probabilities associated with all possible future outcomes, instead of pinpointing one particular outcome as “the” forecast). As with the CIASS system, training will be updated and refreshed as required.

The third forecast and warning component to be scaled up and replicated is the long-distance swell inundation along south-facing coasts, originating from extra-tropical storms near New Zealand and southeastern Australia. This swell can cause damaging inundation along the south-facing coasts of Fiji. In particular, this affects the main transportation corridor between Nadi and the capital Suva, as well as many resorts along the Coral Coast which are an important part of Fiji’s economy. While the methodology for forecasting the inundation-producing swell waves can be replicated in other areas, each implementation requires its own unique high-resolution bathymetry and DEM for the target area (as noted in Activity 2.1.1), wave and still water-level measurements

(Activity 2.1.2). Modelling and forecasting of swell waves, in areas with fringing reefs, is extremely complex and would require far more time than available. For example, a 12-hour forecast would take far more than 12 hours to produce a result, making the product of no use. As a result, the forecast system is developed from running thousands of scenarios of simulated events based on incoming swell properties such as height, period and direction. These scenarios then form the basis for the actual event forecast, essentially a look-up table, which can produce the inundation forecast and associated products such as inundation extent relatively quickly. The incoming swell input will be obtained from a nested high-resolution wave model run in Fiji using the global centres as boundary conditions. This will also have a spin off benefit in supporting FMS' marine services programmes, including early warning of hazardous ocean conditions for fishers, ferries, aquaculture, etc. The areas to be included in the replication of the swell wave inundation are the south coasts of Vanua Levu, as well as an extension to include the entire south coast of Viti Levu, not just the Coral Coast portion. The initial tasks associated with the activity can take place concurrently, with the bathymetry and DEM data acquisition, as well as event monitoring to establish test cases for model set up and validation. This is followed by a very extensive and intensive modelling of thousands of scenarios for each location, requiring considerable computing time and power. Finally, the forecast system will be tested in real time evaluation with feedback from the FMS meteorologists and end users. Training will be updated and refreshed.

Activity 2.1.5 Set up long term advisory system for national staff to receive support

In order for the forecast and warning systems to be sustainable, support for ongoing training and development, mentoring, etc. will be established during the implementation of the project. This will be achieved through continued development of the operational systems, establishment of support mechanisms, e.g. with JMA for the storm surge model upgrade and operation, with the National Institute of Water and Atmospheric Research of New Zealand (NIWA) for the CIASS system, and with regional training programs. Fiji, being a Member country in WMO, has access to various types of training and capacity building activities, and access to WMO resources such as the Tropical Cyclone Programme, the Coastal Inundation Forecasting Initiative, and others. Workshops, both within Fiji and international, such as the International Workshops on Waves, Storm Surge and Coastal Hazards (www.waveworkshop.org) held every two years, are valuable ways to remain current with coastal inundation forecasting developments. WMO Regional Association (RA) V (Southwest Pacific) supports a range of activities in support of storm surge and coastal inundation activities, including the efforts of the RAV Tropical Cyclone Committee for the South Pacific and South-East Indian Ocean. Appropriate linkages will be developed during the course of the project development.

Component 3. Assessing and mapping the risk of coastal inundation hazards

The World Bank notes[14] that hazard and risk assessments are a crucial first step in disaster risk management (DRM) and the basis for formulating DRM policies. Hazard risk maps provide important information to help people understand the risks of natural hazards and to help mitigate disasters. Hazard maps indicate the extent of expected risk areas and can be combined with disaster management information such as evacuation sites, evacuation routes, and so forth. Providing information on inundation risk zones for multiple levels of hazards including low-frequency events is essential; the largest possible hazard should be investigated and considered in formulating DRM policies; this may be from any of the meteorological/hydrological events or might possibly be from a tsunami.

Output 3.1 Hazard risk maps highlighting high risk areas for inundation from swell, storm surge and river flooding adapted for use in IBF

Access to hazard risk maps for coastal communities in Fiji is key to formulating policy for disaster risk management in the event of coastal inundation. It also raises awareness among the public of the areas which may be subject to potentially life-threatening or damaging events and provides a reference for impact-based forecasting of actual events. Sharing information on the hazard and risk data is crucial; this can be done through central repositories that are open to the public, among other means. Risk information must be communicated to the public effectively; the meaning of the information provided on the maps needs to be clear and adequately explained to the users. Climate change impacts on vulnerability and risk must be taken into account; rising sea

[14] Knowledge Note 5-1 Cluster 5, Sagara and Saito

levels and increased intensity of storms will alter the degree of risk for many areas.

Hazard risk maps are currently being developed for Fiji under a separate joint project between Japan International Cooperation Agency (JICA) and the Fiji NDMO. FMS have been involved with these discussions and is closely working with NDMO and JICA on the technical elements. Risk maps will be produced for the primary populated Fijian islands for multiple levels of hazards, for multiple types of events. The objective of this output is to access and adapt the products from the JICA project onto the same base map and the same geo-server application used in the forecast products described in Output 2.1.

Activity 3.1.1 Integrate risk hazard maps into the geo-server application

FMS will integrate the risk hazard maps into the geo-server application. This could then be made available on the internet, via computer or phone app, and also as static maps for brochures and other outreach material, showing what could happen in a tropical cyclone or other coastal flooding event in a worst scenario, i.e. where the water would go. This will provide a logical link to impact-based forecasts issued by FMS.

Output 3.2 Communities at risk and government institutions have access and are trained to interpret the hazard risk map

End users for hazard risk map information will be primarily municipal, regional and national planning departments, national disaster managers, and some non-governmental organizations, e.g., Red Cross. A key output for this activity will be to enhance the awareness, access, usage and understanding of hazard mapping to improve the Preparation part of PPRR (Prevention, Preparation, Response and Recovery), particularly with respect to its relationship to impact-based inundation forecasts. This can be done through a combination of bi-lateral outreach with relevant organizations and broader workshop organization. Such awareness building will be coordinated with NDMO efforts; FMS will focus on the relationship of the risk mapping to forecast products, noting that both are important to understand the potential impacts.

The general public, and in particular disadvantaged groups, should also be made aware of coastal hazards in general, and the hazard risk maps in particular, in workshops targeted to communities and special interest groups such as women’s organizations, schools, etc. Risk map awareness raising can be combined with the coastal inundation awareness videos produced during the demonstration phase.

For both the institutional and public users the hazard risk information should be easily available through multiple communication platforms, including hard copy such as brochures, but also via the internet and phone apps, while noting that high resolution graphical products such as hazard risk maps may require high bandwidth and internet data volumes.

Activity 3.2.2 Develop public awareness materials and conduct educational workshops to train the communities at risk and government institutions

To prime the communities at risk and government institutions to correctly respond and take actions when early warnings are disseminated, there needs to be targeted training on interpretation of the hazard risk maps. The training can be carried out at district level in coordination with NDMO with a focus on improving awareness on scientific and technical elements behind the maps. As government agencies work with various industries by the coast, training to government institutions is also crucial to enable cascading of knowledge to the private sector, especially to the micro and small-scale enterprises in enhancing their readiness to respond to the natural hazards.

Component 4. Establishing a data archive of meteorological hazards for coastal/marine events and their impacts

Output 4.1 Centralized catalogue of meteorological events including marine/ coastal hazards, and related impacts

FMS is the responsible entity at the national level for detecting, monitoring, and managing information on hazardous events linked to weather and climate by leveraging their meteorological, hydrological and ocean observing and monitoring capabilities. FMS is also responsible for developing a list of potential hazards including those for which they issue warnings/alerts, thereby linking to the early warning system. Other agencies may manage special networks for collecting data on specific hazards. In such cases where responsibilities are so distributed, the FMS will play a coordinating role and undertake data collection itself on the events under its mandate.

Impact information is typically recorded by the national disaster management agency (or other mandated agency) in terms of mortality and morbidity, loss of, and damage to, physical assets, and economic damages and losses.

The full value of the catalogue is realized when data on events is linked to data on impacts. This entails an institutional partnership between FMS or other authorities mandated to collect event data and counterpart institutions mandated to assess and document associated impacts.

Benefits to having a centralized catalogue include improved:

- Tracking of indicators relevant to international policy frameworks such as the Sustainable Development Goals (SDGs), Paris Agreement, Ocean Decade, Early Warnings for all and Sendai Framework;
- Risk identification (hazard component, empirical methodology of understanding hazards, how hazards interact with other hazards (compound and cascading hazards), and their combined impacts;
- Risk reduction and adaptation (empirical methodology for ongoing quantification of events as input to developing building standards, land use planning, strengthening Multi-Hazard Early Warning Systems (MHEWS), Impact-Based Forecasts, and disaster reduction planning);
- Tracking of event characteristics (including complex and cascading events) trends in frequency, severity, and temporal and spatial distribution; and,
- Identification of causal contributions of hazards, exposure, and vulnerability to impacts.

Activity 4.1.1: Establish a centralized catalogue

FMS will lead coordinated data recovery activities including digitizing the information collected into the catalogue.

Hazardous events can be identified through different methodologies:

1. Verified occurrence of the event
2. Direct observation such as wind, wave or water level measurement, flooding, etc.
3. Post-event information such as news broadcasts or news articles

The hazardous event catalogue contains the following attributes:

- **Event start**
- **Event end**
- Event Type e.g., tropical cyclone
- **Spatial area** based on the spatial extent of the hydrometeorological phenomena and hydro-meteorologically contiguous phenomena (that is, not the spatial extent of associated impacts)
- **Hazard specification** (type) e.g., storm surge. WMO encourages use of the hazard naming contained within the United Nations Office for Disaster Risk Reduction (UNDRR)-International Science Council (ISC) Hazard definition and classification review and the UNDRR-ISC Hazard Information Profiles to facilitate standardization at the regional and global levels.
- **Description of the event** documents the magnitude or severity of the event using, when available, information such as maximum storm surge heights, tide level, wave and swell heights, wave periods, wave run-up, highest wind speed, Tropical Cyclone intensity etc. The description may also include unique details about the event, e.g. an all-time rainfall record value can be included in a flood event.
- **Event linkage –** link to other events within a compound or cascading event, such as coastal inundation and flash flooding; link to associated metocean database
- **Impact -** general description of any impacts associated with this event (fatality/ damages)

- **Socio-economic sectors** that may have been affected
- **Warnings Issued**
- **Other information** relevant to the event

The catalogue will inform planning, climate change policy and adaptation, and disaster risk reduction. FMS and other relevant operational organizations will be able to serve stakeholders in impacts accounting by providing them with an authoritative and quality assured scalable data set of hazardous events that enables easy association between each hazardous event and its impacts. Furthermore, collaboration between and among the agencies responsible for managing information on hazards (operational data collection, research, and applications) and the stakeholders involved in adaptation, DRM, civil protection, risk transfer, and humanitarian activities will be enhanced.

The catalogue is replicable and scalable to other regions. In the most basic form, hazardous events can be recorded in a simple spreadsheet containing the event's attributes on a standard computer. More advanced implementation can be made in the form of a dedicated database (e.g., MySQL, PostgreSQL), which are open-source. For this activity the project will work with the Bureau of Statistics to ensure data sharing and archive practice is consistent.

Output 4.2 Database of meteorological and oceanographic observations

In addition to the centralized catalogue from Activity 4.1.1, FMS will construct a database of meteorological and oceanographic (metocean) observations. The metocean database does not include socio-economic data such as that from external sources such as NDMO, e.g. lives lost and damage; that is contained in the catalogue in Output 4.1. Similarly, it does not include information on the extent of damage, e.g. maps of affected areas from a Tropical Cyclone such as extent of inundation, which would be useful in validating the forecast models of inundation; those are also contained in the catalogue

This database, in conjunction with the catalogue, will aid in selecting suitable hazard events to validate the coastal inundation model/forecast development, and for verification of operational forecasts. It will also provide a direct benefit to the integration of robust science-based evidence for long term climate policy planning and for disaster risk projection and management, and to inform the climate policy within Fiji.

Activity 4.2.1 Construct a database of meteorological and oceanographic observations

As a companion to the event catalogue, a database will be constructed containing all observations of meteorological, hydrological and oceanographic data measured over land and water areas in Fiji by FMS. The database will include, at a minimum, data for waves, still water level, river levels, river flows (where available) precipitation and related data including air and sea temperature, pressure and wind. Some of these data may reside in other agencies than FMS, so partnerships will be critical to ensure that as much data as possible is included in the archive. This will also require standard quality control and format conversion. For this activity, the project will work with the Bureau of Statistics to ensure data sharing and archive practice is consistent.

Output 4.3 FMS staff trained to monitor and manage the event catalogue and metocean database

Hazardous event recording needs to be designed and developed based on national needs in consideration of various aspects, including hazard and disaster characteristics, hazard monitoring capacity, expertise, and resources available. This requires human resources and training activities for record creation and maintenance, event linking and checking, quality control, hazard data exchange with cooperating centres, liaising with impacts data centres, and report preparation. In addition to the training proposed for this activity, WMO Regional Association V can provide training to support the development implementation of the catalogue.

Activity 4.3.1 Implement training activities for FMS to monitor and manage event catalogue and metocean database

In order to ensure sustainability of the catalogue and the database after the exit of AF funding, FMS staff will be trained sufficiently to undertake the necessary data monitoring and management. Furthermore, training will include documentation steps and quality assurance process to ensure consistency and robustness of the developed data products. This will also enable FMS to improve their data products in the future if necessary.

Component 5.Enhance and streamline communication with stakeholders and communities-at-risk

Dissemination and communication are crucial EWS elements, which must be targeted to ensure people and coastal communities at risk receive, and understand, warnings in advance of possible coastal inundation events. *This is the essence of adaptation to climate-related hazards.* These elements can be through different mechanisms, including the development of last-mile connectivity, so that emergency agencies and the public are able to respond to a flood threat to save lives and/or mitigate negative consequences. In the warning process, it is not only important to *disseminate* warnings to target audiences, but also to make sure warning information is well understood, and effective protective actions are taken.

Dissemination of warnings is often seen as one-way process of delivery of warnings from an EWS to target audiences (without direct feedback), while *communication* is a two-way process which implies interpreting of the warning messages and then feedback from end users. User engagement and feedback is a major principle, which helps to shape warning information and means of delivery according to the changing needs of the users.

The vital issue of the communication process is to be sure that users of coastal hazard warnings receive these warnings in a timely manner, with clearly understood warning information with appropriate action statements or reference to emergency agencies.

According to MHEWS: A Checklist (WMO, 2018) the warning dissemination and communication element should include the following components: organisational and decision-making processes, communication systems and equipment, and impact-based early warnings communication.

The dissemination and communication process structure and informational chain depends on country-specific governmental distribution functions and historical arrangements and existing requirements. In Fiji, the National Disaster Management Office is responsible for warnings and recommended actions, such as evacuations. The Fiji Meteorological Service issues public and marine forecasts and advisories, as well as the information provided to the NDMO.

Output 5.1 End-users including social groups with special needs have access to tailor-made products and channels to give feedback on the products

The agency responsible for running the EWS and issuing coastal inundation forecasting and warnings, the Fiji Meteorological Service, must continually update the list of recipients of coastal hazards warnings. This traditionally includes the national disaster management agency, local government authorities, civil and military authorities, media, private companies in vulnerable areas, community-based organizations, public information, press and media, and others. Requirements, roles and responsibilities of these partners in the E2E process of coastal inundation management should be clearly defined.

Knowledge about the end-users of these warnings and their structure is very important, as it will define the type and means of dissemination and communication systems and equipment. Communication strategies of warnings at different levels (national, subnational, local) should be developed and followed – to make sure that there is a high level of coordination between warnings and dissemination channels (such as web, television, radio, social networks, etc.).

A feedback mechanism with users should be set up – such as, for example, regular coordination, planning and review meetings (including post-event debriefs and surveys). It is valuable to hold meetings prior to the coastal inundation season (if this is the case) and to pay attention to the current prerequisites for possible adverse events, as well as warnings dissemination.

Activity 5.1.1 Develop tailor-made products that are visually friendly and effective communication to communities-at-risk

There are numerous standards and protocols, which can be used by EWS to transmit warnings.

To be effective, forecast and warning products should be easy to read, and easy to understand. Too much complex information in one product makes things worse. Even for text messages for warnings it is important to be short and to the point, using simple language; multiple screens on mobile devices risk the message being ignored.

Graphical products such as colour-coded inundation forecast maps can be provided for more sophisticated users, possibly on a sector-specific basis. Simple colour warning systems such as that used in CIASS – green= no threat, yellow=be aware, amber= beware, red=critical – are also very effective (Figure 16).

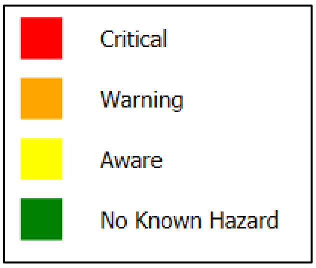

Figure 16 color-coded legend from CIASS Nadi Floodplain Warning

Warning messages should enable appropriate actions, either within the warning or in collaboration with emergency agencies. To make sure this occurs, it is highly recommended that coastal inundation early warnings are communicated in an impact-based way, so that target groups are capable of taking prompt, appropriate actions, through the consideration of vulnerability and exposure mapping. In other words, the warnings should not be based solely on meteorological, hydrological or inundation thresholds, but the impacts on communities and infrastructure.

Three primary types of output will thus be developed and implemented:

(1) Simple text messages for the broadest possible use (possibly following a Common Alerting Protocol-like format and language)
(2) Forecast maps of coastal inundation extent produced for internet access (pull) or phone app dissemination (push)
(3) Colour coded warning information following IBF principles, denoting level of threat, e.g. green, yellow, amber, red; this could link to an NDMO site for recommended actions, e.g. evacuation.

Activity 5.1.2 Provide forecast and warning information, including hazard maps, to communication platforms to maximize access to relevant information and train population to use information correctly

Emergency warning procedures in Fiji include multi-format messages with multi-media dissemination: websites, radio, telephone (automatic calls, SMS), television, press conferences, social media, sirens/alarms, text and phone messages, emails and others. However, capacity and resources to respond - particularly at the community level in Fiji - has often been limited. Since the beginning of CIFDP-F, communication networks have advanced significantly, particularly through the widespread access to, and use of, social media and people's use of mobile and smartphones. The issue of bandwidth was highlighted by stakeholders at the final CIFDP-Fiji meeting as a limitation to receiving additional information on warnings. The FMS has an effective SMS service that includes a subscription service available from its official website. The NDMO and its Commissioners utilise this service and they advised that there is work already underway by the Fiji government to improve the underlying infrastructure. Also, Very High frequency (VHF) broadcasts are part of the dissemination network along with High Frequency (HF) broadcasts to mariners. Further efforts on communication with communities is an ongoing activity by the NDMO and other end users. Usage of these means of dissemination should be analyzed and leveraged to make sure all groups of the population are reached with CIF warnings.

The end user stakeholders advised that the procedure for dissemination of tsunami warnings was well established and a good model that is also used for other warnings.

Activity 5.1.3: Develop a channel to receive feedback on the disseminated products

Once products are disseminated to the government agencies and the public, it is difficult for FMS to get a sense of whether products are used by the end users. While a feedback mechanism exists on the Fiji Meteorological Services website, no such mechanism is available for other platforms like radio and social media which FMS also uses to disseminate its weather products. Hence, this activity will focus on FMS developing various feedback channels and a regular survey to their end-users to systematically collect feedback and assess the early warning products.

Output 5.2 Sector-specific MHEWS forecast products are developed and used by various end users including industries

The CIFDP-F involved a wide range of stakeholders from several economic sectors, including fisheries, agriculture, tourism, maritime safety, port authority, lands and mineral resources and forests. Each of these sectors may have specific requirements for MHEWS forecasts and warnings beyond the primary products produced for the NDMO in its emergency response function. Certainly, many of them will require forecast products that are broader than MHEWS.

Activity 5.2.1: Develop sector specific MHEWS forecast products

Implementation of an EWS can provide many new products as a by-product of the forecast systems: deployment of a wave buoy at the entrance to Suva harbour aids in port management for example, new products from the Fiji waters wave model can aid safe and efficient ferry service operation, and fisheries. By providing sector specific forecasts, the small and medium sized enterprises can make informed decisions in managing the resources by the coast and building their resilience to adverse effects of climate change. Different sectors require various granularity and coverage of information from the forecasts. Tourism for example, a vital part of Fiji's economy, may require forecast information for specific resorts or resort areas. After consultations, and bi-lateral discussions and workshops with Ministries overseeing the industries and the end-users from the sectors, FMS will tailor general products so that they meet the specific needs of the sectors.

Output 5.3 Public awareness of coastal inundation is enhanced

The stakeholders at the final CIFDP-Fiji meeting noted that the coordination and distribution of essential coastal inundation forecasts and warnings has improved since the implementation of CIFDP-F. FMS, the NDMO and its Commissioners and District Officers have put significant effort into providing both hazard and hazard-risk information to at-risk coastal communities - right down to the village levels. This has significantly raised awareness of coastal hazards and provided much valuable and useful information on accessing and responding to warnings. However, there is still a need for resources to support community education programs and community emergency management planning that will focus more on preparation and mitigation and build community resilience.

Training and education of the local population should be also a part of inundation warnings communication strategy. Training sessions can also significantly shape the perception of the flood and inundation risk among population; improve understanding of warning messages, as well as actions needed to be taken in order to mitigate inundation consequences. Mass media could play much more effective role if not only broadcasting flood warnings, but also shaping the perception of a flood and inundation risk through "awareness raising of this risk prior to events and promoting and reinforcing the warning and community response messaging of the responsible agencies" (WMO, 2015). For this output, the WMO project will work with the Climate Change Division in the Ministry of Economy to undertake the activities.

Activity 5.3.1 Create Public Awareness materials and conduct educational workshops

The awareness video on the hazard and response to coastal inundation events prepared for the CIFDP-F was translated into local Fijian languages, and is a prime tool for education and awareness raising at the community level; this should continue to be used as an outreach tool. A second video was developed on the wave buoys so that the local communities are aware of the buoy and its value, in the hopes to reduce vandalism. Public awareness will be developed to illustrate how to receive warning messages in the event of an inundation event, use of hazard maps and other coastal inundation related topics.

The project will work with town centres, non-governmental organizations such as the Red Cross, schools and other fora to outreach information on coastal inundation hazards and response. Depending on the needs of the communities, arrays of various products such as videos, physical maps or phone or computer app (hazard maps and/or forecasts and warnings) and their usage will be demonstrated and explained. This will include workshops and meetings of clubs (women's clubs, youth clubs, ethnic clubs), elderly homes, and other at-risk groups.

Activity 5.3.2 Support inclusion of user communities including social groups with special needs based on gender, ethnicity, language, disability and other characteristics.

The goal of dissemination and communication systems is that EWS warnings have to be tailored to all groups of users, and especially accounting for their possible specific needs – for example urban and rural populations, different genders, elderly and youth, persons with disabilities, seasonal population (tourists) and others. It is vital to reach effective last-mile connectivity by understanding which population groups can be reached by which means and services of dissemination systems and equipment.

Women suffer disproportionally from disasters due to uneven income distribution and lesser access to information, planning and decision making. Women and girls tend to have less access to or control over assets, including the resources necessary to cope with hazardous events, such as information, education, health and wealth, their vulnerability is in general relatively greater than men's.

Stakeholders in the Demonstration Project supported the needs of specific user communities, and noted that there are several community engagement platforms, such as women's information networks and support groups for persons living with disabilities that the FMS can work in partnership with for support in developing user-specific warnings services. Many FMS partner agencies are already represented in these platforms. Targeted outreach activities to these social groups with special needs will be facilitated through workshops and other fora, through these community platforms.

Component 6. Strengthening cross-sectoral partnerships with institutions and NGOs

Output 6.1 Strengthened partnerships with government agencies and NGOs

Undertaking of this project offers unique opportunities to strengthen partnerships across government ministries and NGOs. Many ministries depend on reliable forecasts from FMS as their industries they oversee are affected by the weather and climate. Especially, the national disaster management office works hand in hand with FMS to communicate the forecasts to the vulnerable community. Thus, it is crucial that in order for various sectors and end users from industries located by the coast become resilient to adverse effects from climate change, the communication between FMS and various institutions is seamless. The participants from the stakeholders' workshops in CIFDP-F agreed that their relationships with FMS had improved as a direct result of the coastal inundation project. Given the scope of products which will be developed under this project to support coastal inundation forecasts, as a co-benefit, Fiji ministries will be able to manage the blue economy and natural resources more effectively and sustainably. The list of government and NGOs that worked extensively with FMS during CIFDP is listed in Section H.

Activity 6.1.1. Conduct workshops and hold trainings with government agencies and NGOs

It is necessary to further strengthen these partnerships between institutions to ensure proper response to coastal inundation forecasts and warnings. This project aims to organize workshops and bi-lateral discussions with various institutions to gauge the evolving needs from climate change for policy development and streamline.

NGOs provide a valuable resource in engaging with communities at risk, particularly rural populations, different genders, elderly and youth, persons with disabilities. Awareness raising of natural hazards and effective response can be very effective through these groups. In Fiji, grassroot communities are active in engaging communities at risk. In addition to engaging with communities at risk, it would be effective for FMS work with NGOs to broadcast warnings and information. The Red Cross participated throughout the CIFDP-F project. However, there are many other NGOs active in Fiji. Workshops will be organized to better understand the works of the NGOs in the grassroot communities and how strengthened partnership can further empower communities at risk. Examples of possible NGOs include: Citizen's Constitutional Forum, Fiji Council of Churches, Fiji Disabled People's Association, Fiji Trade Unions Congress, Fiji Women's Crisis Centre, Fiji Women's Rights Movement, Greenpeace Pacific, National Council of Women/Women in Politics, Pacific Concerns Resource Centre, SPACHEE/Ecowomen, FemLink Pacific, Wainimate, Women's Action for Change and YWC

Output 6.2 Arrangement of data sharing system between sectors

Data and information sharing is critical to the success of any MHEWS. This includes meteorological, oceanographic and hydrological observation data, but also data such as topography and bathymetry, river cross-section information, land use data and post-surveys of damage from natural hazard events. This also applies to hazard maps, which do exist for some parts of Fiji but are not always shared. Cross-sectoral and cross-institution cooperation with respect to data sharing, with common formats and definitions greatly benefits the ultimate MHEWS products. Within the WMO Guide on Implementation of a Coastal Inundation Forecasting- Early Warning System, is an agreement to freely share data among institutions. Signing of this agreement was a required precursor to the implementation of the Demonstration Project.

Activity 6.2.1 Arrange seamless data sharing scheme between government agencies in accordance with CIF-EWS

To arrange a data sharing scheme between government agencies, a form of agreement must be in place. Under CIFDP, as part of the Definitive National Agreement, data sharing was agreed as a necessary element of a CIF system. In implementation, such agreement can take the form of MoU or other types. To facilitate the sharing, discussion and workshops would take place. If necessary, a platform that accommodates data sharing between government agencies can be identified and set up. Sharing also applies to the sharing of forecast and warning products among institutions.

B. Describe how the project/programme provides economic, social and environmental benefits, with particular reference to the most vulnerable communities, and vulnerable groups within communities, including gender considerations. Describe how the project/programme will avoid or mitigate negative impacts, in compliance with the Environmental and Social Policy and Gender Policy of the Adaptation Fund.

Economic benefits:

An Early Warning System (EWS) enables mitigation or avoidance of damage and fatalities from the impacts of natural hazards. With EWS, government agencies can better channel resources to mitigate and prevent damage to public infrastructure and properties, leading to better resource mobilization in preparation for hazards. Since 1930, 84% of economic damage from disasters in Fiji has occurred from meteorological hazards, of which 97% is from tropical cyclones. At times of emergency, damage to public infrastructure and coastlines can be mitigated with placement of revetments and sandbags. In the long term, EWS, coupled with ecosystem-based adaptation solutions, for instance building nature-based sea walls and coral reefs, can significantly mitigate the damage from encroaching storms and other coastal hazards. At the household level, households can better prepare for hazards by strengthening roofs, securing windows and moving any valuable assets to shelters. On the industry side, Fiji relies on the tourism sector and any disruptions to the industry lead to major economic and reputation loss. Businesses in the tourism sector can ensure their operations have minimum impact by implementing a business emergency plan and safeguarding their properties. For those whose livelihoods depend on fishing and agriculture livelihoods, EWS enables the artisanal fishermen and smallholder farmers to protect their boat gear and crops against incoming storms. In addition, livestock can be moved to higher ground or shelters that are more protected. EWS encourages the public to plan for natural hazards and with the long-term projection from EWS, climate response can be systematically undertaken at policy and planning levels. EWS creates significant economic benefits by building resilience of the industries and the public. Given that 91% of population resides within 10 km of coasts, early warning systems for coastal inundation will build resilience of industries and coastal communities, enabling them to minimize and avoid economic damage.

Social Benefits

This project has dedicated two components to ensuring the outputs from the project have direct benefits to end users of the coastal inundation forecasting early warning system. The social benefits include a significant reduction in fatalities and mitigated impact on livelihoods of vulnerable coastal communities from meteorological hazards. With EWS, FMS and the NDMO can coordinate and channel resources more effectively to ensure the population in affected areas is evacuated. Component 5 focuses on development of tailored forecast products including for those with special needs and sector-specific products. Component 6 focuses on strengthening partnerships with NGOs such as the Red Cross, who work directly with vulnerable communities to ensure accessibility of the early warnings. In addition to the development of user-friendly forecast products in reaching the last mile, this project intends to increase the involvement of women in meteorology.

In Fiji, there is a tendency for women to not pursue the Science, Technology, Engineering, and Mathematics (STEM) fields and thus, the representation of women forecasters in FMS is small (4 forecasters out of 15). This ratio was improved during the CIFDP as part of the Demonstration Project. Since CIFDP, there have been efforts to recruit more female forecasters from an early stage of career. In this project, the effort will continue, and it is intended that at least two additional female forecasters are hired and trained with resources from the AF fund. Furthermore, at universities every year, FMS holds sessions and there will be particular emphasis to encourage and attract young female professionals to the field of meteorology. Furthermore, during CIFDP, the relationship between femLINK Pacific and FMS was established, and since then FMS has worked extensively with the organization to involve women in villages to disseminate forecasting warnings in a program called Women's weather watch alerts. Furthermore, femLINKpacific, having its long history in the region, has extensive networks and channels of communication which FMS can tap on. During the stakeholders' consultation meeting in November 2022, in preparation for the Concept Note, femLINKpacific was able to attend the consultation and raised valid concerns regarding women who cannot participate in the Women's weather watch alerts program given the lack of internet access. This project will expand the involvement of women in dissemination of forecasts. There will also be workshops aimed at increasing the capacity of women to understand and interpret forecasts.

The project will contain activities under Component 5 to work with persons living with disabilities in enhancing their access to forecast products. Under CIFDP, a number of social awareness activities have been initiated including awareness training for youth groups at church communities and at schools, as well as the Women's weather watch alerts program. However, at the time of CIFDP, no activities specifically geared towards the persons living with disabilities had been established. Hence, through this project, FMS will work closely with the National Council for Persons with Disabilities. The National Council for Persons with Disabilities was also present at the November Stakeholder Consultation Workshop, where they revealed that persons living with disabilities do not have accessible information on the FMS website. Thus, this project will work with the Council to ensure persons living with disabilities have access to timely information in formats that is meeting their needs.

Environmental Benefits:

An Early Warning System (EWS) enables mitigation or avoidance of environmental pollution and degradation. With EWS, ships and artisanal boats at sea and ports minimize the risk of running aground or crashing, leading to spilling environment pollutants including oil and debris harmful for the marine ecosystem. Ships at sea can seek shelter or deviate from routes with early warnings, and harbor masters can move ships and ensure ships are moored safely to docks. Environmental degradation can also occur on land from meteorological hazards at coasts when flooding occurs and drainage, fuel or chemical station, sewage system or energy plants leak pollutants. Such environmental degradation can severely destroy the ecosystem and biodiversity and take years to recover. Furthermore, coastal erosion, saltwater intrusion and flooding can severely disturb soil moisture and nutrients reducing agricultural yields. With EWS, when there is warning of meteorological hazards by coasts, farmers can take measures to protect the soil and optimize irrigation. In the long term, with EWS and effective climate response, the effects of coastal flooding from intensified meteorological hazards can be mediated by planting mangroves and protecting wetlands. As this project enhances the accuracy of coastal inundation forecast early warning system and development of sector-specific products, end-users can be empowered to take actions in the face of approaching meteorological hazards and as a result, build their adaptive capacity.

C. Describe or provide an analysis of the cost-effectiveness of the proposed project/programme.

Component	Benefits Generated	Alternative to project

1. Identifying and assessing institutional and community capacity, state of infrastructure, communication platforms.	Benefits to Component 1 of AF Project include minimizing risk for Components 2,3,4,5, and 6. It has been two years since the completion of the Demonstration Project and since then no assessment has been conducted to evaluate the implemented forecasting system. Also, since the development of the Final Report of CIFDP and formulation of the recommendations, Fiji has undergone much change especially as a result of Covid. Thus, before directly implementing the recommendations from the CIFDP report, it is essential to assess the institutional and community capacity to absorb and incorporate the recommendations made in CIFDP. Such assessment will ensure any AF investment channeled to communities and institutions can be sustained and targets the most vulnerable. Furthermore, it is essential to examine the state of infrastructure and communication platforms before scaling up, updating or replacing any of the existing assets to maximize cost efficiency.	The alternative to project is not conducting any assessment and going straight into Components 2,3,4,5 and 6 as per the recommendations from the Final report and rechanneling the allocated sum in Component 1 to Component 2 or 5. However, a lot has happened in Fiji at the local and institutional level since 2020 especially due to Covid 19. Aselsewhere, Fiji experienced major cutbacks in government budget as a result of Covid 19, and such reduced budget has unavoidably affected operations at FMS. Thus, there may be unidentified gaps that may render unintended consequences without a thorough assessment.
2. Expanding the forecast systems from CIFDP-F to other key parts of Fiji and upgrading the forecasting systems	Component 2 scales up, upgrades and replicates the forecast systems developed from CIFDP to other key parts of Fiji that were not covered under the Demonstration Project. The forecasting system developed under CIFDP is technologically innovative and the first to have become operational in the Region. It contains four components including early warning systems for storm surge, swell and coastal inundation and riverine flooding by the coast. This multi component forecasting system was developed by expert groups including JMA, SPC, Tonkin & Taylor(T&T) and NIWA. These partners were selected based on the rationale to leverage existing partnerships in Fiji to ensure sustainability of the operations. This project will continue to work with the same partners to ensure continuity. With the established partnerships and high awareness of the Fiji context, the partners can go straight into expansion, upgrading and replication without having to start from scratch. Thus, it is cost saving and efficient. Furthermore, the upgraded and scaled up forecast system will cover (~70%) of the Fiji population and give impact-based early warnings, enhancing the resilience of coastal communities and mitigating socio-economic damages from the coastal/marine hazards.	The alternative to Component 2 would be not upgrading, scaling up or replicating the coastal inundation early warning system from the Demonstration Project and trying to maintain the system as status quo. Currently the existing forecasting system is not impact based and produces text-based warnings which is human resource intensive and time consuming. Impact based forecasting automates production of forecast that is visually based. Furthermore, the forecasting system that is currently in place is three separate systems requiring forecasters to monitor all three systems to make a forecast. One output from this Component is to streamline and integrate the systems into a single system that is geospatial. The output from this Component will significantly reduce preparation time for forecasters to disseminate the products. With the current systems, FMS relies on other partners to transform text-based forecast to visually based ones. Another alternative to this project is working with other partners and rebuild the system from scratch; however, such rebuilding will require more time and resources to invested to produce a similar scale of output as Component 2.

3. Assessing and mapping the risk of coastal inundation hazards	Component 3 will enhance the preparedness of coastal communities to coastal hazards. Through this component, three risk maps will be accessed and adapted from the JICA project: storm surge, swell inundation, and hydrology. These risk maps will provide the necessary context for impact-based forecasting. Depending on the needs of the communities, various formats of the maps will be prepared including interactive and physical maps as not all communities have access to the internet. The coastal communities will directly benefit from the information provided in the maps as it will educate the communities regarding the extent of inundation depending on the level and type of coastal hazards. The coastal communities with the information can make more informed decisions on where to crop and establish coastal businesses including tourism and ports. In addition to direct benefit at the local level, the hazard risk map can benefit the policymakers and institutions for more climate resilient land use and urban planning. It can give scientifically robust information to various ministries, for instance in giving out permits and licenses. There is a large socio-economic benefit that can be realized from the information deduced from the maps.	The alternative to this component is not integrating the hazard risk maps into the geo-server system. FMS works with separate maps produced by the NDMO and JICA. However, there is no product that puts together complex layers of information in an impact-based way in one forecasting system. Thus, it is difficult for communities to search and get exposed to all the information that is necessary for them to make informed decisions. Thus, when hazards approach the coastal communities without a single point of information, it is challenging for coastal communities to follow precise actions instructed to them by FMS or NDMO in the moment. With one source of information, communities can take prompt and effective actions and plan ahead of the time as the hazards approach them.
4. Establishing a data archive of meteorological hazards for coastal/marine events and their impacts	Component 4 will enable FMS to guide various institutions and research centers regarding the impacts of historical coastal hazard events. After the occurrence of a natural disaster and aftermaths, FMS is frequently approached by various agencies regarding the impact of the hazards. The database containing information on the impacts of meteorological hazards for coastal/marine events can help decision makers, policy makers and other institutions to quantify more accurately the impacts. Such information will enable institutions to apply for further climate adaptation investment more easily, as many funding agencies require information on the rationale behind the requested funding with scientific and historical information. The information is currently scattered and is often not validated. Thus, this central database that is continuously monitored and updated by FMS can enable other agencies to apply funding for various types of adaptation activities beyond coastal adaptation through early warnings system.	The alternative to this component is not building a central database storing impact information, and keeping the status quo having institutions and FMS to look for scattered information per needs. As Fiji experiences more intense meteorological events, the need to quantify the impacts accurately will grow. Thus, at some point, FMS will need to establish some sort of database or will have to rely on an external database to estimate the impact. Relying on an external database will save FMS immediate capital cost to establish database but it will not build the national capacity to assess the effects of climate change in the long term and result in Fiji being dependent on external partners' funding availability to update the database.

5. Enhancing and streamlining communication with stakeholders and communities-at -risk	Component 5 will strengthen the capacity of coastal communities and industries to respond to early warnings system. The outputs from this component include tailor-made forecasting products including those for social groups with special needsand sector-specific MHEWS products. These outputs will benefit the livelihoods of coastal communities and industries in various sectors especially those relying on the blue economy. Thus, this component aims to bridge various types of end-users to effectively utilize and correctly interpret products issued by FMS, thus ensuring the investment in Component 2 has direct impact on the livelihoods of coastal communities and industries. This component is ensuring that FMS goes to last mile to reach all the end users and understand their needs better.	The alternative to this component is not generating tailor- made products and sector-specific MHEWS products and disseminating the products as they are generated from Component 2. The upgraded forecasting system from Component 2 will render forecasting to be geospatial based and more visually friendly. Thus, such upgrades are already an improvement in communication; however, the needs of coastal communities and industries vary a lot; the types of information that are useful to the end-users vary and thus to ensure the forecasts are incorporated into business plans and everyday decision of various end-users, the information in the products need to be relevant.
6. Strengthening cross-sectoral partnerships with institutions and NGOs	Component 6 will enhance seamless data and information sharing between agencies and NGOs in preparation for and mitigation of meteorological hazards for coastal/marine events. Currently, resources are more pooled to ensuring effective response to the events, but better preparation and mitigation will lead to cost avoidance and saving. Thus, this Component will benefit FMS and other agencies in coordination with NGOs by ensuring no duplication of efforts and collection of data which can be very costly. There are already existing datasets scattered through the government agencies and organizations; thus, an agreement to share data can help Fiji to manage resource and save cost more effectively.	The alternative to this component is not undertaking any additional activities to improve coordination between government agencies and NGOs apart from already ongoing efforts undertaken by FMS. Currently, communication between FMS and other partners does exist and there has been initiation of conversation to encourage more information sharing between agencies. However, with FMS staff hands already full with forecasting duties, it is difficult for FMS to push forward a more organized effort to arrange a formal data sharing between agencies.

D. Describe how the project/programme is consistent with national or sub-national sustainable development strategies, including, where appropriate, national adaptation plan (NAP), national or sub-national development plans, poverty reduction strategies, national communications, or national adaptation programs of action, or other relevant instruments, where they exist.

One of the approaches of Fiji's NAP (2017)[15] is the horizontal and vertical integration. Horizontal integration refers to Government Ministries and Departments incorporating climate change into their work and creating institutional links which enable cross-sectorial issues to be addressed. Severe weather and the associated hazards including coastal inundation is a common occurrence in Fiji. Currently, different Ministries play different roles in preparation/responding to coastal inundation. While FMS prepares the alerts and warnings, NDMO and other Ministries/departments are responsible for alerting the public and prompting the right response. Such arrangement could be strenuous, especially during situations where multiple hazards are happening at the same time (riverine flooding, hurricane force winds and coastal inundation). This project would greatly strengthen and improve the current arrangement enabling Government Ministries/departments such as NDMO, to refer to the new products which incorporate Impact-based forecasting and EWS (Component 2) and the inundation/risk map

[15] https://fijiclimatechangeportal.gov.fj/wp-content/uploads/2022/01/Fiji_National-Adaptation-Plan.pdf

which is an outcome (Component 3) of this project.

The Green Growth Framework (2014)[16] encourages action at all levels to build environmental resilience, nurture social improvement and reduce poverty. This project is directly aligned with the thematic area 1: *Building Resilience to Climate Change and Disasters in the Green Growth Framework*. The majority of Fiji's population either live along the coastal area or along the river. Historically, Fijians have been living in these areas for livelihood and accessibility to work and infrastructure. When hazards such as riverine flooding and coastal inundation occur, people's livelihoods are greatly affected, especially for those who were not alerted/warned prior to the event. This project aims at providing early warning to Fijians who live in such vulnerable areas. Component 5 of the project aims at creating an effective communication mechanism leading up to the event and it aims at creating awareness so Fijians can respond appropriately before the onset of the hazard.

This project is also aligned with Fiji's National Climate Change Policy (NCCP:2018-2030)[17], particularly Objective 5.1 which calls to *Improve data availability, analytical-capacity, risk communication and awareness*. This project will improve the data availability by expanding the river telemetry system into 2 other major rivers in Viti Levu and the Labasa River in Vanua Levu. In accordance with the need to 'Improve data availability' and aligned with the need to enhance and expand the forecast and early warning program, data sharing and communication is consistent with the legal framework of Standard Operating Procedures (SOP) in the Fijian Government. Examples of such critical data are bathymetry and Digital Elevation Model (DEM) data which may be considered sensitive for national security or of commercial value, but are critical for emergency response.

Furthermore, Component 2 of the project as an output would improve the analytical capacity by strengthening the technical capacity of FMS through the utilizing of a HPC and installing a cataloguing database in FMS. In addition, Component 5 of this project specifically addresses risk communication, tailor-made products, and effective awareness. Further, this project is also aligned with Objective 3.5 of NCCP *Integrate climate adaptation and disaster risk management priorities*. This project contributes to Objective 3.5 through the Upscaling of the Forecasting System at FMS (Component 2), adaptation and enhancing access to coastal hazard maps (Component 3) and enhancing communication (Component 5).

At an institutional level, this project directly speaks to the FMS Strategic Development Plan (2021-2024)[18]. Strategic Initiative 1.1 is titled *Support for Multi-Hazard Early Warning Systems (MHEWS) and Impact-based Forecasting and Warning (IBF)* and this project directly works forward this strategic initiative.

At a regional level, this project also aligns with the Pacific Meteorological Council (PMC) to strengthen the capacity of the NMHSs thus contributing to the safety, well-being, and development aspirations of the people of the Pacific through the provision of weather, climate, and related development services. Specifically, it relates to the work carried-out by the PMC's Panel on Marine and Oceans Services (PIMOS) and Panel on Pacific Island Education, Training and Research (PIETR).

E. Describe how the project/programme meets relevant national technical standards, where applicable, such as standards for environmental assessment, building codes, etc., and complies with the Environmental and Social Policy of the Adaptation Fund.

While much of this project deals with improving technical and forecasting competencies at the institutional level, accessibility of data is a prerequisite to implementing EWS. Thus, Component 2 involves installation of 3 sea level gauges, 8 rainfall stations and 5 river level stations in 3 rivers in Fiji as demonstrated in the **Selection process for Project site**. While installation of water level and rainfall stations is the first time for these selected sites, water level and rainfall stations have been installed for the Nadi River basin in Fiji under CIFDP. Prior to installation, the Fiji Meteorological Service will work with other strategic government departments, including the Native Lands Trust Board (NLTB), Lands Department of Fiji, Water Authority of Fiji (WAF) and the Ministry of

[16] https://fijiclimatechangeportal.gov.fj/wp-content/uploads/2022/01/Green-Growth-Framework-for-Fiji-LowRes_0.pdf
[17] https://fijiclimatechangeportal.gov.fj/wp-content/uploads/2022/01/FIJI-NCCP-2018-2030_0.pdf
[18] https://www.met.gov.fj/Fiji%20Meterological%20Service_Strategic_Implementation_plan.pdf

Environment. The Native Lands Trust Board and Lands Department of Fiji ensure that all the legal requirements about the land or river are met prior to any installation. Such requirements would include ensuring that the site of installation is leased properly, ensuring that the landowner agree and endorse the usage of their land.

With respect to installation of equipment and relevant national technical standards, the water level and rainfall stations are powered by small photovoltaic units. While there are no direct regulations relating to PV units in Fiji, similar photovoltaic units installed in the past that were purchased from abroad were cleared by the Customs Authority of Fiji before FMS installed it. As such, they are in accordance with the regulations of the Fiji Revenue and Customs Authority. Furthermore, during site selection, FMS would ensure that rainfall and river level stations are within operating distance of the nearest cell phone towers. In remote areas where satellite communication is the only way of transmitting critical hydrological data, FMS uses the Broadband Global Area Network (BGAN) satellite. FMS has a contract with NIWA on the usage of BGAN satellite network. The contract is endorsed by the Solicitors General Office of Fiji (SG's Office).
In Fiji, nearly all the household and commercial drinking water are sourced from the rivers. As such, the Water Authority Fiji (WAF) is responsible for most of the rivers and streams. Fiji Meteorological Service has a long-running working relationship with the Water Authority and always seeks its endorsement prior to installing any of the river level stations in any of the rivers in Fiji. The rainfall and river level stations being targeted to be installed in the project are small units of approximately 1 square meter so they have minimal environmental effects (if ever at all). Nonetheless, FMS works with the Ministry of Environment prior to the finalization of its installation sites.

In this regard, all elements relating to the installation and operation of water level and rainfall stations in Fiji comply with all national regulations. Internationally, the water level and rainfall stations are installed using the World Meteorological Organization's (WMO) standards and requirements.

F. Describe if there is duplication of project/programme with other funding sources, if any.

This project complements projects and initiatives that are currently ongoing in Fiji. It addresses some of the findings and gaps identified from some of the post-event hazard assessment and studies which we were carried out in Fiji in the past.

Organisation - Relevant Project/Programme	Project Scope	Complementary potential
SPC - Strengthening the Adaptative Capacity of Coastal Communities of Fiji to Climate Change through Nature based Seawalls	16 NbS Seawalls – design and build	The SPC Project contains numerous areas of complementarity as discussed with the SPC project managers. As described in the background section, Fiji faces enhanced extreme weather events and sea level rise forcing communities to relocate. The SPC Project aims to take measures to preserve the livelihoods of coastal communities by building nature-based sea walls, enabling communities to adapt to the adverse effects of climate change while in complementarity, the WMO Project strengthens coastal inundation EWS to enhance preparation and response of communities-at-risk to natural hazards. The two projects are implemented at different scales. The SPC project focuses on 16 coastal communities for building sea walls, while the WMO project covers the whole of Fiji in giving out impact-based forecasting. The 16 communities are covered under the coastal inundation forecasting EWS implemented in Fiji. Furthermore, the SPC Project focuses on capacity building of communities regarding the benefits of NbS, promoting such practices to the communities. For the WMO Project, capacity building for communities-at-risk aims to strengthen understanding of forecasting products, increasing the accessibility of the products, and enhancing their capacity to interpret the products. The two projects are coherent and complementary in their approach and outcome, thereby strengthening the overall capacity of Fiji to adapt to impacts of climate change. There is no duplication of activities in the two projects. The 16 communities in the SPC Project will benefit from the impact-based forecasting enabling them to take action in the event of natural hazards.
JICA – Mainstreaming Disaster Risk Reduction Project	Piloted over the Western Division of Fiji	This project is in the pilot phase and led by JICA and Fiji's National Disaster Management Office (NDMO), with technical advice from FMS. It is being piloted in the Western Division of Viti Levu. It aims at undertaking risk assessment for communities and schools in the Western Division of Fiji which are vulnerable to the ever-increasing effects of riverine flood and inundation, especially near the river mouth where the river run-off interacts with the ocean tide. It also strengthens the capacity of stakeholders to strategically incorporate climate change action and DRR into their strategic policies. Further, given the critical role of schools being used as evacuation centres during times of natural hazards, this project promotes the construction of 'safer schools' which are resilient to the hazards. The two projects are complementary in many ways. While JICA and NDMO focus on the effects of riverine flooding and some elements of coastal inundation in the Western Division, the WMO project aims at strengthening EWS against riverine flooding on 3 rivers which are not in the Western Division. (The Rewa and Navua Rivers are in the Eastern Division

		and Labasa River is in Vanua Levu Island). As such, this project extends EWS against riverine flooding and coastal inundation to geographical locations which are beyond the current scope of the JICA and NDMO project. The provision of Hazard Mapping and Impact-based Forecasting under the WMO project would complement the 'building of safer school' initiative. When FMS provides Early Warning on approaching severe weather, NDMO would proactively mobilize resources including identifying 'safer school' which are resilient to the approaching severe weather. The complementary nature of the 2 projects ensures that resources are mobilized to the safer school well before the arrival of the severe weather. Complementarity is also addressed in public awareness. While the JICA & NDMO projects increase public awareness relating to in the Western Division, this project addresses the need for public awareness for Coastal communities on the dangers of coastal inundation throughout Fiji. Further, this project recognizes the important role which women play in communal DRR and aims at harnessing existing networks between women's groups in Fiji to further strengthen the understanding of impact-based forecasting which FMS would provide through this project. In this regard, the 2 projects complement and strengthen each other.
Asian Development Bank – building-Coastal Resilience through Nature-Based and Integrated Solutions	10 Nature based protection activities across 10 villages in Fiji	This project's objective is similar to the objective of the above SPC Project whereby ADB will work with the Ministry of Economy on the construction of 10 Nature based protection activities across 10 villages in Fiji. The villages are yet to be identified. It aims at increasing resilience and awareness in the 10 coastal villages including village schools and surrounding communities. Regardless of the location of the 10 villages, they are covered under the coastal inundation forecasting EWS implemented in Fiji. The NbS seawall would be the first line of defense against the storm surges or the swells for which FMS will provide forecasts under its coastal inundation EWS. For the WMO Project, capacity building for communities-at-risk aims to strengthen understanding of forecasting products, increasing the accessibility of the products, and enhancing their capacity to interpret the products. The two projects are coherent and complementary in their approach and outcome thereby strengthening the overall capacity of Fiji to adapt to impacts of climate change. There is no duplication of activities in the two projects. The 10 villages in this project will benefit from the impact-based forecasting enabling them to take action in event of natural hazards.
Asian Development Bank - Preparing the Nadi Flood Alleviation Project	Nadi river basin	In the past decades, Nadi has experienced severe flooding, and very important given Nadi's strategic location in hosting the Fiji International Airport. Further, Nadi being part of the Western Division of Fiji, is very critical to the tourism sector. This project aims at alleviating floods from the Nadi River in various ways including the construction of dikes, water retention dams and the possibility of redirecting the Nadi River. While this project focuses on alleviating Nadi from the effects of riverine flooding, the WMO project complements the project because it focuses on the interaction of the water run-off from the Nadi river and ocean as it reaches the Nadi River mouth. If high rainfall events in Nadi highlands coincide with high

		tide or storm surge events at the river mouth, flood water is slow in clearing the Nadi River or they can even ‘back flow’ which amplifies the Flood situation in the Nadi basin. In this regard, the 2 projects complement each other because FMS will provide impact-based forecasting to Fijians living along the Nadi River mouth on the likelihood of elevated flooding. Further, capacity building for vulnerable communities along the Nadi River basin would strengthen the understanding of forecasting products, enhance their capacity to interpret the products, and ensure the appropriate actions are taken before the onset of the severe weather.
Adaptation Fund – Increasing the Resilience of Informal urban settlements in Fiji that are highly vulnerable to climate change and disaster risks	Lautoka, Sigatoka, Nadi and Lami	This project focuses on increasing resilience in informal settlements which are exposed to significant coastal and riverine flooding in urban areas and towns in Lautoka, Sigatoka, Nadi and Lami, while the WMO project includes activities on localized hazard maps, elements of early warning system and capacity development. The coastal inundation forecasting EWS under the WMO Project will cover the whole of Fiji and this AF project would utilize the early warnings provided by FMS, localize them to the setting of the informal settlements. This would enable these highly vulnerable settlements to take appropriate action well before the onset of the severe weather. They also complement in the area of public awareness and capacity building. While this project also incorporates public awareness and capacity development, they are mostly directed towards responding to this EWS. The WMO project complements this project by creating awareness and capacity building on ‘understanding’ and proper interpretation of the forecasts which are provided by FMS. Proper understanding and interpretation of the forecasting products would ensure that appropriate actions are taken. Further, the WMO project also recognizes the local context whereby women play a leading role in disaster preparedness. The WMO project would enhance and strengthen the knowledge of women in appropriate early warning response and DRR within the informal urban settlements identified.
CommonSensing Project	Flood plains in Fiji and 2 remote islands (Vanuabalavu & Totoya)	This project provides the *Flood Susceptibility App* for major rivers in Fiji. The *Flood Susceptibility App* indicates flood risk map areas using satellite imagery analysis and related geographical information. The flood risk map provided is solely directed to riverine flooding and does not include flooding which occurs along the coast or near the river mouth. Also, the CommonSensing project does not include a flood early warning system, which is covered in this project. In this regard, the WMO project will benefit and complement both activities under the CommonSensing Project because the WMO Project will provide a flood early warning system for the Rewa, Navua and Labasa rivers. The flood early warning system would be overlayed on the *Flood Susceptibility App* and would enable decision makers within Fiji to map out the flood prone areas and mobilize resources appropriately.

Climate Risk and Early Warning Systems (CREWS) Pacific SIDS	Regional EWS (14 Pacific SIDS, including Fiji)	Divided into two phases (Phase 1 from 2017-2022 and Phase 2 from 2021-2024), the CREWS Pacific SIDS project focuses on strengthening the RSMC-Nadi and the NMHSs that it serves in the Pacific Region. The two-phased project has supported the development of the Fiji Meteorological Service 2021-2024 Strategic Plan and its Implementation Plan. Furthermore, the project aims to support FMS in the implementation of a high-resolution NWP mesoscale model, which included the purchase of HPC servers and its installation, and the purchase of ECCharts licenses, which provides access to FMS/RSMC-Nadi to products from the European Centre for Medium-Range Weather Forecasts (ECMWF). Training on NWP will be facilitated under the project, with BMKG (Indonesia's Meteorology, Climatology, and Geophysical Agency) support and general technical oversight by WMO. A number of trainings have been provided to FMS throughout the lifespan of the project, including in the field of Tropical Cyclone Forecasting, and Severe Weather Forecasting. Further planned are ICT-related trainings to staff from the Meteorological Service, offered by SPREP. The CREWS Project works closely with SPC and SPREP. As one of the financiers of the CREWS Project, the World Bank is also involved in providing funding for enhancement of forecasting tropical cyclones in Fiji. The WMO project will benefit from the activities undertaken under the CREWS project as the CREWS project aims to build the technical capacity of FMS to generate forecasts for tropical cyclone, one of the natural hazards that can cause coastal inundation. As coastal forecasting EWS also is affected by the technical competency of forecasters at FMS, the enhanced capacity of FMS staff will enable forecasters to effectively learn from trainings facilitated under the WMO project. Furthermore, with respect to HPC, FMS has indicated that it would require additional HPC to undertake the magnitude of activities planned under the WMO project, explaining the additional procurement of HPC in this project. The two projects do not duplicate one another as the CREWS Project focuses on the forecasting ability of FMS to generate tropical cyclone forecasts and implementation of the overall strategy of FMS, whereas this WMO project specifically focuses on the coastal EWS.

G. If applicable, describe the learning and knowledge management component to capture and disseminate lessons learned.

Under the Coastal Inundation Forecast Demonstration Project, learning and knowledge management has been undertaken, where all the generated learning and knowledge have been documented thoroughly and kept within FMS. In particular, in reflection of high staff turnover in the Pacific, all the technical development on the forecasting system from CIFDP has been documented for FMS to sustain the system. During the CIFDP, technical partners came to the FMS' operational office in Nadi to hold training in building the capacity of FMS forecasters with the aim of making the operations in-house. One outcome from CIFDP is that FMS runs CIF-EWS in house and has sustained the system for more than two years. Furthermore, since the completion of CIFDP, two staff had the opportunity to attend training at the Japan Meteorological Agency to improve their technical competencies in EWS. Furthermore, initial stakeholder consultation, mid project review and final stakeholder consultations have been held and the outcomes, action points and lessons have been captured in the reports which are publicly available. With the learning from the CIFDP, further development of the forecasting system has been explored, which initiated the conversation from FMS to examine avenues for scaling up and expanding the activities from CIFDP.

Learning and knowledge management is also a core element of this project. As more technical innovation is introduced to FMS, it is ever crucial to build capacity of FMS staff concurrently and document the training and the systems in an end-to-end manner. One of the requests from FMS for this project includes documenting the technical system to a more granular level, so that FMS would become capable of reinstalling and rebooting the system during events of technical crash. Furthermore, through the project, a long-term advisory system with the partners will be established for events of technical glitches and system failure. In addition to capacity building of forecasters, workshops will be held for end-users and businesses to enhance utilization and understanding of the disseminated products. In these workshops, ways to incorporate traditional knowledge into forecasts will be examined so that such knowledge is retained. Awareness programs for youth, social groups with special needs and remote coastal communities will be carried out. Hazard risk maps will be made in various formats to enable distribution in areas without internet. Hence, communities without access to internet can access learning and knowledge on hazard risks at any time and take appropriate actions at times of hazards. Moreover, component 4 is dedicated to establishing a database to better store and manage historical meteorological events. With the database, learning can be managed more effectively and is backed by robust evidence.

H. Describe the consultative process, including the list of stakeholders consulted, undertaken during project preparation, with particular reference to vulnerable groups, including gender considerations, in compliance with the Environmental and Social Policy and Gender Policy of the Adaptation Fund.

One of the most important aspects of the Coastal Inundation Forecasting Demonstration Project for Fiji was the engagement from the very beginning through to the end of the project of a wide range of local, regional and national stakeholders. These included technical partners involved in the forecast process, including the assembly of key data sets such as bathymetry and topography in selected sites, the disaster management agencies, regional governments, national and international scientific expertise and coordinating bodies, and NGOs.

The participation of this wide array of institutions, including the capacity building activities in which they were beneficiaries, contributed to a strong and sustainable EWS for the island of Viti Levu under CIFDP. That success, sustained over the last two years, has led directly to the development of this project to scale up and expand the EWS to all of Fiji, with increased functionality and outreach of the system. Under CIFDP, initial stakeholder consultation, mid project review and final stakeholder consultation have been held to capture learnings and lessons from CIFDP throughout the Demonstration project period. From the Final Report, recommendations were made to further enhance the interactions between end-users and FMS.

The following organizations took part in stakeholder workshops during the Demonstration Project.

Organizations	
National Disaster and Management Office	Airports Fiji Limited, Nadi
Fiji Ports	Manager Properties/Building Surveyor
Fiji Navy	Special Administrator, Nausori
Ministry of Lands and Mineral Resources	Fiji Red Cross
Ministry of Works, Transport and Public Utility	UNESCO
Ministry of Agriculture	SPREP
Ministry of Forests	New Zealand Meteorological Service
Foreign Affairs - Climate Change Unit	Japan Meteorological Agency
Commissioner Northern Division	US National Hurricane Center
Commissioner Western Office	NZ National Institute of Water and Atmospheric Research
Commissioner Central Office	World Meteorological Organization

The defined scope and limited funding of the CIFDP in Fiji limited their ability to adequately address the last mile of communication. An important aspect of this project is to expand that aspect, to ensure that the dissemination and understanding of the EWS warning messages reaches all Fijians in a timely and effective manner. The project specifically targets services for disadvantaged groups such as women, the elderly, disabled and others. To achieve this, the consultative process for this project includes representatives from these groups from the earliest stage in the project development and continue throughout the duration of the project.

In preparation for this project, the Fiji Meteorological Service has been conducting bi-lateral consultations with other government agencies in Fiji, as well as the World Meteorological Organization over a period of months from the beginning of 2022. Partners including JMA, SPC, NIWA and Tonkin & Taylor have been consulted and their technical feedback is reflected in the Concept Note. This led to the Coastal Inundation Forecasting Initiative stakeholder meeting November 9-10, 2022, in Suva, Fiji, to continue building the necessary partnerships to successfully develop and implement this upscaled EWS. Representatives from both Government and Non-Government agencies were present; WMO also joined the Workshop virtually. Day one was dedicated to Government organizations while Day two was for non-government (NGO's) and Civil Society Organization (CSOs), as both these sectors' inputs would make an impact on further development of the project.

The forum for both days began with a look back at CIFDP-F as well as related MHEWS activities in Fiji, including the Flash Flood Guidance System (FFGS), SWFDP especially for coastal inundation, riverine flooding and flash-flood risk. The Concept Note under which the coastal inundation forecasting will be scaled up was then presented. Each day concluded with general discussions of the Concept Note and way forward for the overall project.

In his opening remarks, Mr George Tavo, Ministry of Infrastructure and Meteorology Service Deputy Secretary of Operations (DSO), stressed the importance of promoting new and innovative solutions, adopting new technologies that focused on climate adaptations, mitigation and resilience within communities. All these can only be achieved through effective stakeholder consultations. WMO acknowledged the willingness of the Fiji Meteorological Services (FMS) under the guidance of the Ministry's Permanent Secretary for taking the lead role in working with World

Meteorological Organization (WMO) on this project.

Following the presentations of the review of the previous coastal inundation project and the current Concept Note, participants were grouped into breakout sessions with a set of questions and opportunities to express their stakeholders' specific requirements present their views.

Figure 17 Day 1 of Stakeholder Consultation Workshop. Representatives from SPC and Special Administrators - Ovalau Town

Figure 18 Day 2 of Stakeholder Consultation Workshop. Director of Ministry of Fisheries

Figure 19 Day 2 of Stakeholder Consultation Workshop Group Photo

The following is a summary list of key requirements expressed by the stakeholders:

Data and data sharing

- Wave buoy data and water level data be made accessible
- DEMs and flood hazard mapping data of coastal communities to be made
- MoU/ MoA required for sensitive data
- A central repository to facilitate data requests i.e., based on its nature e.g. government agencies, sector partners or international organization.
- Ad hoc Community survey and community hazard data carried out by Town & country planning can be made available upon request as data is stored and mapped in GIS format.
- Ad hoc climate vulnerability assessments of waterways (including socio-economic impacts) data also stored and mapped in GIS format

Hazard Maps

- Site specification, Inundation extent, depth, velocity and probabilities are some Information greatly requested to

be reflected on hazard maps.
- Technical officers to be included in project workshops and training

Products, information sharing and feedback process

- Date, time, location, severity of damage, trajectory of event, duration, pre and post effects are the most anticipated information on forecasts.
- FMS to provide high resolution data relevant to local areas as current forecasts are too general
- FMS to reach out to other businesses and organizations who require tailor made products for better interpretation to communities
- Need for warning to be disseminated through text messaging as it is quick and instant
- Impact based forecasting to be available in vernacular
- FMS to provide trainings on interpreting forecasts as most terms are too technical.
- Form a link with the Turaga – ni – koro to incorporate traditional knowledge
- setup regular dialogue and feedback mechanism with sectors. This can be done through consultation workshops as such, surveys, emails, phone calls, teleconference or one-to-one meetings.
- Other forms of disseminating information to communities as some do not have access to mobile phones and internet.

Special Needs Requirements

- National Council for Persons with Disabilities noted that they do not have accessible information on FMS website so that they can interpret and disseminate it better to their members in the communities, accessible in the sense of audio to their vision impaired members etc. They also requested direct engagement with FMS to get the information first-hand.
- FemLink Pacific Women's weather watch alerts are working for those who have access to internet but it's a challenge to those who don't have access to internet. Transistor radio is the current method that is working

The comments and feedback shared by the representatives resonate with the activities planned under the project. For development of the fully developed project, further consultation with wider representations from government officials and NGOs will be held.

Participating Organizations:

The following organizations took part in the Stakeholders Workshop November 9-10, 2022

Organization	
Maritime Safety Authority of Fiji	FemLink Pacific
Pacific Fishing Company (PAFCO)	Fiji Hotels and Tourism Association
Rural & Maritime Development (Commissioner Eastern)	Conservation International
Land Transport Authority	WWF Pacific
Fiji Police Force (Water Police)	Fiji Coral Reef Rescue Initiative
Energy Fiji Ltd	Fiji Times Ltd

Fiji National University	Ministry of Fisheries
Secretariat of the Pacific Community (SPC)	Ministry of Waterways and Environment
Fiji Council of Social Services	The Ministry of Commerce, Trade, Tourism and Transport
National Council for Persons with Disabilities	World Meteorological Organization

I. Provide justification for funding requested, focusing on the full cost of adaptation reasoning.

Baseline (without AF resources)

Fiji has experienced enhanced intensity of meteorological hazards from coastal/marine hazards due to climate change. As projected in the IPCC report, it is very likely that Fiji will experience greater intensity of meteorological hazards, especially by the coasts as it is surrounded by water. Fiji originally requested support from WMO to improve its coastal inundation forecast after the destruction left by Tropical Cyclone Thomas in 2010 and Evan in 2012, leading to the origination of the Coastal Inundation Forecasting Demonstration Project. The CIFDP (1.4 USD million) focused on technical aspects including enhancing the capacity of FMS staff and building a coastal inundation system in addition to procurement of ocean buoys and water level gauges for improved validation. In 2020, FMS was able to operate its CIFI system for Tropical Cyclone Harold and received much media attention for the successful outcome. In the final evaluation of CIFDP, a number of recommendations have been raised, including bringing in more of the social element to forecasting beyond the technical aspects. The rationale behind such recommendation is that, no matter how accurate a forecast is, if the forecasters do not know whether the forecasts are being utilized or correctly understood by the end-users, it is difficult to conclude that resilience of coastal communities has been enhanced. As an outcome of CIFDP, FMS can issue coastal inundation for the main island (Viti Levu), but it still lacks early warning system for other key parts of Fiji and FMS does not have the capacity to generate impact-based forecasts. FMS has raised its desire to upgrade and streamline its coastal inundation forecast and is now relying on other partners to render them impact based. Without AF funding, FMS would continue to work with its partners to produce impact-based forecasts.

Alternative (with AF resources)

With investment from AF, FMS can fully operationalize an early warning system to its two main islands, where 87% of population reside. For an Early Warning System (EWS) to function properly, it needs to ensure that not only the technical but also the social elements have been integrated into the system. From improving the technical components to generate a streamlined forecast system, to reaching the last mile and inducing behavior change from its end-users, FMS would be precipitating a paradigm shift in the region for early warning system and for other Pacific countries to replicate the system. Forecasting for years has been practiced as a one-way communication from forecasters to the end-user; however, one of the key components of an early warning system to work is to ensure the message reaches the end-users and actions are taken by the end-users. In reflection of such aspect, various innovative and service-centric products will be developed through the AF investment to induce behavior change from the end-users to adapt to climate change. Many coastal communities still rely on traditional knowledge and do not pay attention to the forecasts. However, variability in climate is making it more difficult for those who rely on traditional knowledge to accurately predict the weather. Thus, producing tailor-made products for communities with varying needs, including social groups with special needs, will enhance the usability of early warning products. In addition to these innovative social practices, hazard risk maps, a met-ocean database and hazard and impact catalogue will further engender an enabling environment for adaptation to climate change at policy and strategic levels for Fiji. Hazard risk maps are necessary scientific tools for climate resilient land use and urban planning, whereas a robust database with historical impact information on meteorological hazards will enable integration of climate policy to other sectors.

J. Describe how the sustainability of the project/programme outcomes has been taken into account when designing the project/programme.

A successful EWS saves lives and avoids or mitigates damage on infrastructure, land and economy and supports long-term sustainability of the country. With a stronger economy, governments are more inclined to support/sustain EWS. The positive outcomes from the project will demonstrate the benefits of the EWS and the government would be more inclined to continue funding EWS. CIFDP has demonstrated positive outcomes, which was recognized by the Fijian government on numerous media occasions, and thus resources to continue operating the system were secured. Similarly, this Project has embedded in each of the Components' tranches of activities as part of the exit strategy, to ensure once the project is completed that FMS would have the technical and human resources to continue running the system and have a long-term advisory system set up in place.

To sustain an early warning system, it is necessary to have strong political commitment and durable institutional capacities, which in turn depend on public awareness. Public awareness and support are often high immediately after a major natural disaster; such moments can be capitalized to strengthen and secure the sustainability of early warning systems. Thus, considering such reality and as part of the exit strategy, the project has dedicated two components (5 and 6) to public awareness and strengthening relationships between institutions to ensure by the end there is a high awareness of EWS and its benefits to the economy/society/environment. Especially as Fiji experiences a high number of coastal related natural hazards, the public will recognize the benefits of strengthened EWS in Fiji. With high public and institutional support, there is likely stronger political commitment to sustain the EWS after the exit of the project.

Any assessment and planning for sustainability includes an examination of the financial, economic, social, environmental and institutional capacities of the systems needed to sustain net benefits over time, involving analyses of resilience, risks and potential trade-offs. Hence, as part of the exit strategy, Output 1 of this project addresses that issue, carrying out a full assessment of the end-to-end forecasting and warning process, across all participating institutions, from data collection to modelling and forecasting to the last mile of communication.

The keys to sustainability of the project as part of the exit strategy include initiatives aimed at establishing and maintaining effective partnerships, with other government ministries, NGOs and the public:

- emphasizing the active participation of relevant local, regional, national and community stakeholders in decision-making and implementation of the project's activities (Output 5 and 6)
- strengthening the institutional and technical capacity at regional, national and community levels to ensure that stakeholders have adequate knowledge and skill to maintain the benefits of the project (Output 1 and Output 5)
- raising the awareness of coastal inundation hazards and forecasting and warning messages and platforms at a local level (Output 5)
- involving national ministries in the establishment of the EWS and promoting a collaborative approach to developing the strategic framework project management, the project's activities will ensure that institutional capacity is strengthened for all partners, and ownership of the EWS is broadened, thereby increasing the sustainability of the project's activities. (Output 1, 5 and 6)
- supporting the development of long-term research partnerships (Output 4)

There are specific aspects of sustainability related to the operation of the EWS system, primarily by FMS but also with respect to its technical partners (Output 2):

To ensure sustainability of the new coastal inundation forecasting EWS, FMS needs to continue modelling and development activities. Once the systems become operational, there needs to be regular planned re-evaluation of the system (criteria, ensemble, setting up goals for intended key achievements, end users) to assess the impact and effectiveness, and propose modifications if necessary. At the end of CIFDP-Fiji project, the Ministry responsible for

FMS noted that they have, and will continue to have, diversified work, updates, modelling, training, liaison with the users. Continuous training of staff will take place as Fiji

- as a WMO Member has access to training resources through WMO and its Regional Association V
- Collaborates with other RA V countries (Indonesia) to develop products/ conduct research
- Has access to training opportunities via bilateral agreements (JMA)
- Leverages collaboration with regional programs/organizations such as SPC and SPREP for training/research opportunities
- Facilitates continued awareness raising for key stakeholders and the public

    - common understanding between stakeholders and FMS about the value of instruments (buoys/telemetry systems) being placed in particular locations.
    - Continued development of forecast system and new products by FMS in conjunction with partners (Component 2)
    - Continued collaboration with research community (Component 4)

Budget continuity for support of the EWS in the future should be allocated for: appropriate "hours-of-coverage" operations of the system, ongoing staff training, components maintenance (e.g., to be able to replace aging computing and communications resources and associated hardware, maintaining networks of buoys, sea level gauges, river gauges, etc.). It is important for a sustainable EWS that the initial implementation is manageable within a realistic budget envelope; maintaining overly large observational networks, e.g., replacing moored buoys, can be an insurmountable financial hurdle. This is taken into account in Output 2.1 and the magnitude of resources that will be needed to sustain the system will be scoped during the project to equip the FMS staff for exit of the project. The exit strategy is accounted for throughout the lifespan of the project especially regarding competency and capacity development of FMS staff to monitor and manage the system. Furthermore, recognizing the importance of public awareness and relationship with the stakeholders in sustaining the support for EWS, the project has dedicated two components to such aspects.

K. Provide an overview of the environmental and social impacts and risks identified as being relevant to the project/programme.

Checklist of environmental and social principles	No further assessment required for compliance	Potential impacts and risks – further assessment and management required for compliance
Compliance with the Law	X	Risk: **Low** Potential impact: **High** No additional assessment is required. The final project design will be compliant with all relevant regional and national laws. To ensure this, during the consultative process, regional and national stakeholders will be consulted to ensure that all relevant legal requirements are met. The project will not require any prior legal and regulatory approvals for environmental and construction issues as construction is not part of the project. Any legal issues associated with data collection and sharing will be addressed in the agreements with regional and national stakeholders.
Access and Equity	X	Risk: **Low** Potential impact: **High** No further assessment is required. The project activities will allow impartial and equitable access to the associated benefits. In fact, one of the key focus points is to improve access to forecast/warning products to vulnerable groups. In order to maximize the reach of information, awareness training and education will concentrate on community representatives as future trainers who disseminate information to the wider groups. In this regard, schools, service clubs, NGOs and special interest groups especially for disadvantaged groups will be key targets. Training materials will be carefully prepared for targeted audiences to facilitate community representatives disseminate information for locals.
Marginalized and Vulnerable Groups	X	Risk: **Low** Potential impact: **High** No further evaluation is required. The project will contribute to the reduction of existing inequalities in EWS for floods and droughts, particularly those affecting marginalized or vulnerable groups. To avoid the exclusion of marginalised and vulnerable communities, who may not have sufficient knowledge and access to technological devices such as mobile phones, internet, television or good telephone connection, the project will focus on a broad range of warning dissemination platforms to reach these groups, particularly women, girls, the elderly, indigenous people, tribal groups, displaced people, people living with disabilities, and people living with HIV/AIDS. During the development of the full project proposal marginal/vulnerable groups are will be consulted in the design of on-the-ground activities.
Human Rights	X	Risk: **Low** Potential impact: **High** No further assessment is required. The proposed activities do not or will not violate any of the established human rights. Furthermore, the project seeks to ensure that benefits of the project are shared broadly in a non-discriminatory, equitable manner through participatory processes. Extensive stakeholder consultations were held during project preparation and will be continued throughout the project implementation.
Gender Equity and Women's Empowerment	X	**Risk: Low** **Potential impact: Moderate** No further evaluation is required. The proposed project will improve gender equity and women's empowerment through a tool developed by WMO: Training Manual for Gender Mainstreaming in End-to-End Early Warning System for Floods and Integrated Drought Management through a Participatory Design Approach. This will increase the participation of women, girls and other vulnerable groups in flood and

		drought management activities and decision-making processes. Women's participation in disaster preparedness and decision-making is often limited due to cultural and social norms. There is therefore a risk that negative effects are expected to be experienced disproportionately by women compared to men, and that women will not benefit equally from the proposed adaptation measures and capacity development interventions. Participatory planning of activities will ensure that women and representatives of women's groups are well represented.
Core Labour Rights	**X**	Risk: **Low** Potential impact: **Moderate** No further assessment is required. Core labour rights will be respected and considered in the project design and implementation. In particular, national and regional stakeholders will be involved in the design of project activities to ensure that labour legislation is adhered to.
Indigenous Peoples	**X**	Risk: **Low** Potential impact: **Low** No further assessment is required. The indigenous population of the area will be consulted and involved during the design and implementation of the project activities. The traditional knowledge of indigenous people on floods and droughts will be useful in the preparation of risk maps, early warnings and dissemination of information.
Involuntary Resettlement	**X**	Risk: **Low** Potential impact: **High** The project design does not include any activities which would lead to involuntary resettlement.
Protection of Natural Habitats	**X**	Risk: **Low** Potential impact: **High** No further evaluation is required. The international buoy community - through the GOOS Data Buoy Cooperation Panel – has investigated the potential environmental impacts of moored and drifting buoys in numerous ocean basins. The presence of cables and anchors from moored buoys may enhance the physical complexity of marine habitats and provide settling or sheltering locations for marine organisms, resulting in long-term, indirect, minor beneficial effects. If a new buoy would be sited in a marine protected area, consultation with, and permits from the appropriate agency would be completed prior to deployment. The project would not be reasonably expected to have a significant impact on threatened or endangered species, or their critical habitat. Consultations would be held with project partners to avoid such adverse effects, and to avoid harassment of marine mammals. Mitigation measures and best management practices would be implemented to reduce or limit any known adverse effects. The project would not be reasonably expected to adversely affect essential fish habitat. The project would not reasonably be expected to adversely affect vulnerable marine or coastal ecosystems, including deep coal ecosystems. Once a general area is identified for the deployment of a new buoy, any hazards or obstructions are identified, including biological resources i.e., coral reef systems, vulnerable or critical habitats. If resources are identified in this area, they would be avoided to the maximum extent possible.
Conservation of Biological Diversity	**X**	Risk: **Low** Potential impact: **High** No further evaluation is required. The project would not reasonably be expected to adversely affect biodiversity or ecosystem functioning (benthic productivity, predator-prey relationships, etc.). The placement of moorings and anchors could have the potential to affect benthic communities if non-mobile species are crushed and benthic area is no longer productive; however, these impacts would be avoided to the maximum extent possible by avoiding known benthic communities. If an adverse impact were to occur, the magnitude would be negligible compared to the overall size and complexity of Fiji's ocean ecosystem. The project would not be reasonably expected to adversely affect to result in the introduction or spread of nonindigenous species. Procedures are well established in the international buoy community to prevent the spread of invasive and non-native species

		to other waters.
Climate Change	**X**	Risk: **Low** Potential impact: **Moderate** No further assessment is required. The activities of the proposed project will not result in any significant or unjustified increase in greenhouse gas emissions or other drivers of climate change. In addition, the project not only increases the flood adaptive capacity and resilience of the local population, but also contributes to the development of a better governance structure, policies and plans at national, regional and local levels for climate change adaptation.
Pollution Prevention and Resource Efficiency	**X**	Risk: **Low** Potential impact: **High** No further assessment is required. The project activities are expected to result in minimal production of waste and release of pollutants.
Public Health	**X**	Risk: **Low** Potential impact: **High** No further assessment is required. This project does not negatively affect public health. On the contrary, it improves the well-being of the public by identifying at-risk communities that are prone to flooding and, through various capacity building activities, providing effective warning of dangerous climate events, and building resilience to climate change.
Physical and Cultural Heritage	**X**	Risk: **Low** Potential impact: **High** No further assessment is required. The project does not involve any activities that may affect the physical and cultural heritage. The participatory design and mapping approach of the project will involve communities and local authorities to identify areas of physical and cultural importance and ensure that oceanographic and hydrological monitoring instruments are sited so as to avoid conflict with local, regional and national culture and heritage.
Lands and Soil Conservation	**X**	Risk: **Low** Potential impact: **High** No further assessment is required. The project does not involve any activities that might lead to soil degradation or conversion of productive lands or land that provides valuable ecosystem services. The EWS, and in particular the hazard mapping in Output 3, may help with planning to mitigate soil erosion or saline intrusions in coastal inundation events.

PART III: IMPLEMENTATION ARRANGEMENTS

A. **Demonstrate how the project/programme** aligns with the Results Framework of the Adaptation Fund

Project Outcome(s)	Project Outcome Indicator(s)	Fund Output	Fund Output Indicator	Grant Amount (USD)
A coherent and comprehensive mapping to scale up and execute the technical and social innovation recommended from CIFDP-F	A comprehensive report outlining the areas of improvements and gaps from CIFDP	**Output 8:** Viable innovations are rolled out, scaled up, encouraged and/or accelerated.	**Indicator 8.2:** No. of key findings on effective, efficient adaptation practices, products and technologies generated	200000
Enhanced capacity of Fiji Meteorological Service to provide more accurate and user-friendly forecast to communities- at risk	Number of innovative forecast systems Number of training workshops to FMS staff	**Output 8:** Viable innovations are rolled out, scaled up, encouraged and/or accelerated. **Output 2.1:** Strengthened capacity of national and sub-national centres and networks to respond rapidly to extreme weather events	**Indicator 8.1**: No. of innovative adaptation practices, tools and technologies accelerated, scaled-up and/or replicated Indicator 2.1.1. No. of staff trained to respond to, and mitigate impacts of, climate-related events (by gender)	3350000
- Enhanced preparation to coastal hazards - Hazards risk information made available for climate resilience, urban and coastal planning	-Number of developed hazard risk map developed -Number of town/villages receiving awareness workshop	**Output 1.1:** Risk and vulnerability assessments adapted and updated	**Indicator 1.1** No. of projects/programmes that conduct and update risk and vulnerability assessments (by sector and scale)	150000
- Historical impact data is made available for research and formulation of science-backed climate policy -Trained staff from FMS on the monitoring and management of the event catalogue and metocean database.	-Number of downloads requested -Number of workshops with research centres and policymakers regarding integration of the newly available information -Number of trainings carried out to enhance the capacity of FMS staff	**Output 7:** Improved integration of climate-resilience strategies into country development plans **Output 2.1**: Strengthened capacity of national and sub-national centres	**Indicator 7.1.** No. of policies introduced or adjusted to address climate change risks (by sector) Indicator 2.1.1. No. of staff trained to respond to, and mitigate impacts of, climate-related events (by gender)	300000

		and networks to respond rapidly to extreme weather events		
Improved and effective response to early warning system by the public and industries along the coast	-Number of feedbacks from end-users -Number of newly developed tailored forecast products including for social groups with -Number of newly developed sectoral specific products	**Output 3.1:** Targeted population groups participating in adaptation and risk reduction awareness activities **Output 3.2:** Strengthened capacity of national and subnational stakeholders and entities to capture and disseminate knowledge and learning **Output 4:** Vulnerable development sector services and infrastructure assets strengthened in response to climate change impacts, including variability	**Indicator 3.1** No. of news outlets in the local press and media that have covered the topic **Indicator 3.2.2:** No. of tools and guidelines developed (thematic, sectoral, institutional) and shared with relevant stakeholders **Indicator 4.1:** Responsiveness of development sector services to evolving needs from changing and variable climate	500000
Strengthening cross-sectoral partnerships with institutions and NGOs	-Number of data exchange between institutions -Number of workshops between NGOs and government institutions	**Output 2.1:** Strengthened capacity of national and sub-national centres and networks to respond rapidly to extreme weather events	**Indicator 2.1.2:** No. of targeted institutions with increased capacity to minimize exposure to climate variability risks (by type, sector and scale)	200000

[1] The AF utilized OECD/DAC terminology for its results framework. Project proponents may use different terminology, but the overall principle should still apply

PART IV: ENDORSEMENT BY GOVERNMENT AND CERTIFICATION BY THE IMPLEMENTING ENTITY

A. Record of endorsement on behalf of the government[2]

Provide the name and position of the government official and indicate date of endorsement. If this is a regional project/programme, list the endorsing officials all the participating countries. The endorsement letter(s) should be attached as an annex to the project/programme proposal. Please attach the endorsement letter(s) with this template; add as many participating governments if a regional project/programme:

Mr.Shiri Gounder, Permanent Secretary, Ministry of Economy	Date: (09, January, 2023)

B. Implementing Entity certification

Provide the name and signature of the Implementing Entity Coordinator and the date of signature. Provide also the project/programme contact person's name, telephone number and email address

I certify that this proposal has been prepared in accordance with guidelines provided by the Adaptation Fund Board, and prevailing National Development and Adaptation Plans and subject to the approval by the Adaptation Fund Board, commit to implementing the project/programme in compliance with the Environmental and Social Policy and the Gender Policy of the Adaptation Fund and on the understanding that the Implementing Entity will be fully (legally and financially) responsible for the implementation of this project/programme.

Moyenda Chaponda
Implementing Entity Coordinator
Project Management and Implementation Unit

Date: January 09 20203	Tel. and email: 00+41227308646 mchaponda@wmo.int
Project Contact Person: Dr Sarah Grimes	
Tel. And Email: +41 22 730 8242 and sgrimes@wmo.int	

6. Each Party shall designate and communicate to the secretariat the authority that will endorse on behalf of the national government the projects and programmes proposed by the implementing entities.

MINISTRY OF FINANCE, STRATEGIC PLANNING, NATIONAL DEVELOPMENT AND STATISTICS

P.O Box 2212, Government Buildings, Suva, Fiji; Tele: (679) 3307011, Fax: (679) 3308654
Website: www finance.gov.fj_ Email: FinanceInformation@finance.gov.fj
Ro Lalabalavu House, 370 Victoria Parade, Suva

9 January 2023

By Email: Secretariat@Adaptation-Fund.org

The Adaptation Fund Board
c/o Adaptation Fund Board Secretariat

Dear Secretariat

Endorsement for "Enhancing Climate Adaptation through scaling up Fiji's coastal inundation forecasting early warning system project"

1. In my capacity as the designated authority for the Adaptation Fund in Fiji, I confirm that the above national project proposal is in accordance with the Fijian Government's national priorities in implementing adaptation activities to reduce adverse impacts of, and risks, posed by climate change in Fiji.

2. The outcome of the proposal complements key areas of Fiji's Climate Change Act, Fiji's National Development Plan, the National Climate Change Policy, National Adaptation Plan, Fiji's Updated Nationally Determined Contributions and Fiji's National Ocean Policy.

3. Accordingly, I am pleased to endorse the above project proposal with support from the Adaptation Fund. If approved, the project will be implemented by World Meteorological Organization and executed by the Fiji Meteorological Service.

4. Please note that this Letter of Endorsement ('LOE') applies to the Concept Note only. We will issue a subsequent LOE to the accredited entity for the implementation of the project upon receipt of a Full Funding Proposal. This will also be subject to a comprehensive review from the Fiji Climate Finance Sectorial Working Group.

5. For any enquiries, please contact Mr. Prelish Lal on email via prelish.lal@govnet.gov.fj or by phone on +679 322 1216.

Thank You.

Yours sincerely

Shiri Gounder
Permanent Secretary for Finance (AF DA)