Flood Management

Enhancing Flood Management and Mapping in Fiji through GIS: A Comparative Analysis

Visiting Researchers Program FY 2024

Research Report

Submitted by: VR Fiji

Submitted to: ADRC, Japan

Disclaimer

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The report compares flood management strategies in Fiji and Japan, drawing insights from Japan's experience to explore potential applications in Fiji. While every effort has been made to ensure accuracy, the information presented is based on available data and research at the time of writing. The author does not assume responsibility for any errors, omissions, or unintended misinterpretations.

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Abstract

Flooding remains a major challenge in Fiji due to its tropical climate, frequent heavy rainfall, and exposure to extreme weather events. This research examines the role of Geographic Information Systems (GIS), remote sensing, and flood modelling in strengthening flood risk management, drawing lessons from Japan's advanced disaster resilience strategies. A comparative analysis of flood management practices in both countries highlights gaps in Fiji's current approach, particularly in early warning systems, high-resolution flood modelling, and structural flood mitigation measures. Field visits to Japan provided insights into effective flood risk reduction strategies, including real-time flood monitoring, AI-driven hazard mapping, and community-led disaster preparedness initiatives. The findings underscore the need for Fiji to invest in high-resolution digital elevation digital elevation models, enhance flood early warning dissemination, and integrate modern geospatial technologies to improve risk assessment and mitigation. This study provides recommendations for strengthening Fiji's flood resilience through a combination of structural improvements, policy reforms, and adaptative flood management strategies.

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Acronyms

AI — Artificial Intelligence (22)
ADRC VR — Asia Disaster Reduction Center’s Visiting Researcher (22)
ADB — Asian Development Bank (23)
EWS — Early Warning System (19)
FRM — Flood Risk Management (10)
GIS — Geographic Information System (8)
GHA Earthquake — Great Hanshin Awaji Earthquake (29)
GCF — Green Climate Fund (23)
LiDAR — Light Detection and Ranging (19)
NDRM — National Disaster Risk Management Act 2024 (17)
NDRRP — National Disaster Risk Reduction Policy (15)
PICs — Pacific Island Countries (14)
PRP — Pacific Resilience Partnership (15)
PRP — Pacific Resilience Partnership (15)
FRDP — Resilient Development in the Pacific(14)
SFDRR — Sendai Framework for Disaster Risk Reduction (15)
DRR — Disaster Risk Reduction (15)
2D — Two-dimensional (19)

1.0 Research Overview

1.1 Statement of the Research Problem/Question

Despite the existence of flood management plans, published research, and proposed measures to mitigate flooding impacts, the situation remains largely unchanged. This is evident in the high number of evacuations during local flood events. Therefore, it is essential to evaluate current flood management plans and identify the factors contributing to ongoing challenges.

This research investigates whether existing or previously published flood management plans lack flood modelling or detailed mapping. The primary objective is to determine whether incorporating these elements can enhance flood management effectiveness by comparing practices in Fiji to those in Japan.

1.2 Significance of the Research

The significance of this research lies in its potential to enhance flood management planning in Fiji through the integration of advanced geospatial techniques, such as Geographic Information Systems (GIS) and Remote Sensing (RS). These tools can provide detailed mapping and real-time data analysis, which are crucial for effective flood risk assessment and mitigation.

By analyzing Japan's flood management strategies this research aims to derive lessons that can be adapted to Fiji's context. The integration of detailed mapping and geospatial analysis is anticipated to improve the accuracy of flood risk assessments, improve the design mitigation structures, and advance overall disaster preparedness and response in Fiji.

1.3 Research Objective

This research aims to explore how Geospatial Techniques [Geographic Information System (GIS)] can enhance flood management planning in Fiji by lessons learned from Japan.

1.4 Research Methodology

This research uses a comparative analysis methodology to investigate flood management practices in Fiji and Japan, with a special consideration of the role of Geospatial techniques (GIS and Remote Sensing), in strengthening flood resilience and management strategies. Given the diverse nature of flood management, the study integrates both qualitative and quantitative data from secondary sources, which includes case studies, government reports, and academic literature as well as primary data collected through direct observations from lectures and field visits.

1.5 Scope and Limitations

1.5.1 Scope

This research focuses on evaluating flood management practices in Fiji and Japan, with an emphasis on the role of flood modelling and geospatial techniques- such as Geographic Information Systems (GIS) and Remote Sensing (RS)- in flood management plans. The study examines both structural and non-structural flood risk management (FRM) approaches, analyzing case studies where flood modeling has been effectively integrated.

The research further explores how flood modelling contributes to improve preparedness, mitigation, and response strategies, drawing comparisons between the flood management frameworks of Japan and Fiji. By assessing primary and secondary data, the study aims to provide insights and recommendations for enhancing Fiji's flood management strategies, particularly considering increasing flood frequency and severity.

1.5.2 Limitation

While this research provides a comparative analysis of flood management practices between Fiji and Japan, several constraints are acknowledged:

Data availability- the research relies on secondary data sources, reports, and case studies, which may vary in terms of accuracy, details, and timeline. Primary data sources reflect the observations made by a single researcher, which might lead to a certain degree of bias.

Temporal limitations- Given the dynamic nature of flood management technologies, policies, and climate conditions, the findings may become less relevant over time.

Infrastructure and Policy Differences- The study acknowledges the socio-economic and infrastructural differences between Japan and Fiji, which may affect the direct applicability of certain flood management strategies from one country to another.

Focus on GIS and RS- While geospatial techniques are a central aspect of this research, other critical components of flood management, such as governance, community engagement, and financing mechanisms, are only discussed as secondary considerations.

Despite these limitations, the study aims to provide insights into the role of flood modelling in strengthening flood resilience, offering recommendations that can contribute to improved flood risk management in Fiji.

2.0 Introduction

Fiji, a country located in the South Pacific Ocean, comprises of 332 islands, 110 of which are uninhabited. Viti Levu and Vanua Levu are the largest and most populated islands, housing the main urban centers, infrastructure and ports of entry. As per the 2007 census, the population of Fiji stands at 884,887 most of whom reside along coastlines. Fiji's main economic drivers are the tourism and agriculture industries. Fiji is highly vulnerable to climate extremes, like drought and heavy rainfall, flooding, posing a threat to livelihood and infrastructure. Over the years, respective government ministries have implemented flood reduction measures such as river dredging, small check dams and early warning systems for flood. Despite these measures, flood frequency and impacts continue to be an issue.

2.0.1 Flood impacts in Fiji

Floods have damaged schools and have devastating impacts on education. Schools such as the Ba Muslim Primary School in the western division of Fiji, have experienced frequent flooding. Inundated homes have resulted in the damage of school children's textbooks, leading to school disruption. Not only this, but school closures in anticipation of poor weather and the use of schools as evacuation centres cause delay in the reopening of schools for classes. The aftermath of flood events brings its fair share of impacts on the health sector, with increased cases of diarrhoea, leptospirosis, and typhoid due to contaminated water; increased incidences of dengue fever (due to mosquito breeding in stagnant waters) and increased skin infections[1].

Additionally, floods have caused major damage to infrastructure, especially to roads, bridges, and water supply, as pipes are exposed to flood water and flood-borne debris. Major bridges at the Ba Province and Sigatoka in Fiji were destroyed in 1993, and cost millions to replace. Not only this, but it also caused a massive halt to transport within these areas, affecting local economies. In recent flooding events, of January 2025, continuous torrential heavy rainfall led to flash floods in Ba and Sigatoka towns, leading to the closure of low-level crossings and essential businesses (Fiji Meteorological Services, 2025)[2].

Presently, frequent flood events have continued to worsen, as evident by the number of residents that evacuate during local flooding events. Flooding event on December 25, saw a total of 200 of people moving into a local primary school that opened as an evacuation centre in the Western division (Fiji Broadcasting News, 2024)[3]. Although efforts have been made to strengthen the resilience of communities through improvements in the productions, dissemination and effective Multi-Hazard Early Warning[4], not much focus has been directed to evaluate the status of flood management strategies and structures in the country.

This research evaluates flood management practices in Japan and Fiji, with a particular focus on the role of flood modelling, using geospatial techniques (GIS and RS) in flood management plans. It examines the Flood Risk Management (FRM) approaches in each country, analysing case studies where flood modelling has been integrated. Additionally, the study includes recommendations based on insights gained from primary and secondary data.

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[1] (Stephen Yeo, 2017)
[2] (Fiji Meteorological Services, 2025)
[3] (Fiji Broadcasting News, 2024)
[4] (Green Climate Fund, 2024)

2.1 Background of the Study

2.1.1 Current Climate Conditions

Fiji is highly exposed to tropical cyclones. Islands in Fiji have in the past and present experienced both direct and indirect effects of cyclones on an annual basis. Climate risks in Fiji can be categorized into two types: rapid onset and long-term changes[5]. Although, Tropical cyclones normally occur between the months of November- April, it is less common during the El Nino periods.

Temperatures in Fiji are normally constant throughout the year, with an average range around 23°C-25°C, during the dry season (May- October) and 26°C-27°C in the wet season (November to April). The most seasonal change is seen in the areas where precipitation is frequent, with an average of around 250-400 millimeters (mm) of rainfall per month, during the wet season and 80-150 mm per month in the dry season. On the other hand, there have been periods of drought known to occur during the El Nino periods. In terms of precipitation pattern, Viti Levu, sees much more rainfall on the east (windward side), compared to the west (leeward side).

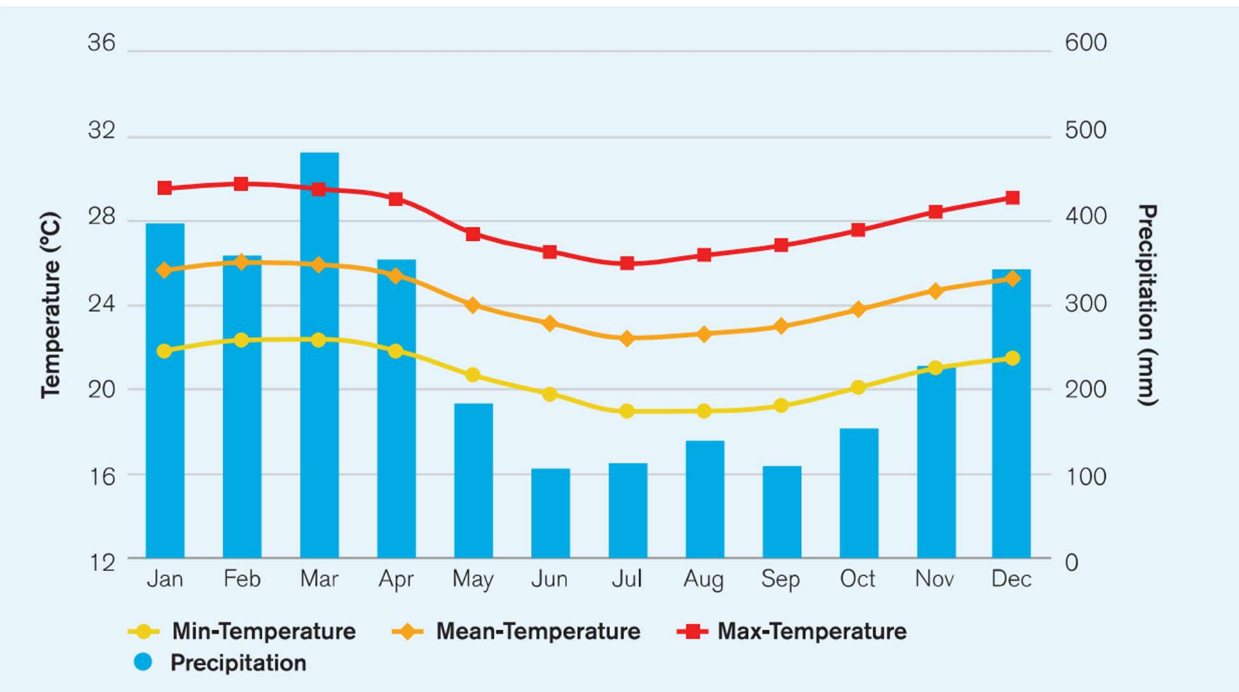

Figure 1: Average monthly mean, max and min temperatures and rainfall in Fiji (1991-2021)[i6]

However, in recent climate summary reports in 2024, there have been significant change in temperature and rainfall patterns across Fiji. In December 2024, Fiji experienced significantly wetter-than-usual conditions influenced by low-pressure systems, including Tropical Depression 01F. Many areas recorded more than double their normal monthly rainfall, with the highest

[5] Climate Risk Country Profile: Fiji (2021): The World Bank Group

[6] (The World Bank Group, 2021)

recorded in Nadarivatu district with 1353.5 mm a record since 2013[7]. Also, Tavua district recorded its highest monthly rainfall of 473.0 mm since 2009[8]. Both districts are in the western part of the main island Viti Levu, which, in previous years received fair amounts of rainfall, but the same can not be said recently.

Additionally, most areas across Fiji experienced near to above-normal temperatures. With the warmest daytime temperature recorded on Viwa Island at 36.0℃, the highest since 1978[9]. While the lowest nighttime temperature was recorded in the Nadarivatu district at 13.9℃.

Although the month of December is generally associated with the wet season in Fiji, over the years, rainfall and temperature patterns have varied due to climatic influences such as El Nino and La Nina events. Below are brief comparisons:

2.1.2 Rainfall Patterns

Previous year's rainfall: many Decembers experience high rainfall but the extraordinary amounts seen in December 2024 were above typical averages, especially in comparison to 2023[10], where the average rainfall was at a lower peak compared to December 2024. Similarly, high rainfall recorded in 2022 was not close to the extremes of 2024 totals[11].

[7] (Fiji Meteorological Services, 2024)
[8] (Fiji Meteorological Services, 2024)
[9] (Fiji Meteorological Services, 2024)
[10] (Fiji Meteorological Services, 2024)
[11] (Fiji Meteorological Services, 2024)

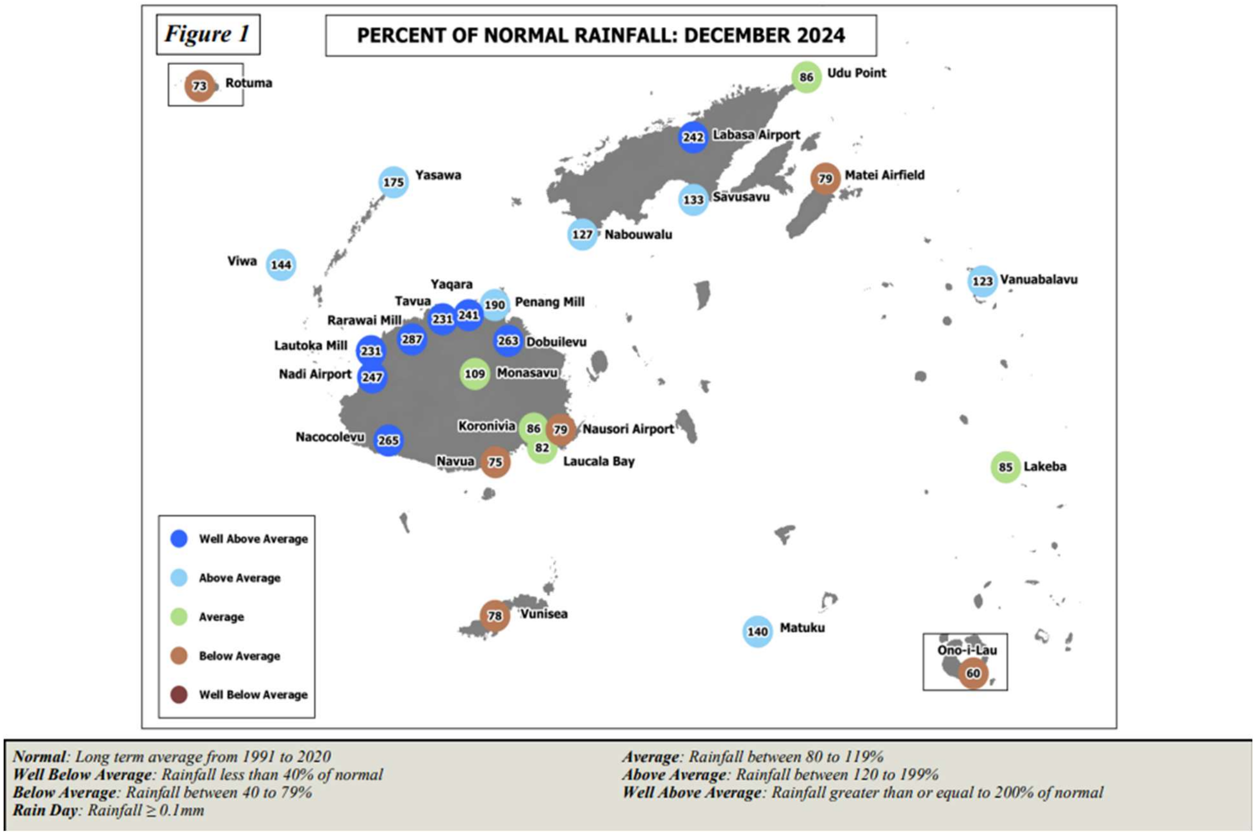

Figure 2: Map of percentage normal rainfall recorded in December 2024[12]

2.1.3 Temperature trends

While December typically sees warm temperatures, the peaks recorded in December 2024 (like the 36.0°C) are noteworthy. Previous records often hovered below this mark, indicating a potential warming trend.

[12] (Fiji Meteorological Services, 2024)

Table 1: Climate records established in December 2024

Element	Station	Observed (record)	On	Rank	Previous (record)	Year	Records Began
Monthly Rainfall	Tavua	473.0mm	-	New High	466.5mm	2022	2009
Monthly Rainfall	Nadarivatu	1353.5mm	-	New High	754.5mm	2022	2013
Daily Maximum Temperature	Viwa	36.0°C	21st	New High	35.7°C	1996	1978
Monthly Mean Minimum Temperature	Monasavu	20.0°C	-	New High	19.7°C	2003	1980

Note: All comparisons in this summary are with respect to "Climatic Normals". This is defined to be the average climate condition over a 30-year period. Fiji uses 1991-2020 period as its "climatic normal" period.

As a result of the higher-than-normal temperatures, over both land and sea, combined with above normal cloud cover and above normal sea level anomalies persistent across most parts of Fiji, there was an increase in flash flooding occurrences across some parts of Fiji. Continuous torrential rainfall led to flashfloods at low-level crossings in low lying areas within the Westen Division and led to the closure of several low-level crossings, essential businesses and even made some areas inaccessible for transportation[13]. There was a spike in areas that experienced water cuts and power failure due to continuous flooding[14]. For a visual representation of December 2024 flooding events, see Appendix A.

Such severe flooding events which have led to inundated houses have caused tens to hundred of fatalities in Pacific Island Countries (PICs)[15]. Although this may not appear to be large on an international scale, for countries like Fiji, they represent a major consequence when measured as a proportion of the national population and they have a pronounced impact on the communities and families directly affected.

Table 2: Estimated human and economic cost of past PIC flood events

Flood	Death toll	Damage and Loss	% GDP	Source
Northern Fiji Jan. 2003	16	F$105 million	Data not available	NDMO 2003; Yeo 2011
Central Fiji Apr. 2004	12	F$ 13 million (Navua only)	Data not available	Holland 2008; Yeo 2011
Western Fiji Jan 2009	7	F$440 million (government and private losses)	~7%	Holland 2009; Ambroz 2009; Yeo 2011
Western Fiji Jan 2012	8	F$41 million	Data not available	"Fiji Live" May 8, 2012, "March

[13] (Fiji Meteorological Services, 2024)
[14] (Fiji Meteorological Services, 2024)
[15] (Stephen Yeo, 2017)

				floods cost govt $90 million"; Kuleshov et al. 2014
Western Fiji Mar 2012	12	F$90 million (government only)	Data not available	"Fiji Live" May 8, 2012, "March floods cost govt $90 million". ; Fiji Times, April 7, 2012, "Loss and grief"

3.0 Literature Review

3.1 Disaster Management Arrangements

3.1.1 Global frameworks: Sendai Framework

At the global level, Fiji aligns its National Disaster Risk Reduction Policy (NDRRP) to the relevant frameworks: Sustainable Development Agenda 2015-2030; Sendai Framework for Disaster Risk Reduction (SFDRR) 2015-2030; Paris Agreement on Climate Change 2015; Small Island Developing States Accelerated Modalities of Action (S.A.M.O.A) Pathway 2014; Addis Ababa Accord 2015; Agenda for Humanity 2016; and Convention on the Elimination of All Forms of Discrimination against Women (CEDAW) 197916.

Although the Sendai Framework is a voluntary and non-binding agreement which recognizes the State as having the primary role to Disaster Risk Reduction (DRR). Given that DRR is a priority for Fiji, the Fiji Government, based on this direction, has made it a priority to take rapid and accurate measures to reduce disaster risks to ensure that the indicators of the Sendai Framework are achieved by the year 2030. Fiji reflects the priority actions of the SFDRR in its NDRRP to show areas where the two policies overlap.

3.1.2 Regional framework- Framework for Resilient Development in the Pacific

The Framework for Resilient Development in the Pacific (FRDP) was established in 2016, to help Pacific nations reduce their exposure to climate and disaster risks. A key component of the FRDP is the Pacific Resilience Partnership (PRP)- a network of stakeholders driving resilience efforts at national, sub-national, regional, and international levels[17].

Under the FRDP, Pacific Island Countries and Territories (PICTs)are required to integrate climate change and disaster resilience initiatives into their sustainable development strategies,

[16] (Government of Fiji, 2018)
[17] (Government of Fiji, 2018)

social development plans, sector policies, and resource mobilization efforts. Where possible, PICTs are encouraged to adopt integrated approaches for more effective implementation.

Additionally, the Pacific Framework for the Rights of Persons with Disabilities (2016-2025) outlines five key goals, with Goal 4 directly linking to the FRDP. This goal emphasizes the inclusion of persons with disabilities in Disaster Risk Reduction (DRR) strategies. By embedding inclusivity into DRR policies, this regional initiative marks a significant step toward more resilient disaster management in the Pacific.

3.1.3 National Disaster Management Approach

The National Development Plan (NDP) 2025-2029 and Vision 2050 prioritizes DRR to enhance the nation's resilience against natural hazards. The document emphasizes the need to integrate climate resilience and DRR measures into all aspects of development planning, including infrastructure, spatial, and sectoral strategies. The government has made commitments to enforce stricter compliance with relevant standards and codes, increasing investments in adaptation initiatives, and strengthening national capabilities for early detection of disasters.

A vital component of this approach is the development of a joint action plan for climate change and DRR by the National Disaster Risk Management Office (NDRMO), alongside the formulation of a Disaster Risk Financing Policy incorporating financial solutions. These efforts are directed at addressing critical gaps in early warning systems, broadband connectivity, and international funding for disaster management, thereby ensuring a comprehensive and proactive stance toward disaster resilience.

At the National level, Fiji's National Disaster Risk Management Act 2024 (NDRM) introduces new institutions and mandates to ensure that there is effective disaster risk governance across national and subnational levels. The NDRM Act delineates the roles and responsibilities of committee such as the National Risk Management Council, Disaster Risk Reduction Committee, and Emergency Committee (see Appendix B, p.13-16 for details).

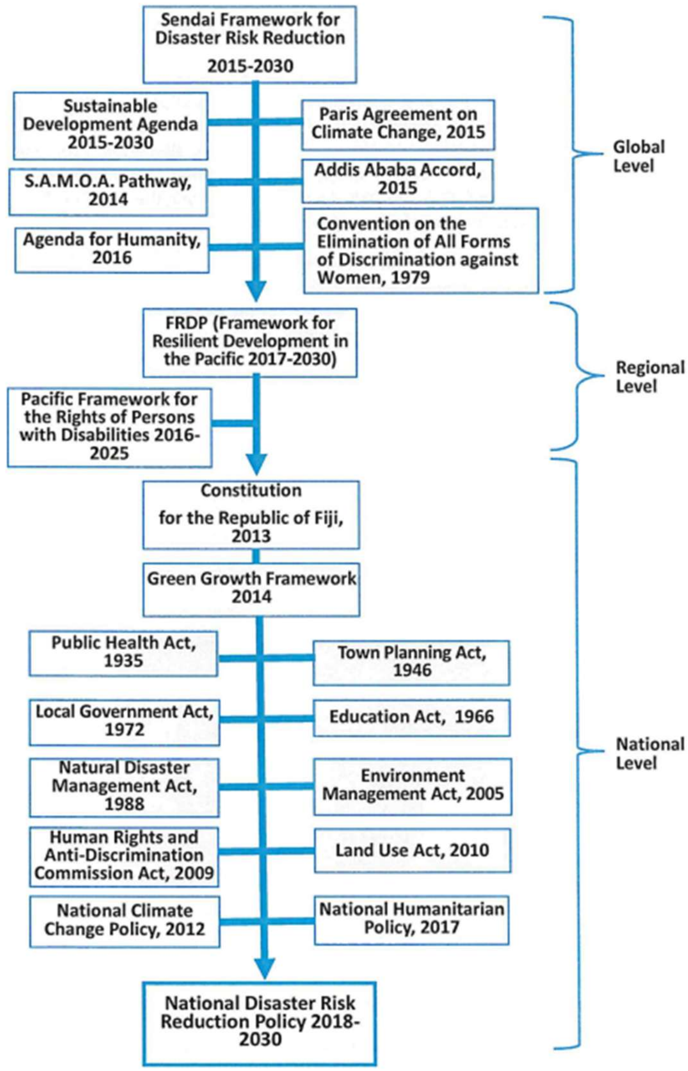

Figure 3:Formation Background of National Disaster Risk Reduction Policy 2018-2030[18]

3.2 Status of Flood Management Strategies

3.2.1 Flood Management Strategies in Fiji

Fiji has implemented a range of structural and non-structural measures to mitigate flood risks, particularly in vulnerable areas such as the Rewa and Nadi River basins. Assessments of these measures indicate varying degrees of effectiveness, highlighting achievements and areas for improvement.

Structural measures, including river dredging, seawalls, levees, and drainage systems, have played a significant role in managing floodwaters. The Nadi Flood Alleviation Project has

[18] (Government of Fiji, 2018)

focused on improving the Nadi River's flow capacity, thereby reducing the extent and severity of flooding[19]. Similarly, the Fiji Islands Flood Management Rewa River Basin Report [20] outlines how dredging and embankments have contributed to controlling floodwaters in the Rewa region.

However, while structural approaches have proven effective in reducing immediate flood impacts, they require regular maintenance and are often limited by financial constraints. Furthermore, they do not always account for extreme climate variability, leading to frequent failures during severe flood events.

On the other hand, non-structural measures have also been a critical part of Fiji's flood risk management strategy. The National Disaster Management Plan 1995 (NDMP)[21] emphasizes community-based preparedness, flood early warning systems, and land-use planning as key components of disaster risk reduction. These initiatives have improved early detection of flood risks and have allowed for better response strategies. The Integrated Flood Management in the Nadi River Basin proposal highlighted efforts in integrating watershed management with sustainable urban planning[22]. However, despite these advances, non-structural measures still face challenges related to data accuracy, public awareness, and policy enforcement.

Local-level flood risk management plans have historically incorporated GIS, remote sensing, and flood modelling, as seen in the Nadi Flood Alleviation Project[23] and the Rewa River Basin Report. More recently, flood early warning systems and forecasts issued by the Fiji Meteorological Service Centre have also integrated GIS mapping. However, these are at a broad scale, making it difficult to accurately determine the extent and location of potential inundation. This limitation affects the precision of public advisories and evacuation orders, as authorities cannot confidently specify which areas will be flooded, impacting both residents and travelers. The primary challenge stems from the lack of high-resolution digital elevation models and topographical data, which are crucial for more accurate flood predictions.

3.2.2 Flood Management Strategies in Japan

Japan has developed a comprehensive approach to flood management, integrating advanced engineering solutions, community participation, and long-term investment in disaster risk reduction (DRR). Given the country's vulnerability to typhoons, heavy rainfall, and river flooding, Japan has implemented extensive infrastructure projects, such as floodways and raised mounds, alongside community-led initiatives to mitigate risks.

One of the significant structural measures in Japan is the construction of floodways, which divert excess water from rivers to prevent overflow in populated areas. These large-scale projects, such as the excavation of floodways, often take decades to complete, demonstrating Japan's long-term commitment to flood prevention. Additionally, raised mounds are constructed by residents as a means of DRR, helping to elevate critical areas above flood levels. Other structural solutions

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[19] (Asian Development Bank, 2019)
[20] (Raj, 2010)
[21] (Government of Fiji, 1995)
[22] (The Land and Water Resource Management Division of the Ministry of Agriculture, 2004)
[23] (The Land and Water Resource Management Division of the Ministry of Agriculture, 2004)

include levees, dams, and underground flood storage tunnels, all designed to control water flow and minimize damage from heavy rainfall and typhoons.

Beyond physical infrastructure, Japan places great emphasis on non-structural measures to enhance community preparedness. Residents actively participate in flood management activities, contributing to initiatives such as early warning systems, evacuation drills, and public awareness campaigns. Education and training programs help communities understand flood risks and take proactive measures during emergencies. Moreover, Jaona's disaster risk management framework includes policies that regulate land use in flood-prone areas, ensuring urban development aligns with safety standards.

By integrating both structural and non-structural strategies, Japan has built a resilient flood management system that balances engineering solutions with community engagement and long-term planning. These efforts highlight the necessity of sustained investment in flood management, as seen in large-scale projects that can take decades to complete. By combining technological innovation with proactive local engagement, Japan continues to refine its flood resilience strategies to protect lives and property.

3.3 Gaps in Flood Management Practices in Fiji

Fiji, like many PICTs face significant flood risk due to tropical climate, heavy rainfall, and exposure to extreme weather events. While efforts have been made to implement flood management strategies, several gaps hinder effective flood risk reduction. Firstly, a major limitation in Fiji's flood risk management is the inadequacy of detailed or high-resolution flood modelling[24]. Previous application of Light Detection and Ranging (LiDAR) technology for two-dimensional (2D) flood modelling has provided some insights. However, there remains a strong justification for more precise and detailed flood hazard models. The lack of high-resolution data limits the accuracy of flood predictions and preparedness measures. The lack of high-resolution data limits the accuracy of flood predictions and preparedness measures, making it difficult for authorities to design effective mitigation strategies.

Another critical gap in Fiji's flood management is the need for improvements in early warning (EW) systems. The current EW mechanisms lack the necessary precision and coverage to ensure timely alerts for all vulnerable communities[25]. In addition, existing structural measures for flood management in Fiji require significant enhancement. While some flood control infrastructure is in place, there is a notable lack of local-level structural interventions tailored to specific community needs. The absence of adequately designed drainage systems, flood barriers, and retention basins increases flood impacts, especially in urban areas.

Flood hotspot mapping remains an area of weakness in Fiji's flood management framework[26]. The identification and monitoring of flood-prone zones are critical for targeted mitigation efforts.

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[24] (Stephen Yeo, 2017)
[25] (Stephen Yeo, 2017)
[26] (Stephen Yeo, 2017)

However, existing mapping efforts are insufficient, leading to a lack of clarity on the most vulnerable areas.

Fiji's flood management system has made progress, but significant gaps remain in flood modelling, early warning systems, structural measures, and hotspot mapping. Addressing these issues requires investments in high-resolution flood modelling, enhanced early warning mechanisms, improved structural interventions, and comprehensive flood hotspot mapping. By closing these gaps, Fiji can build a more resilient flood management system and better protect its communities from the increasing threats of climate change and extreme weather events.

4.0 Results and Discussion

Fiji's flood management strategies have made notable strides, but challenges remain in both structural and non-structural measures. Structural interventions such as river dredging, seawalls, levees, and drainage systems have proven effective in mitigating immediate flood impacts. Projects like the Nadi Flood Alleviation Project and the Rewa River Basin flood control efforts have demonstrated success in managing water flow and reducing flood severity. However, the sustainability of these measures is threatened by the need for continuous maintenance and the constraints of limited financial resources. Furthermore, structural solutions do not always account for extreme climate variability, resulting in frequent failures during severe flood events.

Non-structural measures, including community-based preparedness, flood early warning systems, and land-use planning, have played a crucial role in improving flood risk management. These measures have enhanced early flood detection, allowing for better response strategies. However, gaps exist in areas such as data accuracy, public awareness, and policy enforcement, limiting the full potential of these initiatives. Despite the integration of GIS, remote sensing, and flood modelling in local-level management plans, the lack of high-resolution flood hazard models remains a significant challenge. The absence of detailed and accurate data limits the effectiveness of flood predictions, hindering authorities' ability to design targeted mitigation strategies.

One of the major gaps identified in Fiji's flood management is the inadequacy of early warning systems. Current mechanisms lack precision and comprehensive coverage, leading to delays in issuing alerts to vulnerable communities. Additionally, while Fiji has implemented several structural flood control measures, there is a clear need for localized interventions tailored to specific community needs. The absence of well-designed drainage systems, flood barriers, and retention basins in urban areas exacerbates flood impacts, highlighting the need for enhanced infrastructure.

Another critical area for improvement is flood hotspot mapping. Existing efforts to identify and monitor flood-prone zones are insufficient, limiting the ability to focus mitigation efforts on the most vulnerable areas. These gaps in flood modelling, early warning systems, structural measures, and hotspot mapping call for urgent attention and investment. Closing these gaos through improved data, enhanced systems, and targeted infrastructure development will significantly bolster Fiji's flood resilience and better protect communities from the growing risks posed by climate change and extreme weather events.

5.0 Conclusion and Recommendations

5.1 Summary of findings

5.1.1 Flood Management Lessons from Field Visits

As a Visiting Researcher from Fiji participating in the Asia Disaster Reduction Center's (ADRC) Visiting Researchers Program, participants had the opportunity to participate in various filed visits across Japan to observe and learn about the country's disaster risk reduction measures. Flood management was one of the key areas of focus, given Fiji's vulnerability to frequent flooding due to tropical cyclones and heavy rainfall. The visits to flood-prone regions and disaster management institutions provided valuable insights into Japan's proactive approach to flood mitigation, early warning systems, and community engagement.

5.1.1.1 Structural Flood Management Measures

Japan also places great emphasis on non-structural flood management techniques. Japan divided its Disaster Management Plan into two categories, namely short-term and long-term plans. As part of its long-term plan, Japan, has prioritized the safety of towns and cities by widening roads and widening of streams. In addition, Japan has over the course of 3 decades, completed 90% of school building retrofitting.

Japan has implemented innovative flood control infrastructure, including floodgates, underground reservoirs, and drainage channels, to mitigate urban flooding. The visit to Kusaka River Discharge Channel in Shikoku showcased how diversion channels and levees can effectively redirect floodwaters away from populated areas. Another notable example is the Osaka Floodgate System, which automatically close river inlets to prevent overflow into residential areas. In urban centers, like Tokyo, underground flood reservoirs help to absorb excess water during heavy rainfall events, reducing surface flooding.

Figure 4: Kusaka River Discharge Channel, Shikoku

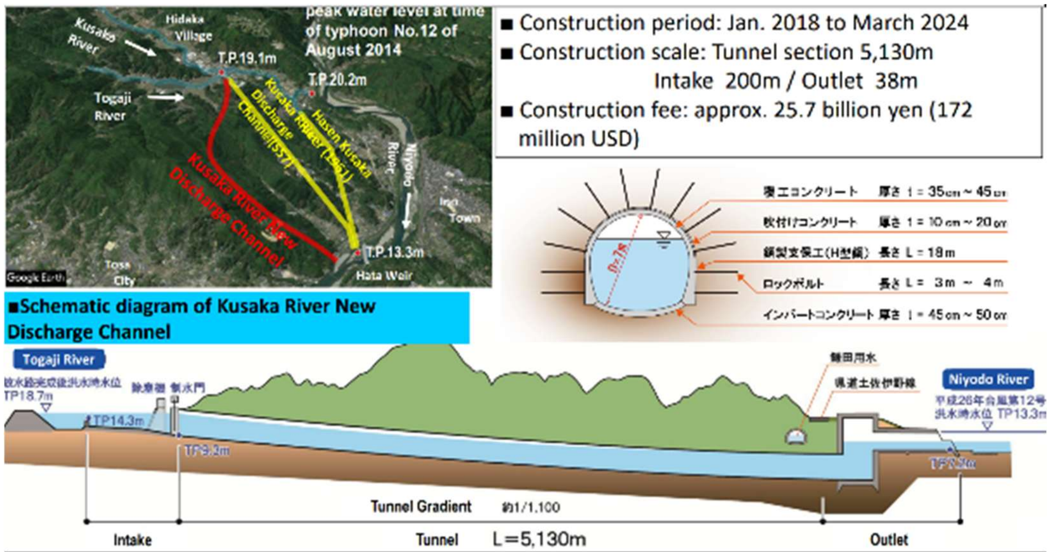

Figure 5: Schematic diagram of Kusaka River (New) Discharge Channel, Shikoku

5.1.1.2 Non-Structural Flood Mitigation Measures

Japan has a structured flood risk management policy, integrating flood mitigation into national and local disaster response frameworks. The visit to Japan's Cabinet Office highlighted how flood preparedness is deeply embedded in urban planning, land use policies, and building regulations. For instance, zoning laws prevent residential development in high-risk flood zones, while municipalities are required to maintain update hazard maps. Additionally, pre-disaster recovery planning is a core component of Japan's disaster resilience strategy, ensuring that reconstruction efforts prioritize climate and hazard resilient infrastructure.

Japan has integrated advanced technology into flood management, including GIS mapping, AI-driven flood models, and drone-assisted damage assessment. During the visit to Gaia Vision, it was revealed how satellite data, machine learning, and hydrodynamic modelling are used to forecast floods with high accuracy. Their technology also calculates flood damage costs using real-time data, allowing authorities to allocate resources efficiently during recovery. Additionally, the Asia Air Survey (AAS) visit demonstrated how drones and satellite imagery assess flood damage quickly, helping response teams prioritize affected areas.

On the same note, the Kusaka River Special Emergency Project is a large-scale flood management initiative in the Niyodo River Basin, Japan. The project includes the construction of the Kusaka River New Discharge Channel, a 5,368-meter-long tunnel designed to mitigate flood risks, particularly in Hidaka Village, Kochi Prefecture, which has a history of severe flooding. More specifically, the use of GIS, remote sensing, and mapping technologies in various aspects of the project helped analyze historical flood data, identify high-risk areas. Remote sensing also contributed to the monitoring of rainfall patterns and assess water flow. In addition, detailed basin and topographic map were also used to study the elevation differences between upstream and downstream areas, which were key contributors to the region's flooding issues. The application of these technologies significantly enhanced the planning and execution of the project, allowing for a more data-driven approach.

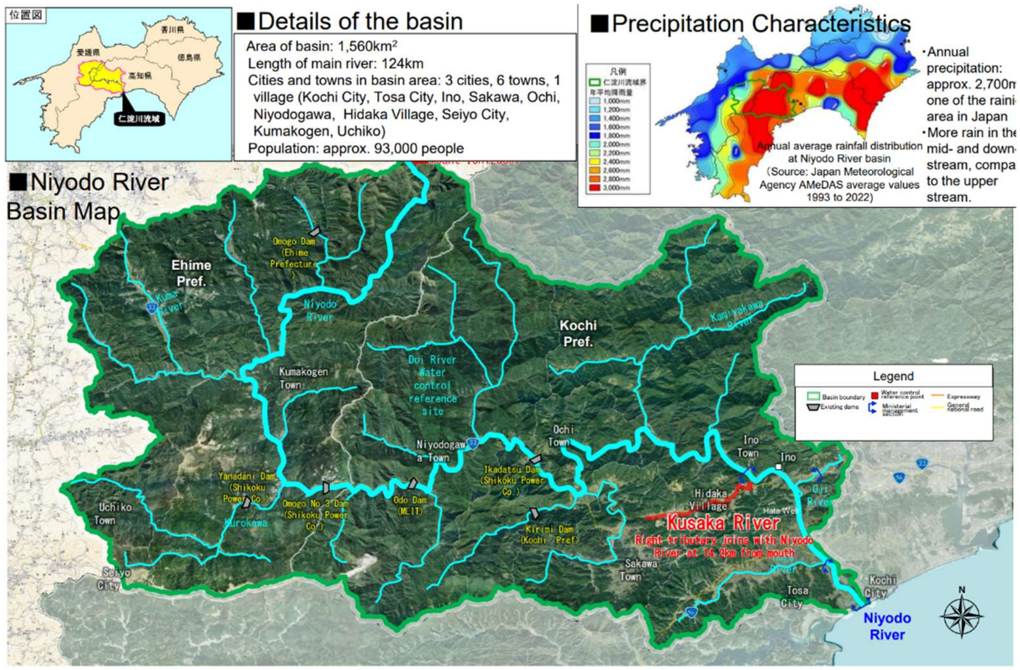

Figure 6: Application of GIS and mapping for the Kusaka River Discharge Channel Project

The Japanese government, through its prefectural, municipal, and local offices, appoints three members from at-risk communities to receive training in evacuation procedures and emergency drills. These members are then responsible for conducting drills and evacuation within their respective communities. These appointed members are primarily elders, and retired individuals, and their participation is entirely voluntary. This initiative reflects the dedication and commitment of community members to safeguarding one another.

Similarly, at the municipal and local level, Japan through town watching and GIS mapping created hazard maps. Through town watching activities, local office and members of communities work together to contribute to identifying potential hazard and risk within their community. Such a method for data collection is inclusive, in that it recognizes the input of local members in identifying risk and mapping out of potential evacuation routes. The information gathered, are then mapped using GIS. The end-product (hazard map) are then distributed to each household, for their awareness and information.

On the same note, the Kobe City in Japan, has effectively utilized a GIS platform to provide comprehensive disaster risk information, enhancing resilience and informed decision-making. The platform, accessible online, contributes to informed decision-making. The platform integrated hazard maps, historical disaster data, and real-time monitoring to assess risks such as earthquakes, tsunamis, and landslides[27]. By overlaying infrastructure, population density, and

[27] (Kobe City, 2025)

hazard-prone zones, the GIS tool aids in urban planning and land use management, ensuring that development aligns with safety considerations. This system supports local authorities, businesses, and residents in understanding vulnerabilities and making data-driven decisions to mitigate disaster impacts, ultimately contributing to a safer and more sustainable urban environment.

Figure 7: Kobe City Information Map.

Similarly, the Japanese government and prefectural authorities prioritize the development of engaging educational tools to enhance public understanding of Disaster Risk Reduction (DRR). These tools often take the form of carnivals, community-based disaster prevention activities, and town-watching initiatives. During my tenure in ADRC's VR program, I had the opportunity to participate in such initiatives, gaining insight into how different age groups engage with DRR information, prevention, and preparedness. See Appendix D for more details.

Moreover, prefectural and local municipalities in Japan recognize the importance of investing in corporate and household safety. This is reflected in new lending mechanisms and subsidies for seismic evaluation and retrofitting. Additionally, the Japanese government actively promotes school-based disaster education for both teachers and students. Currently, DRR is integrated as a chapter within the existing curriculum, but the long-term vision is to establish it as a standalone subject in middle and high schools across Japan.

One of the key takeaways from Japan's flood management strategy is its multi-layered Early Warning System (EWS), which combines real-time river monitoring, automated alerts, and satellite data to provide timely flood warnings. The field visit to Togagawa River highlighted how sensors, rain gauges, and water level indicators are installed along riverbanks to detect rising water levels. These data points are fed into a central database, allowing authorities to issue public alerts, via mobile notifications, sirens, and media broadcasts. In some regions, AI driven forecasting models help predict potential flooding days in advance, allowing for proactive.

5.1.1.3 Community- Based Flood Management

Japan places strong emphasis on community involvement in flood preparedness, response, and recovery. The visit to the Kobe City Fire Department introduced the Bokomi model- a community- based disaster risk reduction group run by volunteers. These groups are trained in evacuation procedures, fist aid, and disaster response coordination, acting as the first line of defense before government responders arrive. In some areas, local communities develop their own hazard maps, identifying flood-prone zones and designing evacuation routes with minimal government supervision.

5.2 Conclusion

Fiji has made progress in flood risk management through structural and non-structural measures, but key challenges persist. The lack of high-resolution flood modelling, limitations in early warning dissemination, and funding constraints for large-scale infrastructure projects continue to hinder effective flood risk reduction. Comparative insights from Japan's flood management strategies highlight the benefits of integrating advanced geospatial technologies, real-time monitoring, and community-based disaster preparedness.

Addressing these gaps requires targeted investments in high-resolution topographical data, improved flood forecasting models, and enhanced early warning systems. Cost-effective structural interventions, such as better drainage systems, flood retention basins, and flood-resilient infrastructure, can further mitigate flood risks. Strengthening local-level hazard mapping, enforcing with flood zoning regulations, and leveraging public-private partnerships for disaster financing will also improve long-term resilience. By adopting a multi-faceted approach that balances technology, policy, and community engagement, Fiji can significantly enhance its flood management capabilities and better protect vulnerable communities from future flood events.

5.3 Recommendations

Japan's flood risk management practices offer valuable lessons for Fiji, particularly in integrating structural, non-structural, and technological measures to enhance resilience.

5.3.1 Structural measures

Japan has heavily invested in flood levees, embankments, and underground flood ways which help divert excess water and protect urban areas. Large-scale engineering projects like Tokyo's underground flood control system showcase the effectiveness of long-term infrastructure planning. In contrast, Fiji's flood management infrastructure is more limited, with drainage systems and embankments often struggling to handle extreme rainfall. Given Fiji's smaller economy, large-scale infrastructure projects like Japan's may not be financially feasible. However, Fiji can prioritize more cost-effective solutions such as upgrading urban drainage systems, constructing retention basins, and reinforcing embankments in high-risk areas. Additionally, adopting Japan's approach of elevated infrastructure can help protect homes, business, and essential services in flood-prone areas. Financing these initiatives can be achieved through a mix of government funding, public-private partnerships, and international development assistance from organizations such as the Asian Development Bank (ADB), THE World Bank, and climate finance mechanisms like the Green Climate Fund (GCF).

5.3.2 Non-structural measures

Beyond physical infrastructure, Fiji can also adapt Japan's non-structural and technological approaches to flood management in ways that align with its local context and financial capacity. Japan's strict land-use policies, which restrict development in flood-prone zones, can be adapted to Fiji through stronger zoning regulations and incentives for flood-resilient construction. Fiji's early warning systems, while improving, could benefit from additional investment in real-time flood monitoring using affordable smart sensors and community-based warning networks. Japan's use of AI and GIS mapping for flood forecasting is a valuable model, but Fiji can focus on simpler, cost-effective digital solutions, such as mobile-based flood alerts and community radio broadcasts. Localizing flood management efforts also means engaging traditional landowners, local councils, and disaster response agencies in a collaborative approach that blends modern technology with indigenous knowledge, such as using natural buffers like mangroves and wetlands for flood mitigation. To finance these measures, Fiji can seek funding through regional climate adaptation programs, disaster risk reduction grants, and innovative financing models, such as parametric insurance schemes that provide rapid financial support after flood events. By tailoring Japan's successful flood management strategies to its own economic and environmental realities, Fiji can develop a sustainable and adaptative system that protects communities while also being financially viable

5.3.3 Technological Measures/ Flood Early Warning

Additionally, technologies developed by companies like Gaia Vision and Asia Air Survey, who utilize machine learning and global flood hazard maps for real-time monitoring and prediction of flood events, could provide valuable insights for flood forecasting in Fiji. Implementing these types of measures could significantly improve Fiji's capacity to manage and mitigate flood risks effectively. While solutions developed by Gaia Vision and Asia Air Survey are worthwhile, there is a need for high resolution topographic data and river network data for Fiji, to ensure that flood prediction and simulation are as accurate as possible. Learning from Japan's Kusaka River Special Emergency Project, a similar approach could be beneficial for Fiji. Implementing GIS, remote sensing, and mapping technologies can help identify flood-prone areas, assess rainfall patterns, and monitor river systems more effectively. By utilizing detailed topographic and basin maps, Fiji can potentially develop better flood mitigation strategies. Although the acquisition of high-resolution data is considered to be a costly exercise, such data procurement will be beneficial for the long-term and sets the foundation for future modelling and machine learning opportunities.

6.0 References

Asian Development Bank. (2019). *Nadi Flood Alleviation Project- Early Warning System.* Suva: ADB.

Fiji Broadcasting News. (2024, December 26). Retrieved from FBC News: https://www.fbcnews.com.fj/news/floods-force-200-into-evacuation/

Fiji Meteorological Services. (2024, December Wednesday). *Fiji Meteorological Services.* Retrieved 2025, from Fiji Meteorological Services: https://www.met.gov.fj/aifs_prods/Climate_Products/December%202024climateSum2025.01.08%2015.09.29.pdf

Fiji Meteorological Services. (2025). *Fiji Climate Summary January 2025.* Nadi.

Government of Fiji. (1995). *National Disaster Management Plan.* Suva: National Disaster Management Office.

Government of Fiji. (2018). *National Disaster Risk Reduction Policy 2018-2030.* Suva: Ministry of Disaster Management and Meteorological Services.

Green Climate Fund. (2024). *Projects & Programmes FP 258: Multi-country Project Early Warning for All (EW4LL)*. Retrieved from GCF: https://www.greenclimate.fund/project/fp258

Kobe City. (2025). *Kobe City Information Map.* Kobe: Kobe City.

Raj, R. (2010). *Fiji Islands Flood Management- Rewa River Basin Report.* Suva: Global Water Partnership.

Stephen Yeo, S. E.-G. (2017). *Urban Flood Risk Management in the Pacific: Tracking Progress and Setting Priorities.* Urban Floods Community of Practice.

The Land and Water Resource Management Division of the Ministry of Agriculture. (2004). *Integrated Flood Management in the Nadi River Basin.* Nadi: Economic and SOcial Commission of Asia and the Pacific.

The World Bank Group. (2021). *Climate Risk Country Profile: Fiji.* Washington DC: The World Bank Group.

7.0 Appendices

Include tables, graphs and pictures from literature review.

7.1 Appendix A

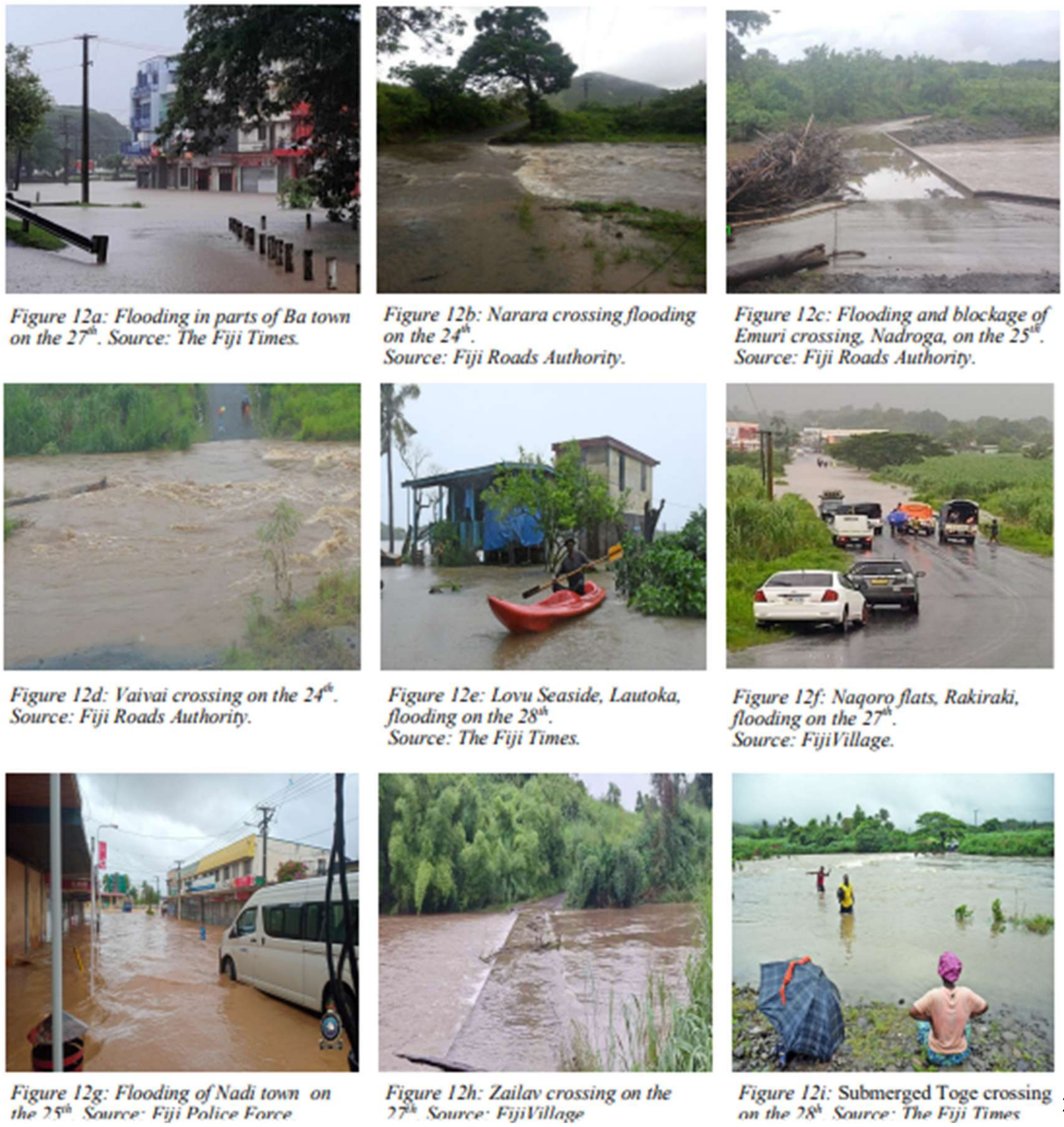

Figure 12a: Flooding in parts of Ba town on the 27th. Source: The Fiji Times.

Figure 12b: Narara crossing flooding on the 24th. Source: Fiji Roads Authority.

Figure 12c: Flooding and blockage of Emuri crossing, Nadroga, on the 25th. Source: Fiji Roads Authority.

Figure 12d: Vaivai crossing on the 24th. Source: Fiji Roads Authority.

Figure 12e: Lovu Seaside, Lautoka, flooding on the 28th. Source: The Fiji Times.

Figure 12f: Naqoro flats, Rakiraki, flooding on the 27th. Source: FijiVillage.

Figure 12g: Flooding of Nadi town on the 25th. Source: Fiji Police Force.

Figure 12h: Zailav crossing on the 27th. Source: FijiVillage.

Figure 12i: Submerged Toge crossing on the 28th. Source: The Fiji Times. [28]

7.2 Appendix B

VR_Fiji_Country Report_Lita Uaniceva.pdf

[28] (Fiji Meteorological Services, 2024)

7.3 Appendix C

FEWS_Training Material_2024.pdf

7.3 Appendix D

 *Figure 8: First Aid demonstration during the Great Hanshin Awaji Earthquake-Public Awareness Event (17/01/2025)*	 *Figure 9:DRR Learning Center- Osaka. Pictured is a simulated exercise of putting out fires using fire extinguishers.*	 *Figure 10: Takashio Tsunami Station, Osaka. Pictured (in blue) is the lecturer who highlighted some of the innovative structural DRR measures implemented in Osaka.*

Figure 11: Itami City Disaster Management Event (25/01/2025)- pictured is a cardboard bed/bench, with tents in the background. These are some of the things that one can expect to find at an evacuation center

Figure 12: Simulated earthquake disaster. This session was part of the Itami City Disaster Prevention Event (25/01/2025). The public had the opportunity to observe some of the pre-arranged response mechanisms for an earthquake disaster.

Figure 13: Iza Mikaeru Public Awareness Event (26/01/2025)- Pictured is one of the many exercises of the today, which involved the use of newspaper to design eating bowls that can be used at evacuation centers.

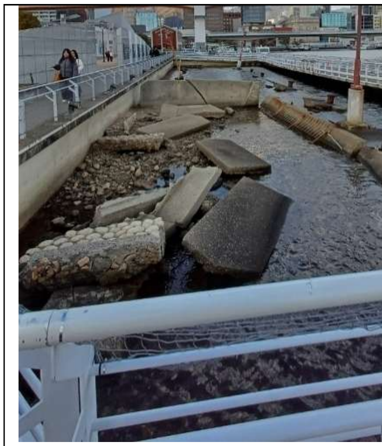

Figure 14: Kobe Port Earthquake Memorial

Figure 15: Great Hanshin Awaji Earthquake (GHA Earthquake) Memorial Museum (29/01/2025)

Figure 16: Pictured is Akiko Nakamura, highlighting some of the early warning messages installed at the Togagawa River

Figure 17: Great Hanshin Expressway Research Institute for Technology (05/02/2025)- the institute houses selected remnants from the GHA Earthquake. The institute sets remnants against retrofitted designs, to show improvements made in the design for retrofitting

Figure 18: Global Bosai Youth- presentation by representatives from the Global Bosai Youth

Figure 19: Tokyo Rinkai Disaster Prevention Park- Pictured are one of the many exhibits at the Tokyo Rinkai Disaster Prevention Park. The pictured exhibit is display of items that can be included in as part of an emergency kit

Figure 20: Pictured is a portable facility for a debris flow simulator at the Shikoku Regional Development Office