

Republic of Fiji

The Project for Mainstreaming Disaster Risk Reduction (Second Period)

Project Completion Report (Annex)

1. Project Completion Report
 - 1.1. Work Plan
Omitted (Already submitted).
 - 1.2. Monitoring Sheets
 - 1.3. Brief notes
2. Technical Cooperation Materials Produced by the Project
 - 2.1. Guidelines on Hazard and Risk Assessments
 - 2.2. Nationwide Expansion Plan of Hazard and Risk Assessments
 - 2.3. Guideline for Division Disaster Risk Reduction Plan
 - 2.4. Implementation Plan for the Nation Wide Rollout of Local Disaster Risk Reduction Plans
 - 2.5. Roadmap for National Disaster Risk Reduction Plan Implementation
 - 2.6. National Annual Report on Disaster Risk Reduction (DRR Annual Report for Fiji)
 - 2.7. Guidelines for Preparing National Annual Report on Disaster Risk Reduction
 - 2.8. Materials for disseminating project outcomes at international conferences
 - 2.9. Central Division Disaster Risk Reduction Plan
 - 2.10. Priority Area Plan
3. Monthly Reports
Omitted (Already submitted).
4. Other Materials
 - 4.1. Project Design Matrix
 - 4.2. Meeting Minutes of the Joint Coordination Conferences

End

TO CR of JICA FIJI OFFICE

Project Monitoring Sheet

Project Title: the Project for Mainstreaming Disaster Risk Reduction (2nd Period)

Version of the Sheet: Ver. 1.0 (Term: August 2024 – February 2025)

Name: Napolioni Boseiwaqa

Title: Acting Director of National
Disaster Risk Management Office

Name: Yoshihiko Uchikura

Title: Team Leader / DRR Governance

Submission Date: February 28, 2025

I. Summary

1. Progress

1.1 Progress of Inputs

(1) Dispatch of Japanese Experts

The following Japanese Experts were dispatched during the monitoring period (From August 2024 to February 2025).

Table 1 Dispatch of Japanese Experts in the 2nd Period of the Project

Assignment	Name	Period of Assignment
Leader/ DRR Governance	Yoshihiko UCHIKURA	Sep. 21 – Sep. 27, 2024 Nov. 20 – Nov. 30, 2024 Feb. 12 – Feb. 22, 2025
DRR Activity Management 1	Koji SUZUKI	Sep. 14 – Oct. 01, 2024 Nov. 9 – Nov. 23, 2024 Feb. 22 – Mar. 15, 2025
Deputy Team Leader / Local DRR Planning	Masaaki CHIDA	Sep. 14 – Sep. 27, 2024 Nov. 16 – Nov. 30, 2024 Feb. 8 – Feb. 18, 2025
Disaster Risk Assessment 1	Tomohiro UMEKI	Nov. 11 – Nov. 25, 2024 Dec. 7 – Dec. 21, 2024 Feb. 9 – Feb. 28, 2025
Disaster Risk Assessment 2 (Coastal Disaster / Climate Change)	Daiki TSUJIO	Nov. 10 – Nov. 20, 2024 Jan. 27 – Feb. 8, 2025
DRR Information Management / Inter-institutional Coordination Capacity Enhancement	Takuya ITO	Sep. 14 – Sep. 27, 2024 Nov. 16 – Nov. 30, 2024 Jan. 26 – Feb. 15, 2025
Earthquake Disaster	Koichi HASEGAWA	Sep. 14 – Sep. 27, 2024
DRR Activity Management 2	Ai SHIGEMATSU	Sep. 14 – Sep. 27, 2024 Nov. 16 – Nov. 27, 2024 Feb. 15 – Mar. 8, 2025

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Project Coordination / Capacity Development	Ryoya KYUZAKI	Nov. 9 – Nov. 30, 2024 Jan. 22 – Feb. 5, 2025
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(2) Assignment of Counterparts

From the Fijian Side, the Project Director and the Project Manager are as follows.

(a) Project Director: Ratu Isoa Talemaibua, Permanent Secretary (PS) for Rural and Maritime Development and Disaster Management (MRMDDM)

(b) Project Manager: Vasiti Soko, Director of National Disaster Management Office (NDMO) (Director for Disaster Management (DDM)) (since December 2020 to September 2024), Napolioni Boseiwaqa, Acting Director of National Disaster Risk Management Office (NDRMO) (DDM) (since October 2024)

NDMO provides leaders and members from its officials to each Working Group (WG).

In addition, resulting from the First Joint Coordination Committee (JCC) meeting held on May 18, 2022, the following organizations were identified as WG members. In the Second JCC meeting held on June 2, 2023, names of the member agencies were updated. In the Kick-off Meeting for the 2nd Period of the Project, members from the Japanese side were updated.

Proposed revisions as of September 2024

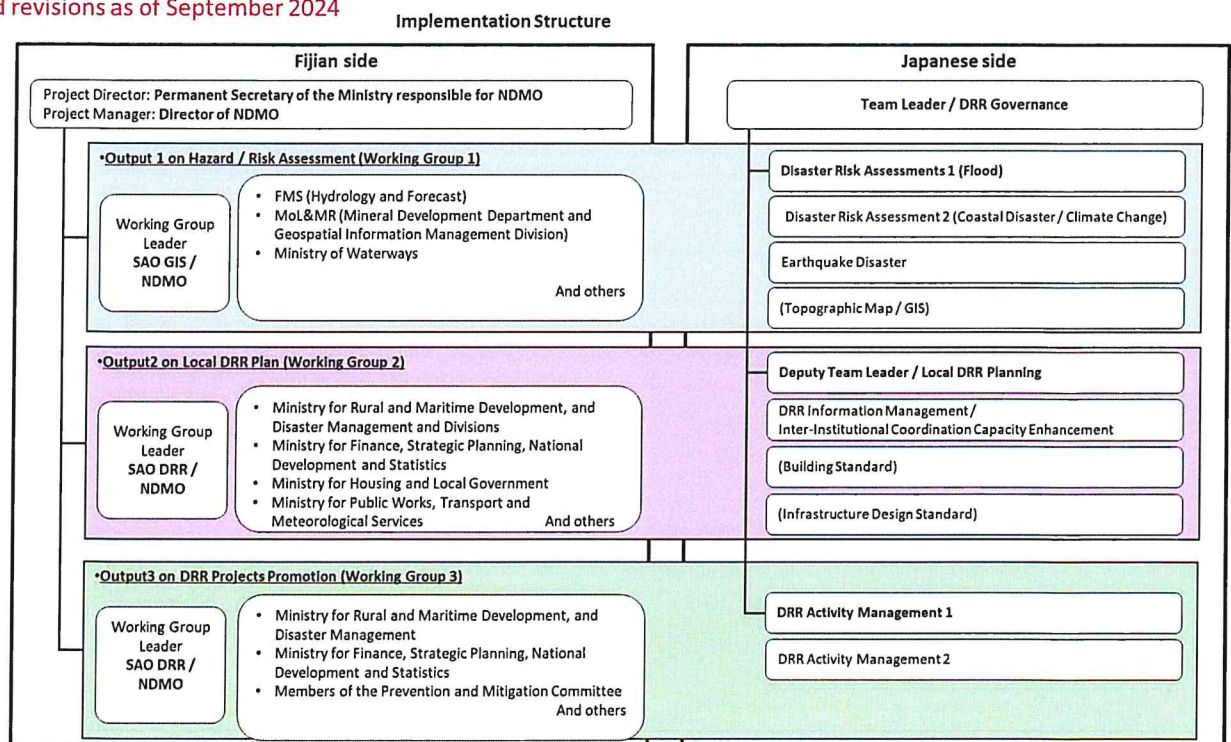


Fig. 1 Implementation Structure

1.2 Progress of Activities

(1) Overall Project

[Common/Task-1] Conduct Joint Coordination Committee (JCC) Meetings and prepare Progress Report

Kick-off, JCC and progress meetings were held during the monitoring period.

Table 2 Outlines of JCC Meetings in the 2nd Period of the Project

Title	Date	Agenda	Participants
Kick-off Meeting	Sep. 23, 2024	- Progress in the First Period - Work Plan in the Second Period - Invitation Programme in Japan - Discussion	14 participants - NDRMO - JICA Fiji Office - JICA Expert Team
Third Progress Meeting	Feb 20, 2025	- Overall Project Progress - Progress of Each Output - Report of Study Tour in Japan - Introduction of Nadi River Flood Management MP - Discussion	23 participants - MoFA - MFSPNDS - MTCA - MHMS - Min. of Education - MPWMST - MLMR - MHLG - MWCPA - Min. iTaukei - EFL - WAF - FRA - MRMDDM - NDRMO - JICA Tokyo HQs - JICA Fiji Office - JICA Expert Team

[Overall/Task-5] Preparation and discussion on the Work Plan (Japanese Version)

The Work Plan (Japanese Version) was prepared by Japanese Expert Team and explained by JICA HQ.

[Overall/Task-6] Preparation and discussion on the Work Plan

The Work Plan (English Version) was discussed in the Kick-off meeting and finalized.

[Overall/Task-7] Conduct of an end-line survey to assess the project achievements

The task will be conducted in the coming day in the Project.

[Overall/Task-8] Conduct of invitation program in Japan

A delegation programme was conducted in October 2024 for 6 higher officials from C/P agencies. Details were mentioned in 1.2 (5).

(2) Output 1

[Output1/Task3]: Conduct hazard assessments of targeted disasters at pilot areas (PDM Activity 1-3)

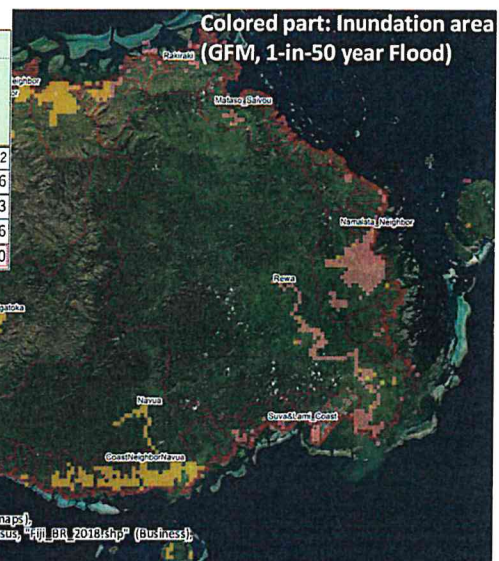
Preliminary assessments for the Central Division to select a priority area were conducted. Enhanced assessments of coastal disaster and earthquake were conducted based on the guidelines developed.

Validation of the assessment results with the past disaster records, actual status of the site and so on is essential, therefore compiling the actual inundation records were discussed with the NDRMO and the FMS, and the on-site validation survey for sediment disaster was conducted with the MRD.

Inundation area, affected household & population and infrastructures based on the Global Flood Map (GFM, 1-in-50 year Flood)¹⁾

Basin	Assumed			
	Inundation Area ²⁾ (km ²)	Affected Household ³⁾	Affected Population ³⁾	Affected Business ³⁾
Navua	44.7	1,484	6,599	122
Coastal Neighbor Navua	92.7	1,420	6,285	56
Rewa	99.3	4,678	21,732	433
Namalata Neighbor	116.5	1,463	6,873	76
Suva & Lami Coast	22.0	4,378	18,885	1,350

Basin	Actual Damage		
	Frequency of Flood damage ⁴⁾	Year ⁴⁾	Damaged infrastructures in GFM inundation area ⁴⁾
Navua	1	2016	10
Coastal Neighbor Navua	1	2012	6
Rewa	3	2012/Jan&Mar, 2016	10
Namalata Neighbor	-	Unknown	4
Suva & Lami Coast	-	Unknown	2



1) inunriver_historical_00000000WATCH_1980_r00050.tif, (source: <https://www.wrri.org/data/aqueduct/flood-hazard-maps/>)
2) Difference of inundation depth is not considered, 3) Based on the 2017 Census (Household & Population) & the 2018 Census, "Fiji BR 2018.ksh" (Business),
4) Based on the "Infrastructures Affected by Flood" prepared by NDRMO.

No.	Division	District	Affected Population (<10m)			Affected Households(<10m)		
			<1km	1-3 km	>3 km	<1km	1-3 km	>3 km
1	CENTRAL	Suva	21,619	2,688	24,307	4,543	559	5,102
2	CENTRAL	Naitasiri	7,224	3,973	11,197	1,559	812	2,371
3	CENTRAL	Deuba	4,694	2,849	7,543	1,025	644	1,669
4	CENTRAL	Nakelo	2,356	902	3,258	450	174	624
5	CENTRAL	Batiwai	1,788	3	1,791	360	1	361
6	CENTRAL	Noco	1,669	-	1,669	322	-	322
7	CENTRAL	Serua	1,602	635	2,237	326	126	452
8	CENTRAL	Bau	1,555	9	1,564	317	2	319
9	CENTRAL	Veivatu	1,484	693	2,177	280	145	425
10	CENTRAL	Namena	1,177	14	1,191	252	5	257



Affected Population

Fig. 2 Preliminary Assessment for the Central Division (Flood and Coastal Disaster)

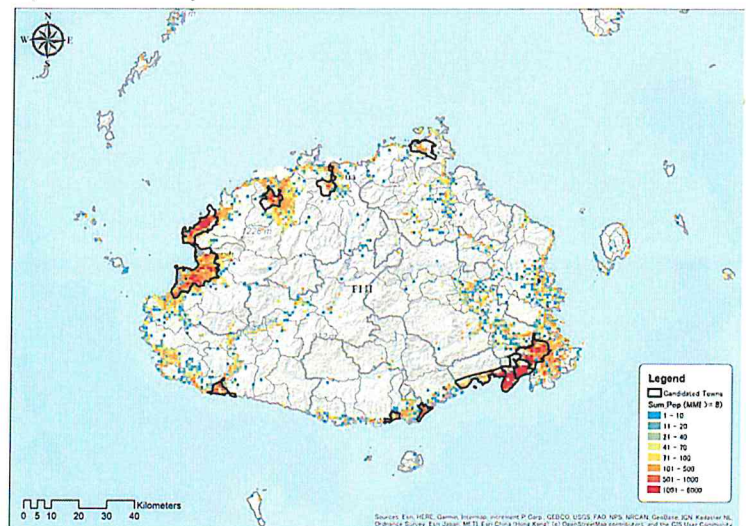
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Population Exposure to PGA ≥ 150 (MMI $\geq$ VIII)

OBJECTID	Name	Population Exposure to Probabilistic PGA
1	Rakiraki Town Area	5,280
2	Ba Town Area	15,280
3	Lautoka Town Area	68,244
4	Tavua Town Area	7,784
5	Sigatoka Town Area	9,745
6	Nadi Town Area	68,405
7	Pacific Harbour	1,919
8	Korovou	
9	Lami	19,332
10	Nasinu	85,945
11	Nausori	60,155
12	Navua	5,111
13	Suva	91,272



The result will be a basic
information to select Priority Areas



Population Exposure and Priority Area Location

Fig. 3 Preliminary Assessment for Central Division (Earthquake)

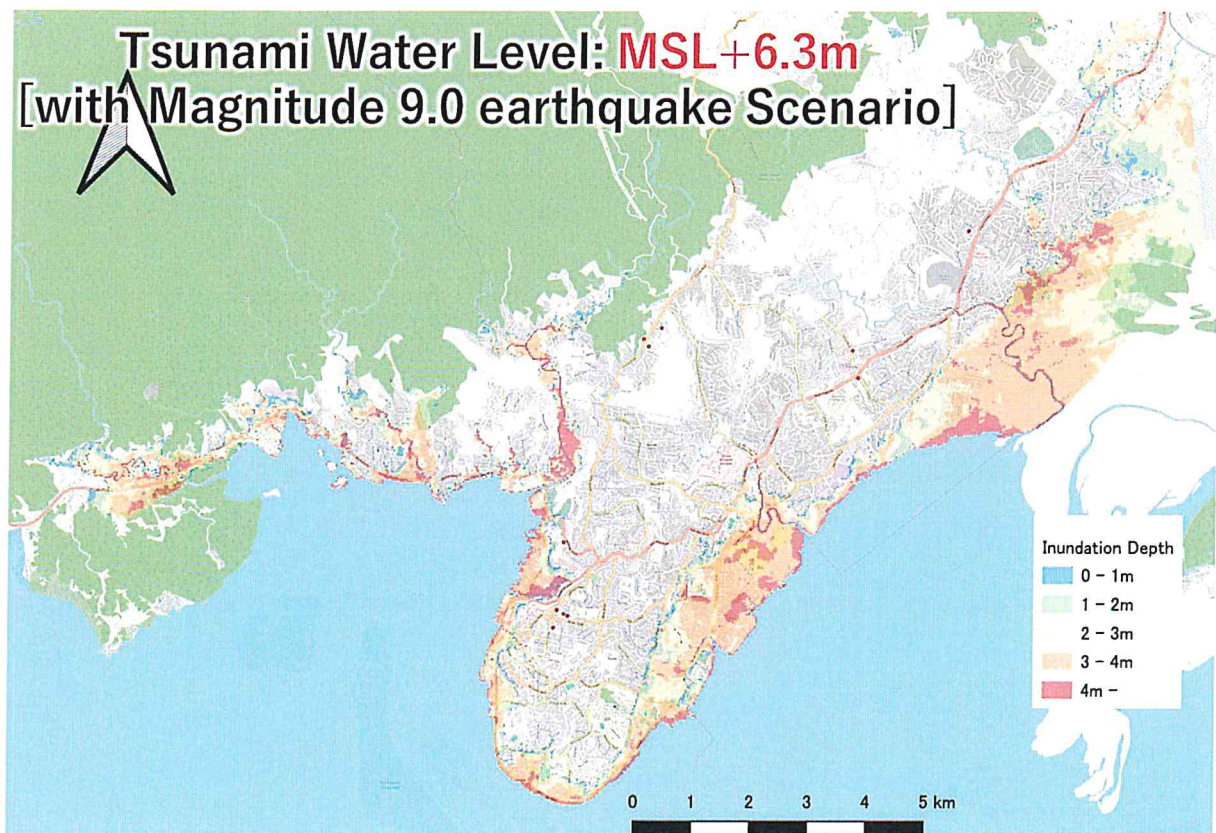


Fig. 4 Enhanced Assessment for the Central Division (Tsunami)

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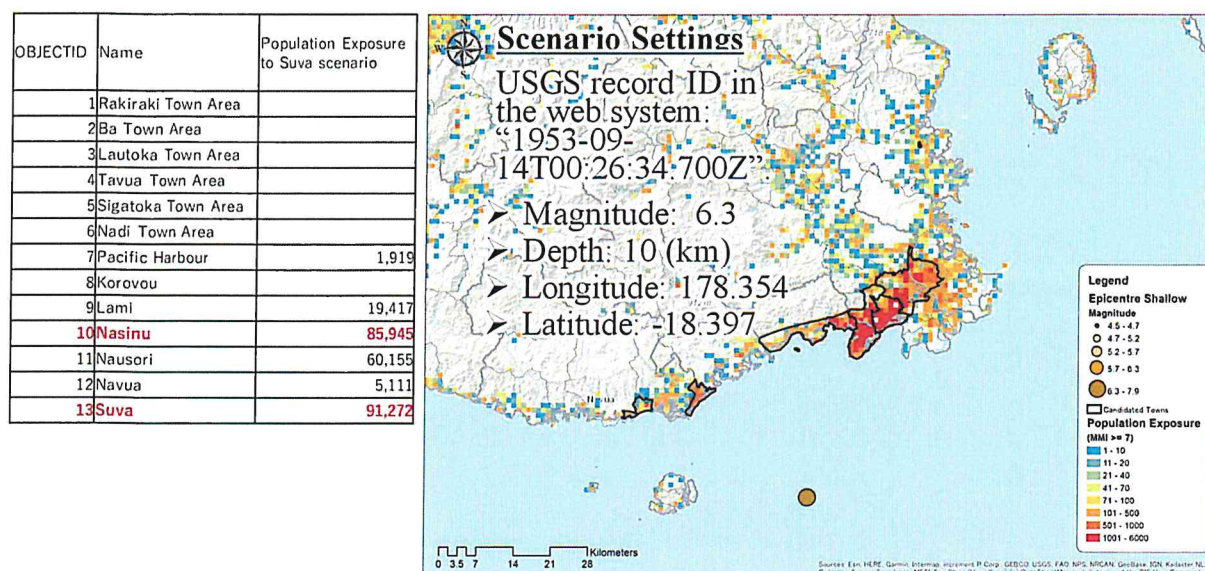


Fig. 5 Enhanced Assessment for the Central Division (Earthquake)

[Output 1/Task-5] Provide technical assistance to conduct hazard assessment nationwide based on the developed guideline (PDM Activity 1-4)

The guidelines to assess flood, sediment disasters (debris flow and steep slope collapse), coastal disaster (tsunami and storm surge) and earthquake were developed in the first phase and they were continuously updated based on the project activities in the pilot areas. Also, the “Nationwide expansion plan of hazard and risk assessments” is currently under development.

(3) Output 2

[Output 2/Task-6] Development of Local DRR Plans in pilot areas using a practical formulation process (PDM Activity 2-3)

In Fiji, DRR Plan in the local city or town level is not mandated in by any Law or Act. Therefore, in the first period of the project, the methodology to formulate the DRR plan as a Divisional DRR Plan and to formulate the city/town area level through the formulation of the priority area DRR Plan was considered.

In the first period, the JICA project team have developed the Divisional DRR plan for the Western Division and Priority Area Plan for coastal hazard in Nadi and flood in Ba. Based on the learnt in the DRR plan formulation process, the “Guide on the DRR Plan Formulation in Fiji” was prepared as a practical formulation process guide. Additionally, based on the outcome of the activity in the first period, the guide includes specific methodologies, lessons learned, and recommended practices to effectively address hazards in the division by formulating the Priority Area Plan.

Following the guide, in the second period NDRMO is now taking the lead in advancing the DRR Plan and the Priority Area Plan for the Central Division. However, although the basic approach for the DRR Plan formulation is followed, considering the different situation of expansion of the urban area in the greater Suva metropolitan area, different approaches to determinate the priority area were considered.

Due to the ongoing urban expansion, defining specific Priority Areas for the DRR Plan is more complex, and the approaches taken in the Western Division are insufficient to address the challenges. Therefore, NDRMO, supported by the JICA project team, is providing strategic guidance to identify and prioritize areas effectively, taking into account the distinct urban dynamics in the Suva region.

Based on the approach taken in the Western Division, it was identified that most of the population is concentrated in the greater Suva metropolitan areas.

Table 3 Elements Susceptible to each Hazard in each area

Item	Suva	Lami	Nasinu	Nausori	Navua	Deuba	Korovou
Area (km ²)	66.14	45.93	28.66	66.14	12.26	9.69	0.38
Administrative Category	City	Town			Incorporated city		
Population (2017)	93,874* [±]	24,637* [±]	92,046* [±]	57,866* [±]	5,812* [±]	1,963* [±]	329* [±]
Number of Businesses	2,860* [±]	159* [±]	549* [±]	790* [±]	131* [±]	74* [±]	36* [±]
Susceptibility to Flood							
Population	12,074	6,151	20	12,069	4,909	1,726	388
Number of Businesses	1,318	26	0	410	115	38	34
Number of EC	18	4	0	17	8	2	1
Susceptibility to Coastal Hazard							
Population	18,677	3,265	8,251	2,342	3,990	819	331
Number of Businesses	1,409	117	35	9	38	13	33
Number of Businesses	70	24	61	10	8	2	1

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Number of EC							
Susceptibility to Earthquake							
Population highly affected	20,395	1,397	19,385	50,137	5,111	819	331
						13	33
						2	1

However, in the Suva metropolitan area the urban expansion is one of the major issues exaggerating the disaster risk, the detailed population distribution was confirmed (Figure 6). Based on the distribution of the population, the area to focus on the Priority Area Plan in the Central Division was decided. The Priority Area Plan was decided to consider the impact of urbanization and how the hazard in the area is existing covering coastal hazard (Tsunami, Storm Surge), flood, and steep slope failure. Detail digital elevation data (DEM) will be acquired by the JICA project team and analysis of the hazard mentioned above will be conducted by WG1.

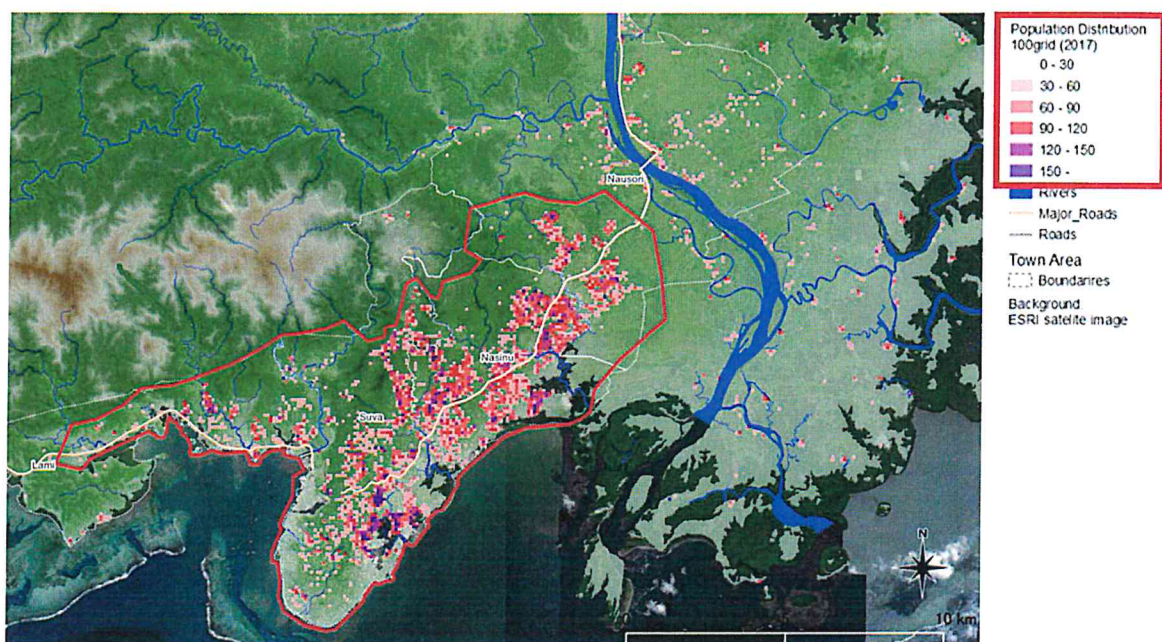


Figure 6 Population Distribution and Area to Consider Priority Area Plan

In the process to understand the development perspective in the Western Division, since in the Central division, the divisional development plan is not developed. Therefore, in collecting the information by each sector and areas, individual consultations were conducted to agencies in responsible for each sector and Provincial Administrator in each Province was conducted. The challenges and solutions confirmed as of Feb 2025 are summarized in the table below.

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Table 4 Challenges and Solutions Identified in each Sector

Sector	Challenges	Solution
Road	• High traffic volume in greater Suva • Insufficient drainage, Forest degradation and upstream development to increase run-off • Riverbank/Coastal erosion causes major impact	• Road network improvement in greater Suva • Resilient design for approach of bridges • Recovery for riverbank/coastal erosion and landslide measures implemented
Housing	• Improvement of Informal Settlement • Relocation of community in high-risk area	• Pilot project for informal settlement improvement and public housing
Town & Country Planning	• Update of the risk information in case to include hazard perspective to town and urban planning	• Advisory policy may be utilized for risk-informed development • Suva planning scheme under revision
Seismic	• Update of the Tsunami risk area (20m - 10m) • Lack in data and information for details Tsunami analysis	• Tsunami Ready activity to be continued • Tsunami Database to be developed including LiDAR observation

Table 5 Challenges and Solutions Identified in each Area

Area	Challenges	Solution
Rewa	• Salinization in Rewa delta area impacting agricultural productivity • Access to villages in Rewa delta in flooding situations and flood gate is not functioning	• Improving access to villages in Rewa delta and in the islands • Improvement of drainage and flood gate in the Rewa delta area (consultation on-going)
Naitasiri	• Flooding from Wainimala river • Landslides damaging access roads • Providing relief items to mountain villages	• Relocation of houses damaged by flood • Construction of access roads for evacuation and response, evacuation centers.
Serua	• Landslide and coastal erosion impacting Queens Road and villages • Flood in major rivers including Navua river • Island and coastal villages in high-risk area	• Improvement of seawalls • Dredging in major rivers (Navua river etc.) • Floodgate to prevent coastal disaster • Relocation of island and coastal villages

In addition to understanding the risk profile on the Central Division, information and GIS data was summarized by NDRMO officer, and information on specific issues at the local level was collected through the individual consultation to the Provincial Administrator. Some situations collected are summarized in the figure below.

DRR Plan Section 3: Risk Profile (Flood)

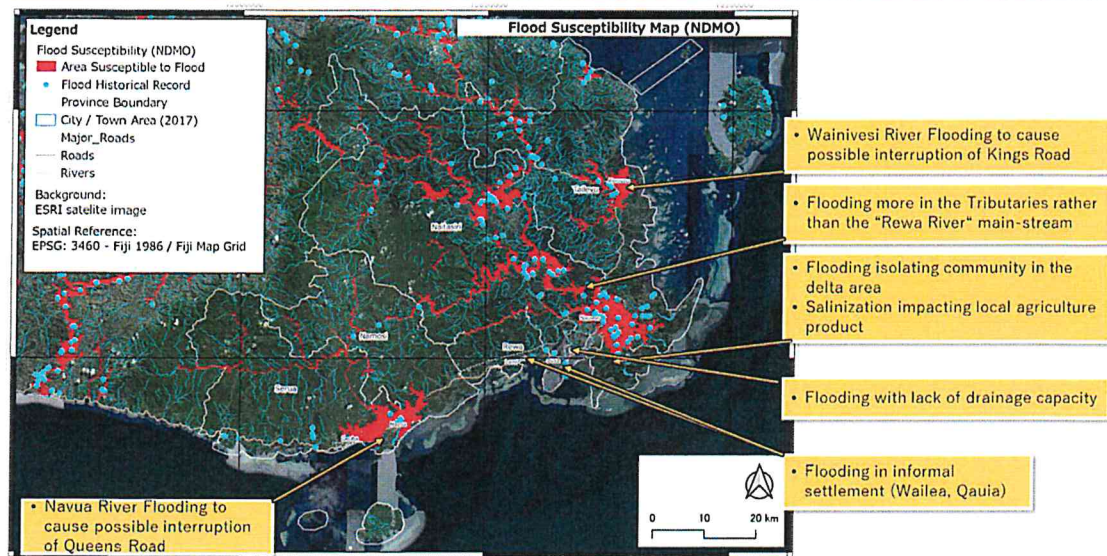


Figure 7 Risk Profile for Central Division for Flood

DRR Plan Section 3: Risk Profile (Landslide)

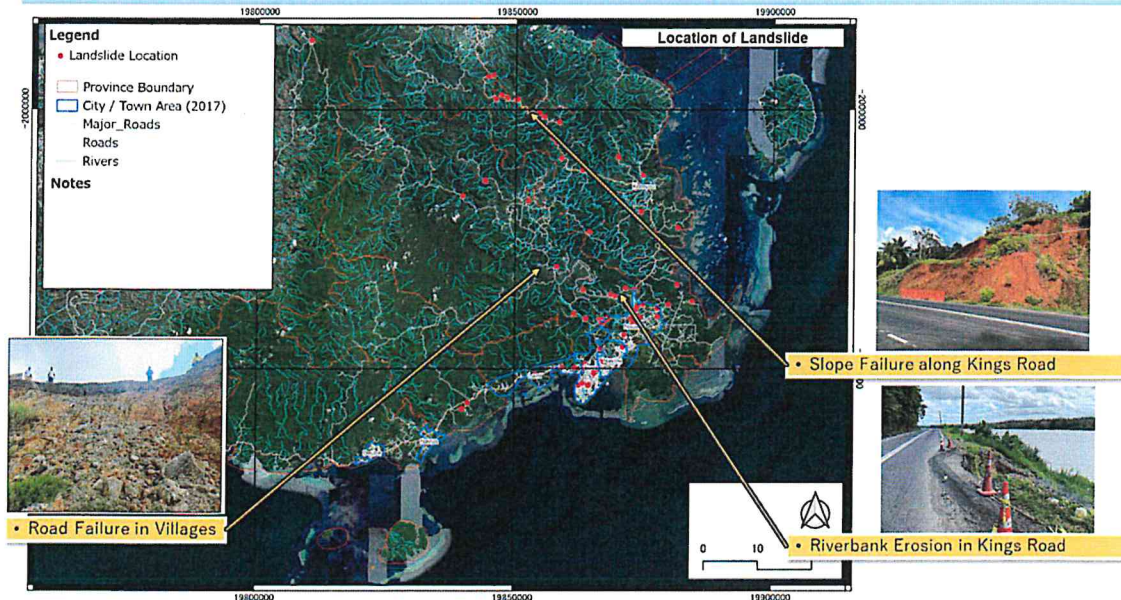


Figure 8 Risk Profile for Central Division for Landslide

DRR Plan Section 3: Risk Profile (Coastal Disaster)

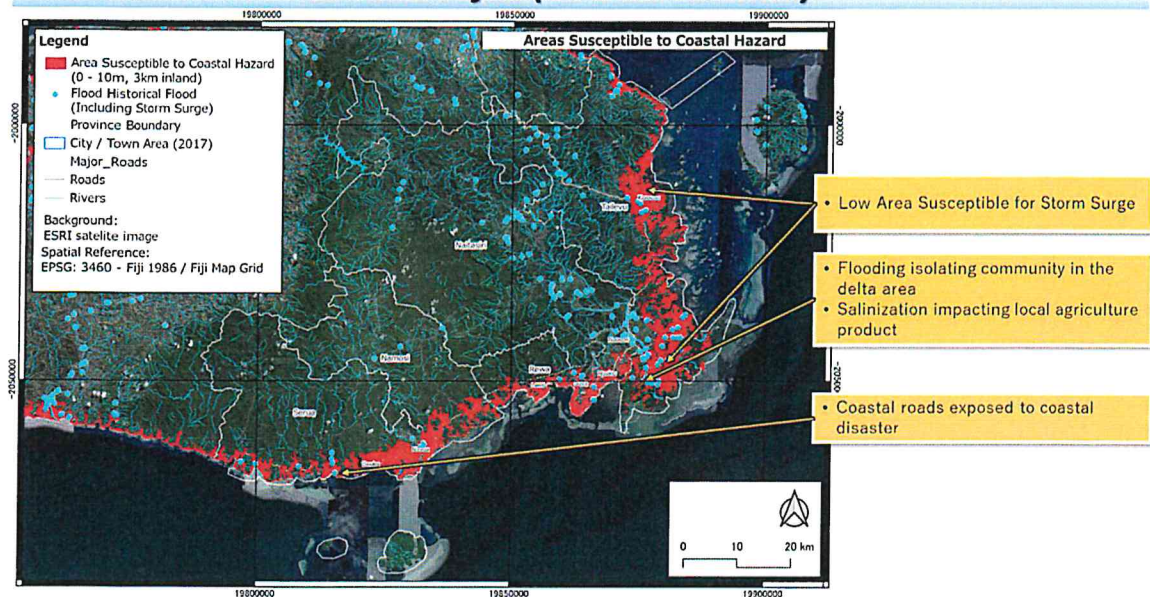


Figure 9 Risk Profile for Central Division for Coastal Disaster

Based on the challenges and solutions identified from the individual consultation, NDMRO have discussed with the divisional commissioner on the DRR direction in the Central Division. Considering the expanding urbanization in the greater Suva area, the importance of risk-informed development to avoid future development in high-risk areas was identified as DRR direction. In addition, with increasing intensity of rainfall and changing land use, flood management also with focus on urban expansion area was also identified as DRR direction.

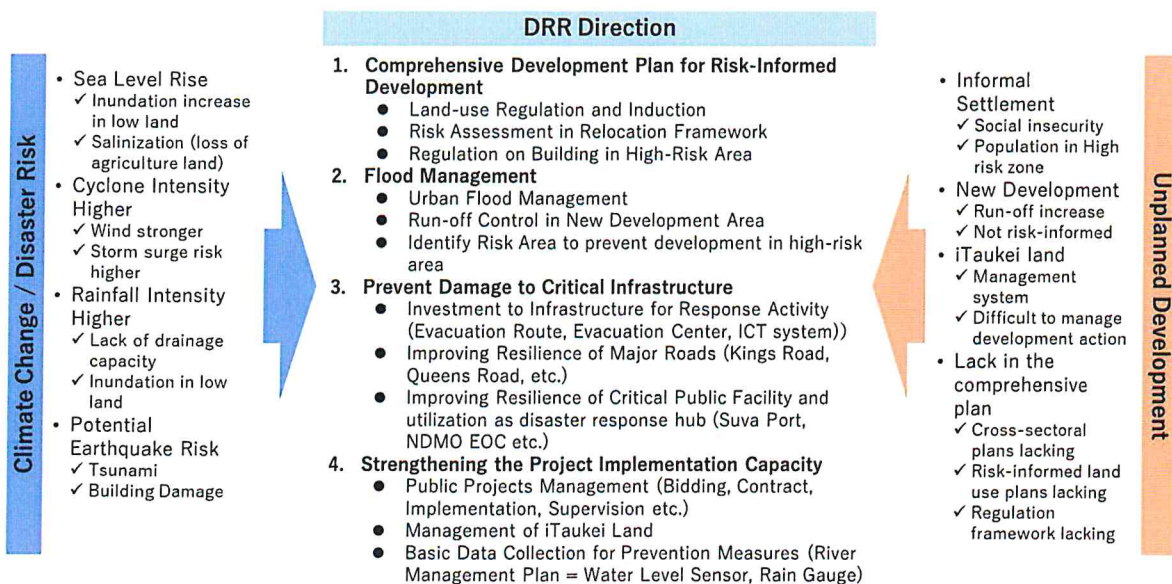


Figure 10 DRR Direction Identified in the Central Division

[Output 2/Task-7] Provide technical support to implement priority DRR measures identified in the Local DRR Plans developed in pilot areas (PDM Activity 2-3)

Discussions on specific disaster prevention infrastructure measures in the Priority Areas of the Western Division were considered. Based on consultations with the NDRMO and the discussion at the local level, the following countermeasure proposals were considered:

Ba town: Flood control measures including diversion channels, retention basins, river channel improvements, and road elevation.

Nadi town: Road elevation to prevent inundation of major roads due to storm surges and tsunamis.

The direction of these measures was approved by the town councils of Nadi and Ba, and the content of the Western Division Priority Area Plan was endorsed. The endorsement of the plan is an initial step for the implementation of the plan.

In order to facilitate the implementation of the priority DRR measures, the methodology for the monitoring and DRR measures planning was considered. Advice which could be made by the JICA project team are summarized as bellow. The detail methodology will be discussed with NDRMO and to be finalized.

1. Break Down Challenges into Smaller, Simple, and Concrete Actions

Large challenges or projects can feel overwhelming if attempted all at once, therefore, breaking down tasks into smaller, concrete actions is effective to make the implementation manageable, promote clearer understanding among stakeholders, and enable step-by-step progress monitoring.

2. Utilize Monitoring as "Proof of Progress" Instead of an additional task for the officers

Developing monitoring sheets as something the officer "must do" can be a burden for officers just giving additional tasks. However, when the monitoring sheet is utilized as evaluation material to prove the progress, it is possible to encourage active participation in the monitoring activity. This can be achieved by identifying also small accomplishments and by utilizing them to share the progress among stakeholders.

3. Setting Priorities for Budgeting

Since the budget and resources are limited, clear prioritization of DRR measures is necessary. It is proposed to provide clear priority in the list of DRR measures and to consider realistic scheduling where budget allocation is feasible.

4. Conduct "Targeted Assessments" Instead of Comprehensive Health Check-ups

Instead of making the monitoring an obligation, identify the monitoring activity as detecting issues in implementing DRR measures and make the monitoring to be a simplified checklist.

5. Make a system to share "Success Project (Small Wins)" to attract local stakeholders

Create a mechanism to share the project success to the stakeholders which may benefit from the achievement by visualization and engagement of stakeholders in the monitoring progress.

[Output 2/Task-8] Provide technical assistance to implement the action plan and the monitoring and evaluation procedures in order to ensure the nationwide formulation, implementation and revision of Local DRR plans (PDM Activity 2-5)

The formulation of the DRR plan in the divisional level has been included in the Fiji National Development Plan 2025 – 2029 and Vision 2050 (NPDP) which was endorsed in November 2024. In the National Development Plan, it is targeted to develop 2 divisional DRR plan by 2027 and to cover all the division DRR plan by 2029. NDRMO is currently leading the activity to formulate the Divisional DRR plan for the Central Division, it is expected for NDRMO to continue this activity. In addition, in the Western Division, as an expansion of DRR plan in the priority area, the NDRMO is now targeting Rakiraki town as an expansion and have started the discussion with the town councils.

Based on the National Development plan it is expected for NDRMO and the divisional office to secure the budget for the formulation, implementation and revision of the local DRR plans. The “Guide on the DRR Plan Formulation in Fiji” will be updated based on the lessons also from the DRR plan formulation activity in the Central Division. In addition, the JICA project team will consider the appropriate material to facilitate the future planning activities during the second phase of the project.

(4) Output 3

[Output 3/Task-7] Assess and upgrade the system to plan, implement, monitor and review DRR activities (PDM Activity 3-3)

As a result of the first Period of the project, one of the goals in the National Development Plan 2025-2029 (NDP), which was reviewed by the new administration due to strong advocacy from NDRMO, is "Building resilience through risk informed socioeconomic development". A specific indicator for this goal is the development of DRR Divisional Plans across all divisions.

In the first half of the roadmap, titled "NDRRP Roadmap for LDP Development," NDRMO addresses this indicator and have decided to monitor the development status of Division DRR Plans and Priority Area DRR Plans. The methods and responsible parties for conducting monitoring will be outlined in the forthcoming monitoring guidelines. Here, WG3 also refer to the NDRRP M&E conducted separately by NDRMO and its implementation guidelines, proposing ways to minimize the burden on both NDRMO and implementing agencies as much as possible.

In the latter part of the roadmap, titled "NDRRP Roadmap for LDP Implementation," WG3 are considering a method to aggregate the monitoring results of each LDP's implementation status. The monitoring system is being discussed by WG2 and Commissioner Offices, with WG3 also joining this discussion to create synergy.

[Output 3/Task-8] Conduct inter-organizational meetings under NDMC on the planning, implementation and monitoring of DRR activities (PDM Activity 3-4)

The National Disaster Risk Management Act, which was reformed in October 2024, determines that the NDMC must meet at least twice a year. The act establishes the function of the Disaster Risk Reduction Committee guided by the NDMC.

NDRMO is proposing discussion subjects to the Committee to endorse the outputs of the project.

As stated above, while the NDMC is mandated by law, its actual scheduling depends on the minister's availability. To facilitate regular meetings, both NDRMO and the project will make efforts to frequently provide input to the minister and the PS regarding the importance of these councils and DRR-related proposals that they wish to discuss.

[Output 3/Task-9] Support the mainstreaming of DRR into activities implemented by related organizations (PDM Activity 3-5)

WG3 have held consultations with the following organizations to concretize the DRR related activities outlined in the roadmap. WG3 will reflect these contents and update both the roadmap and monitoring guidelines accordingly.

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The following table shows outlines of discussion for DRR project promotion.

Table 6 Outlines of Discussion for DRR Project Promotion

Date	Agencies and Organizations	Main Subjects
Sep. 27, 2024	Waterways	• Discussion on Local DRR Plans and Promotion of Implementation
Nov. 11, 2024	FRA	• Discussion on Local DRR Plans and Promotion of Implementation
Nov. 15, 2024	MFSPNDS	• Discussion on Local DRR Plans and Promotion of Implementation
Feb. 21, 2025	MFSPNDS	• Discussion of NDRRP Roadmap and Mainstreaming DRR
Feb. 27, 2025	MOE	• Discussion on Local DRR Plans, Promotion of Implementation, NDRRP Roadmap, and Education Emergency Policy

[Output 3/Task-10] Organize a system for the publication of the DRR white paper (PDM Activity 3-6)

DRR White Paper was renamed to DRR Annual Report in Fiji. Contents and function of the document were kept.

NDRMO prepared a council paper for DRR Annual Report FY22-23 to submit the report to the DRR Committee in March 2025 and NDMC, which will probably be held in April 2025. In the council paper, NDRMO highlighted that Annual Report is to be published annually. The annual Report FY23-24 is currently being drafted for presentation at the April NDMC. There are some difficulties to collect required information within the Ministry.

(5) Invitation Programme in Japan

A delegation programme was conducted in October 2024 for 6 higher officials from C/P agencies.

a) Summary of the Programme

Course title: Invitation Programme for the Project for Mainstreaming Disaster Risk Reduction in the Republic of Fiji

Duration: Sat 19th October to Sat 26th October 2024. 8 days

Participants: 5 representatives shown below.

Table 7 List of Participants of the Invitation Programme in Japan

Name	Designation
Hon. Sakiasi Ditoka	Minister for Rural and Maritime Development and Disaster Management
Mr. Ratu Isoa Talemaibua	Permanent Secretary for Rural and Maritime Development and Disaster Management
Mr. Apolosi Lewaqai	Commissioner Western Division, Ministry of Rural and Maritime Development and Disaster Management
Mr. Josefo Navuku	Commissioner Central Division, Ministry of Rural and Maritime Development and Disaster Management
Mr. Naipolioni Boseiwaqa	Acting Director for Disaster Management

b) Purpose of the Programme

To gain a concrete understanding of the objectives of the Project for Mainstreaming DRR and the activities towards their achievement (such as the development and promotion of local DRR plans in the Western and Central Divisions) by learning from DRR projects based on hazard and risk assessments and practices of their implementation and promotion in Japan. Additionally, by understanding the effects of the project, it aims to accelerate project activities.

Target

1. Decision-makers of the national disaster management authority in Fiji will visit various DRR projects in Japan. Through this visit, they will gain a better understanding of the outputs and effects of DRR projects, aiming to raise awareness about importance of DRR planning and its implementation in Fiji.
2. By meeting with JICA and Japanese disaster management stakeholders, they will have a network to promote mainstreaming DRR and pre-investment against disaster in Fiji.
3. Although individual discussions have been conducted with the five invitees, this invitation brings them together in one place to examine and discuss the overall promotion of DRR projects in Fiji, aiming to catalyze the activation of DRR investments.

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c) Syllabus

In the first 2-days of the programme, the delegates visited national headquarters of disaster management in Japan and some project sites in Tokyo. In the other days, the delegates went to Kanagawa Prefecture and Shizuoka Prefecture to learned about practical policies and project operations.

Table 8 Programme Syllabus

No.	Session Title	Host / Lecturer
1	Visit to JICA HQ	Senior Vice President / Global Environment Department, JICA
2	Lecture by Prof. Nishikawa	Senior Advisor, JICA
3	Site visit to an earthquake absorbing structure (core medical facility)	Japanese Red Cross Medical Center
4	Courtesy call to the Cabinet Office for National Space Policy Secretariat	Cabinet Office for National Space Policy Secretariat
5	Lecture from the Cabinet Office for Disaster Management	International cooperation, Disaster Management Bureau, Cabinet Office
6	Site visit to an earthquake resistant structure (public school)	Komadome Junior High School, Setagaya City Office
7	Site visit around the Tsurumi River Embankments	OCG
8	Flood management and integrated water resources management in Tsurumi River	Keihin River Work Office, Kanto Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism
9	Site visit around the Tsurumi River Basin Center 1. (Rooftop)	Keihin River Work Office, Kanto Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism
10	Site visit around the Tsurumi River Basin Center 2. (Exhibition room)	Keihin River Work Office, Kanto Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism
11	Site visit at Multi-Purpose Water Utilities	Keihin River Work Office, Kanto Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism
12	Site visit at Kawawa anti-flood pond	OCG
13	Site visit at Ooba Kayanoki Park	OCG
14	Site visit around Miyamae bridge	OCG
15	Tea brewing experience	World Green Tea Association
16	Disaster Management in Shizuoka Prefecture	Shizuoka Prefectural Government
17	Tour in the exhibition	Shizuoka Prefectural Earthquake Disaster Prevention Center
18	Site visit to sediment disaster countermeasures around Shizuoka City area	Shizuoka Prefectural Office
19	Local community development (Tour in a "Shizuhata Jiman-ichi" roadside market)	OCG
20	Local community development (Tour in a "michi-no-eki" roadside station / rest area)	OCG
21	Tsunami and storm surge countermeasures (Structural Measures and Non-Structural Measures)	Shizuoka Prefectural Government Numazu City Office

d) Summary of Lessons

The programme allowed delegates to learn about DRR projects based on hazard and risk assessments in Japan and how to promote their implementation. It emphasized the economic benefits of pre-disaster measures, which are more cost-effective than disaster response expenses. Through discussion and site visits, delegates gained an understanding of the roles of the implementing bodies (national, prefectural, and municipal governments) and the importance of archiving data, as well as the need for disaster risk assessment. Additionally, the importance of pre-disaster investment at the political, practical, and community levels was recognized, along with the necessity of securing budgets. The understanding of the delegate improved during the programme. The Minister deepened their understanding of DRR investments and proposed new funding ideas for funding them. The PS learned about disaster risk-based planning and implementation, while the Commissioners developed a higher awareness of DRR. The Acting Director NDRMO, already aware of the importance of DRR, is expected to contribute to promoting DRR investments. Although there are differences between Japan and Fiji in terms of economic scale and administrative structure, the programme deepened understanding of how to collaborate on DRR measures. Going forward, it is expected that each participant will promote project activities from their respective positions in Fiji.

The Project for Mainstreaming Disaster Risk Reduction
PM Form 3-1 Monitoring Sheet Summary



Fig. 115 Visit to JICA HQ



Fig. 12 Visit to Cabinet Office for Disaster
Management



Fig. 13 Site Visit to Generator Room in
Japan Red Cross Medical Center



Fig. 14 Site Visit to a Seismic Reinforced
School (Komadome Junior High School)



Fig. 15 Site Visit to Shizuoka Pref.
Earthquake Disaster Prevention Center

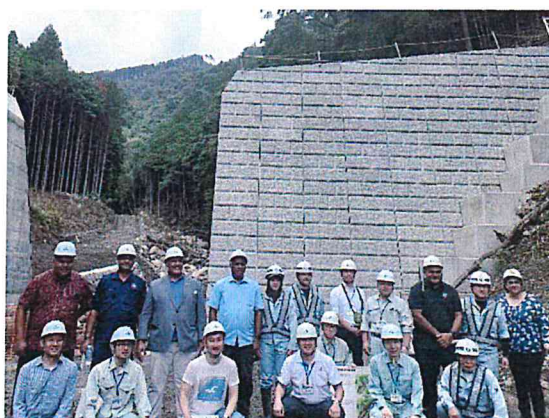


Fig. 16 Site Visit to Sediment Disaster
Countermeasure Structure

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1.3 Achievement of Output

The following table shows the objectively verifiable indicators to evaluate the achievement of each Output based on the PDM, and the progress of each achievement.

Table 7 Achievement of each Outputs

Outputs	Objectively verifiable indicators	Progress
Output 1	The hazard assessment guideline and the expansion plan are developed.	The guidelines to assess flood, sediment disasters, coastal disaster and earthquake were developed and continuously updated. Draft nationwide explanation plan was developed.
	Hazard assessments are conducted with technical agencies at pilot areas.	Preliminary assessments have been conducted for the central division. Enhanced assessments on coastal disaster and earthquake were conducted for the priority areas in the central division.
	The results of hazard assessments are shared at meetings under NDMC structure.	Not yet achieved.
Output 2	Local DRR plans based on the results of hazard assessments at pilot areas with the assistance of JICA experts and NDMO are developed.	Local DRR Plan in the Western Division (Divisional Plan and the priority area plan in selected areas (Nadi, Ba)) was formulated and waiting for official approval by the council. Local DRR Plan in the Central Division is now being formulated.
	A guideline to develop, implement and review a local DRR plan is developed, revised based on lessons learned and uploaded on the website of NDMO.	A guideline for DRR planning was drafted, but has not yet been uploaded on the website of NDRMO.
	A plan to expand local DRR plan nationwide is developed.	A plan to expand local DRR Plan nationwide was drafted.
Output 3	A road map to implement prioritized actions of NDRRP (NDRRP road map) is developed.	NDRRP Roadmap with 2 sections, one for LDP development and the other for LDP implementation was drafted.
	DRR-related meetings under NDMC structure are held.	The DRR Committee is to be held in March 2025.
	A guideline to plan, implement, monitor and revise the NDRRP road map is developed.	- Initial idea of Monitoring & Evaluation method has been proposed. - DRR Annual Report in Fiji was drafted.

1.4 Achievement of Project Purpose

The following table shows the objectively verifiable indicators to evaluate the achievement of project purpose based on the PDM, and the progress of each achievement.

Table 8 Achievement of Project Purpose

No.	Objectively verifiable indicators	Progress
1	A DRR white paper is issued every year (from the 2nd year of the project) and referred to in reports, speeches, websites and so on.	The DRR White Paper (The DRR Annual Report in Fiji) FY2022-2023 was drafted and FY2023-2024 is being drafted. These two reports will be endorsed in the DRR Committee scheduled in March.
2	The prioritized actions in the NDRRP road map are implemented and monitored.	Not yet achieved. However, formulation of the DRR plans in the Northern and Eastern Divisions are prioritized in the NDRRP road map, and they have been included as one of the Key Performance Indicator (KPI) in Fiji National Development Plan.
3	Local DRR plans for 2 divisions are developed based on the results of hazard assessments with the assistance of NDMO and related agencies.	Local DRR plan for the Western Division was developed and the plan for the Central Division is now being developed.

1.5 Changes of Risks and Actions for Mitigation

N/A

1.6 Progress of Actions undertaken by JICA

N/A

1.7 Progress of Actions undertaken Gov. of Fiji

N/A

1.8 Progress of Environmental and Social Consideration (if applicable)

N/A

1.9 Progress of Considerations on Gender/Peace Building/Poverty Reduction (if applicable)

N/A

2. Delay of Work Schedule and/or Problems (If any)

2.1 Details

The Local DRR Plans in the Western Division and the DRR Annual Report in Fiji are expected to be endorsed in the NDMC. However, they have not been endorsed yet.

2.2 Cause

The NDMC has not been held for a long time.

2.3 Actions to be taken

The Local DRR Plans in the Western Division and the DRR Annual Report in Fiji will be endorsed in the DRR Committee under the NDMC first, which is substantially the decision-making body on DRR. However, the project will request NDRMO and its Ministry to hold the NDMC as soon as possible. At the same time, the project will seek for the alternative way such as “flying minute requesting the council's endorsement” by the circulation of the minute instead of holding the council meeting for the endorsement.

2.4 Roles of responsible Persons/Organization (JICA, Government of Fiji, etc.)

NDRMO will take a necessary arrangement for holding the NDMC or taking other measures for the council's endorsement. JICA team will support NDRMO technically.

3. Modification of the Project Implementation Plan

3.1 Plan of Operation (PO)

Due to the suspension of the Project in the COVID19 pandemic, extension of the Project period was agreed in a JCC meeting in the 1st period and R/D was updated. The current PO was modified based on the R/D.

3.2 Other Modifications on Detailed Implementation Plan

N/A

4. Preparation of the Government of Fiji toward after the Completion of the Project

N/A

II. Project Monitoring Sheet I & II *as Attached*

The Project for Mainstreaming Disaster Risk Reduction
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Abbreviations

Abbreviations	English
a/~	Acting ~ (ex. a/PS stands for Acting Permanent Secretary)
BCP	Business Continues Plan
CCA	Climate Change Adaptation
C/P	Counterpart
DBGA	Department of Building and Government Architect
DDM	Director for Disaster Management
DoE	Department of Energy
DLG	Department of Local Government
DRR	Disaster Risk Reduction
DWS	Department of Water and Sanitation
EFL	Energy Fiji Limited
EMS	European Macroseismic Scale
FAL	Fiji Airports Limited
FMS	Fiji Meteorological Service
FNBC	Fiji National Building Code
FNU	Fiji National University
FPCL	Fiji Ports Corporation Limited
FRA	Fiji Road Authority
GEM	Global Earthquake Model
GIS	Geographic Information System
HQs	Headquarters
IFRC	International Federation of Red Cross and Red Crescent Societies
JCC	Joint Coordination Committee
JICA	Japan International Corporation Agency
JMA	Japan Meteorological Agency
M&E	Monitoring and Evaluation
MAW	Ministry of Agriculture and Waterways (former MAWE)
MAWE	Ministry of Agriculture, Waterways and Environment
MCTTT	Ministry of Commerce Trade, Tourism and Transport
MDNP	Ministry of Defense, National Security and Policing
M&E	Monitoring and Evaluation
MEPIR	Ministry of Employment, Productivity and Industrial Relations
MFSPNDS	Ministry of Finance, Strategic Planning, National Development and Statistics (former MoE)
MHCD	Ministry of Housing and Community Development
MHLG	Ministry of Housing and Local Government (former Dept. of Housing, MHCD and DLG)
MHMS	Ministry of Health and Medical Services
MIMS	Ministry of Infrastructure and Meteorological Services
Min.iTaukei	Ministry of iTaukei Affairs
MLIT	Ministry of Land, Infrastructure, Transport and Tourism of Japan
MLMR (MoLand)	Ministry of Lands and Mineral Resources
MLGEHA	Ministry of Local Government, Education, Heritage and Arts
M/M	Meeting Minutes
MoC	Ministry of Communication
MoE	Ministry of Economy
MoFA	Ministry of Foreign Affairs
MoYS	Ministry of Youth and Sports

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Abbreviations	English
MPWMST	Ministry of Public Works, Meteorological Services and Transport (former MIMS)
MRD	Mineral Resources Department
MRMDDM	Ministry of Rural and Maritime Development and Disaster Management (former MRMD)
MRMD	Ministry of Rural and Maritime Development
MTCA	Ministry of Tourism and Civil Aviation
MWCPA	Ministry of Women, Children and Poverty Alleviation
NDMC	National Disaster Management Council
NDMO	National Disaster Management Office
NDRMO	National Disaster Risk Management Office (former NDMO)
NDRRP	National Disaster Risk Reduction Policy
NRW	Non-Revenue Water
OCG	Oriental Consultants Global
OCW	Office of Commissioner Western
OPM	Office of the Prime Minister
PGA	Peak Ground Acceleration
PS	Permanent Secretary
PSIP	Public Sector Investment Programme
R/D	Record of Discussion
RMR	Policy, Research and Risk Management Unit
RRI model	Rainfall-Runoff-Inundation model
SAO	Senior Administrative Officer
SPC	The Pacific Community (former the South Pacific Commission)
TAF	Telecommunication Authority of Fiji
UNDRR	United Nations Office for Disaster Risk Reduction
USGS	United States Geological Survey
USP	University of South Pacific
WAF	Water Authority of Fiji
WG	Working Group

TO CR of JICA FIJI OFFICE

Project Monitoring Sheet

Project Title: the Project for Mainstreaming Disaster Risk Reduction (2nd Period)

Version of the Sheet: Ver. 2.0 (Term: March 2025 – August 2025)

Name: Napolioni Boseiwaga

**Title: Director of National Disaster Risk
Management Office**

Name: Yoshihiko Uchikura

Title: Team Leader / DRR Governance

Submission Date: September 01, 2025

I. Summary

1. Progress

1.1 Progress of Inputs

(1) Dispatch of Japanese Experts

The following Japanese Experts were dispatched during the monitoring period (From March 2025 to August 2025).

Table 1 Dispatch of Japanese Experts in the 2nd Period of the Project

Assignment	Name	Period of Assignment
Leader/ DRR Governance	Yoshihiko UCHIKURA	May 10 - May 17, 2025 June 25 - July 5, 2025 Aug. 27 - Sep. 6, 2025
DRR Activity Management 1	Koji SUZUKI	May 24 - June 21, 2025 Aug. 16 - Sep. 3, 2025
Deputy Team Leader / Local DRR Planning	Masaaki CHIDA	Apr. 3 - Apr. 19, 2025 May 31 - June 1, 2025 Aug. 9 - Aug. 24, 2025
Disaster Risk Assessment 1	Tomohiro UMEKI	Mar. 29 - Apr. 27, 2025 Aug. 26 - Sep. 12, 2025
Disaster Risk Assessment 2 (Coastal Disaster / Climate Change)	Daiki TSUJIO	
DRR Information Management / Inter-institutional Coordination Capacity Enhancement	Takuya ITO	Apr. 5 - Apr. 19, 2025 May 31 - June 1, 2025 Aug. 9 - Aug. 30, 2025
Earthquake Disaster	Koichi HASEGAWA	
DRR Activity Management 2	Ai SHIGEMATSU	May 10 - May 31, 2025 June 21 - July 5, 2025 Aug. 16 - Sep. 3, 2025
Project Coordination / Capacity Development	Ryoya KYUZAKI	Apr. 12 - Apr. 23, 2025 May 28 - June 14, 2025

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		June 28 - July 1, 2025 Aug. 27 - Sep. 6, 2025
Project Coordination / Capacity Development 2	Kentaro IMANI	June 21 - July 5, 2025

(2) Assignment of Counterparts

From the Fijian Side, the Project Director and the Project Manager are as follows.

(a) Project Director: Ratu Isoa Talemaibua, Permanent Secretary (PS) for Rural and Maritime Development and Disaster Management (MRMDDM)

(b) Project Manager: Vasiti Soko, Director of National Disaster Management Office (NDMO) (Director for Disaster Management (DDM)) (since December 2020 to September 2024), Napolioni Boseiwaqa, Director of National Disaster Risk Management Office (NDRMO) (DDM).

NDRMO provides leaders and members from its officials to each Working Group (WG).

In addition, resulting from the First Joint Coordination Committee (JCC) meeting held on May 18, 2022, the following organizations were identified as WG members. In the Second JCC meeting held on June 2, 2023, names of the member agencies were updated. In the Kick-off Meeting for the 2nd Period of the Project, members from the Japanese side were updated.

Proposed revisions as of September 2024

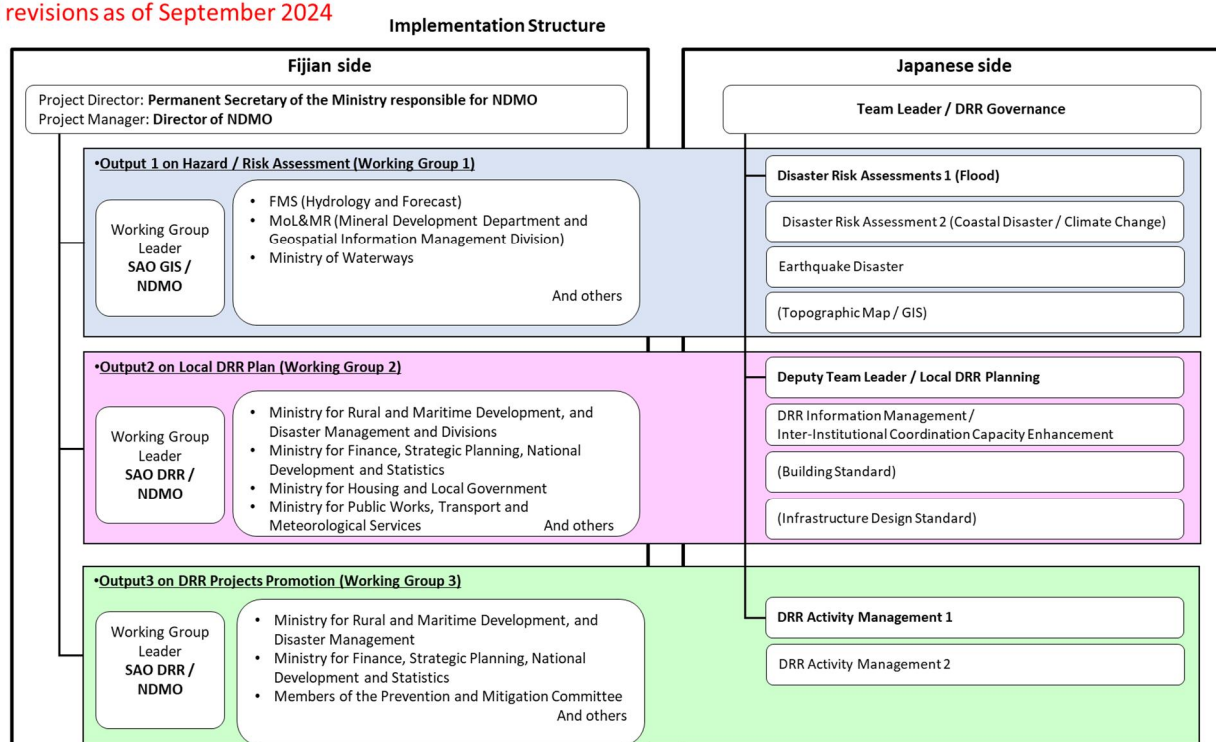


Figure 1 Implementation Structure

1.2 Progress of Activities

(1) Overall Project

[Common/Task-1] Conduct Joint Coordination Committee (JCC) Meetings and prepare Progress Report

Kick-off, JCC and progress meetings were held during the monitoring period.

Table 2 Outlines of JCC Meetings in the Second Period of the Project

Title	Date	Agenda	Participants
Kick-off Meeting	Sep. 23, 2024	- Progress in the First Period - Work Plan in the Second Period - Invitation Programme in Japan - Discussion	14 participants - NDRMO - JICA Fiji Office - JICA Expert Team
Third Progress Meeting	Feb 20, 2025	- Overall Project Progress - Progress of Each Output - Report of Study Tour in Japan - Introduction of Nadi River Flood Management MP - Discussion	23 participants - MoFA - MFSPNDS - MTCA - MHMS - Min. of Education - MPWMST - MLMR - MHLG - MWCPA - Min. iTaukei - EFL - WAF - FRA - MRMDDM - NDRMO - JICA Tokyo HQs - JICA Fiji Office - JICA Expert Team

[Overall/Task-5] Preparation and discussion on the Work Plan (Japanese Version)

The Work Plan (Japanese Version) was prepared by Japanese Expert Team and explained by JICA HQ.

[Overall/Task-6] Preparation and discussion on the Work Plan

The Work Plan (English Version) was discussed in the Kick-off meeting and finalized.

[Overall/Task-7] Conduct of an end-line survey to assess the project achievements

The task will be conducted in the coming day in the Project.

[Overall/Task-8] Conduct of invitation program in Japan

A delegation programme was conducted in October 2024 for 6 higher officials from C/P agencies.

(2) Output 1

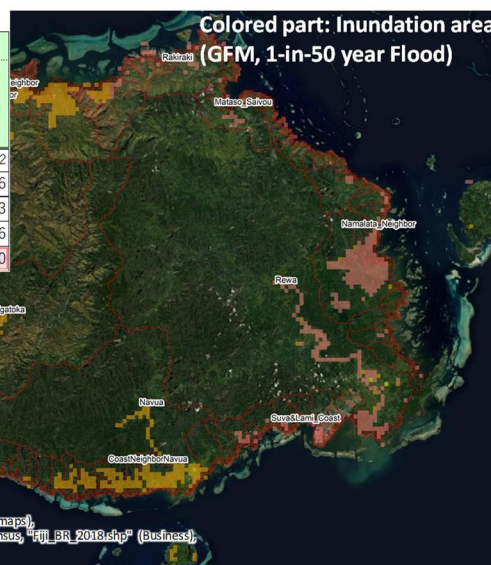
[Output1/Task3]: Conduct hazard assessments of targeted disasters at pilot areas (PDM Activity 1-3)

Preliminary assessment for the Central Division to select a Priority Area was conducted. Enhanced assessments of coastal disaster, earthquake and sediment disaster were conducted in Suva and Rakiraki based on the developed guidelines. Validation of the assessment results with the past disaster records, actual status of the site and so on is essential. Compiling the actual inundation records were discussed with the NDRMO and the FMS. And the on-site validation survey for sediment disaster was conducted with the MRD.

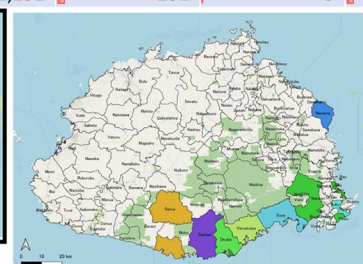
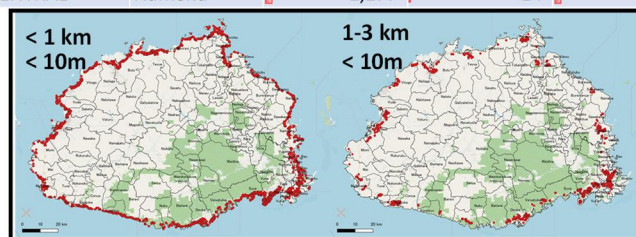
Inundation area, affected household & population and infrastructures based on the Global Flood Map (GFM, 1-in-50 year Flood)¹⁾

Basin	Assumed			
	Inundation Area ²⁾ (km ²)	Affected Household ³⁾	Affected Population ³⁾	Affected Business ³⁾
Navua	44.7	1,484	6,599	122
Coastal Neighbor Navua	92.7	1,420	6,285	56
Rewa	99.3	4,678	21,732	433
Namalata Neighbor	116.5	1,463	6,873	76
Suva & Lami Coast	22.0	4,378	18,885	1,350
Basin	Actual Damage			Damaged infrastructures in GFM inundation area ⁴⁾
	Frequency of Flood damage ⁴⁾	Year ⁴⁾		
Navua	1	2016		10
Coastal Neighbor Navua	1	2012		6
Rewa	3	2012Jan&Mar, 2016		10
Namalata Neighbor	-	Unknown		4
Suva & Lami Coast	-	Unknown		2

1) inunriver_historical_00000000WATCH_1980_rp00050.tif, (source: <https://www.kwr.org/data/aqueduct-floods-hazard-maps/>)
2) Difference of inundation depth is not considered, 3) Based on the 2017 Census (Household & Population) & the 2018 Census, "Fiji BR 2018" (Business),
4) Based on the "Infrastructures Affected by Flood" prepared by NDRMO.



No.	Division	District	Affected Population (<10m)			Affected Households(<10m)		
			<1km	1-3 km	<3 km	<1km	1-3 km	<3 km
1	CENTRAL	Suva	21,619	2,688	24,307	4,543	559	5,102
2	CENTRAL	Naitasiri	7,224	3,973	11,197	1,559	812	2,371
3	CENTRAL	Deuba	4,694	2,849	7,543	1,025	644	1,669
4	CENTRAL	Nakelo	2,356	902	3,258	450	174	624
5	CENTRAL	Batiwai	1,788	3	1,791	360	1	361
6	CENTRAL	Noco	1,669	-	1,669	322	-	322
7	CENTRAL	Serua	1,602	635	2,237	326	126	452
8	CENTRAL	Bau	1,555	9	1,564	317	2	319
9	CENTRAL	Veivatuloa	1,484	693	2,177	280	145	425
10	CENTRAL	Namena	1,177	14	1,191	252	5	257



Affected Population

Figure. 2 Preliminary Assessment for the Central Division (Flood and Coastal Disaster)

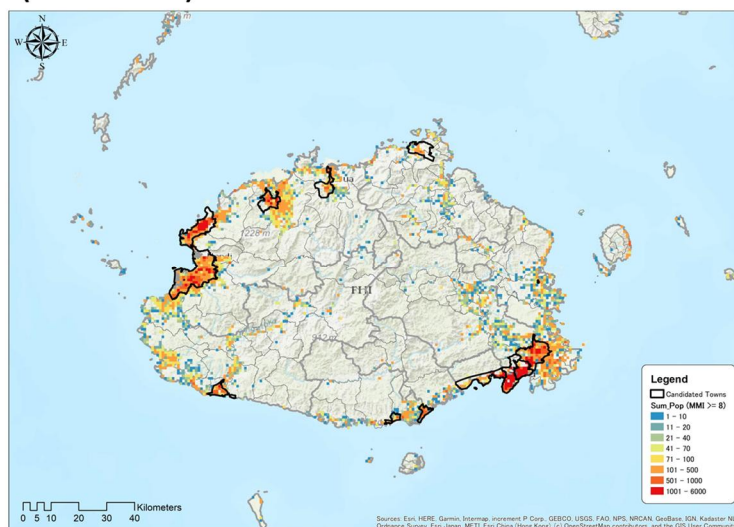
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Population Exposure to PGA >= 150 (MMI >= VIII)

OBJECTID	Name	Population Exposure to Probabilistic PGA
1	Rakiraki Town Area	5,280
2	Ba Town Area	15,280
3	Lautoka Town Area	68,244
4	Tavua Town Area	7,784
5	Sigatoka Town Area	9,745
6	Nadi Town Area	68,405
7	Pacific Harbour	1,919
8	Korovou	
9	Lami	19,332
10	Nasinu	85,945
11	Nausori	60,155
12	Navua	5,111
13	Suva	91,272



The result will be a basic information to select Priority Areas



Population Exposure and Priority Area Location

Figure 3 Preliminary Assessment for Central Division (Earthquake)

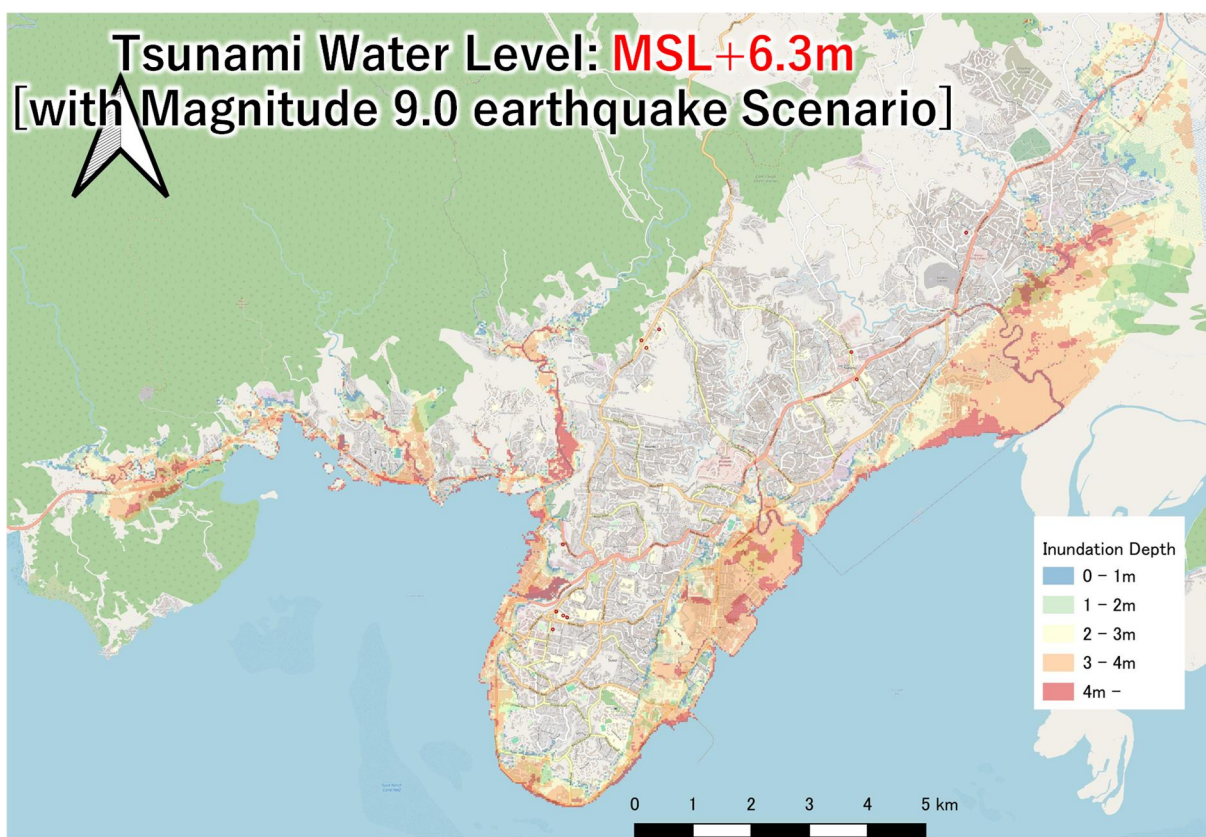


Figure 4 Enhanced Assessment for the Central Division (Tsunami)

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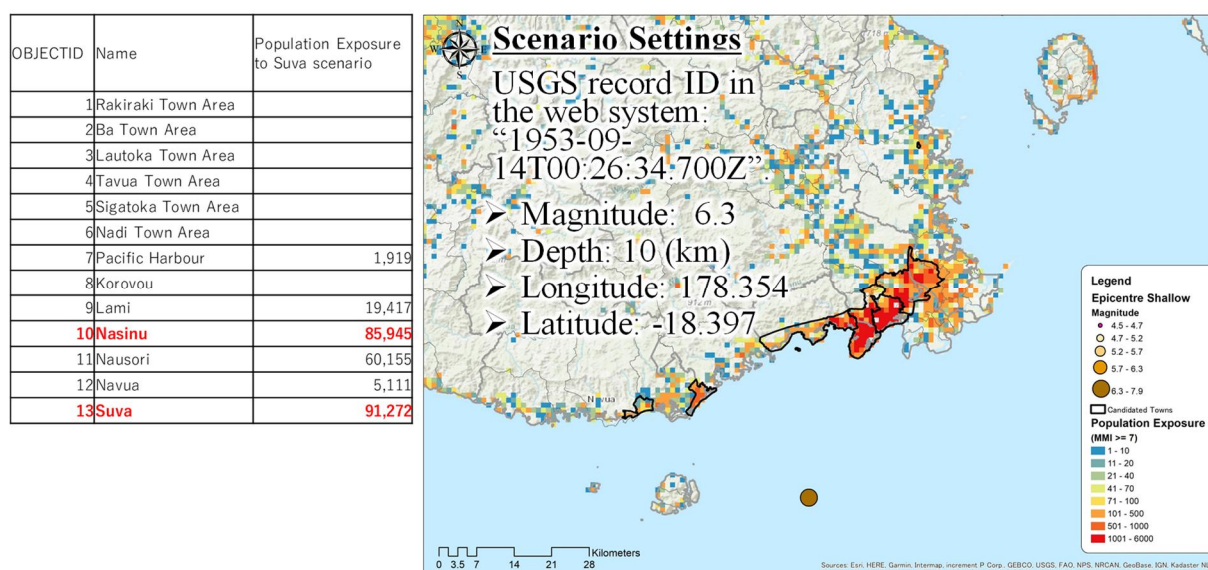


Figure 5 Enhanced Assessment for the Central Division (Earthquake)

[Output 1/Task-5] Provide technical assistance to conduct hazard assessment nationwide based on the developed guideline (PDM Activity 1-4)

The guidelines to assess flood, sediment disasters (debris flow and steep slope collapse), coastal disaster (tsunami and storm surge) and earthquake were developed in the first period. And the guidelines were continuously updated based on the project activities and the C/P's feedback in the pilot areas.

Also, the “Nationwide expansion plan of hazard and risk assessments” is about to finalize after receiving the feedback from the NDRMO and related agencies.

(3) Output 2

[Output 2/Task-6] Development of Local DRR Plans in pilot areas using a practical formulation process (PDM Activity 2-3)

In Fiji, DRR Plan in the local city or town level is not mandated in by any Law or Act. Therefore, in the first period of the project, the methodology to formulate the DRR plan as a Divisional DRR Plan and to formulate the city/town area level through the formulation of the Priority Area DRR Plan was considered.

In the first period, the Divisional DRR plan for the Western Division and Priority Area Plan for coastal hazard in Nadi and flood in Ba were developed. Priority Area were selected based on the result of the preliminary assessments. "The Guide on the DRR Plan Formulation in Fiji" was prepared through the activity.

In the second period, NDRMO is developing the DRR Plan and the Priority Area Plan for the Central Division by following the guide. The Priority Area was selected as the greater Suva metropolitan area, considering its concentrated population and the current situation of urban area expansion. Urban expansion is one of the major issues exaggerating the disaster risk.

Detail digital elevation data (DEM) was acquired by the JICA project and analysis of the hazard mentioned above were conducted by WG1.

Table 3 Elements Susceptible to each Hazard in each area

Item	Suva	Lami	Nasinu	Nausori	Navua	Deuba	Korovou
Area (km ²)	66.14	45.93	28.66	66.14	12.26	9.69	0.38
Administrative Category	City	Town			Incorporated city		
Population (2017)	93,874* ¹	24,637* ¹	92,046* ¹	57,866* ¹	5,812* ¹	1,963* ¹	329* ¹
Number of Businesses	2,860* ¹	159* ¹	549* ¹	790* ¹	131* ¹	74* ¹	36* ¹
Susceptibility to Flood							
Population	12,074	6,151	20	12,069	4,909	1,726	388
Number of Businesses	1,318	26	0	410	115	38	34
Number of EC	18	4	0	17	8	2	1
Susceptibility to Coastal Hazard							
Population	18,677	3,265	8,251	2,342	3,990	819	331
Number of Businesses	1,409	117	35	9	38	13	33
Number of EC	70	24	61	10	8	2	1
Susceptibility to Earthquake							
Population highly affected	20,395	1,397	19,385	50,137	5,111	819 13 2	331 33 1

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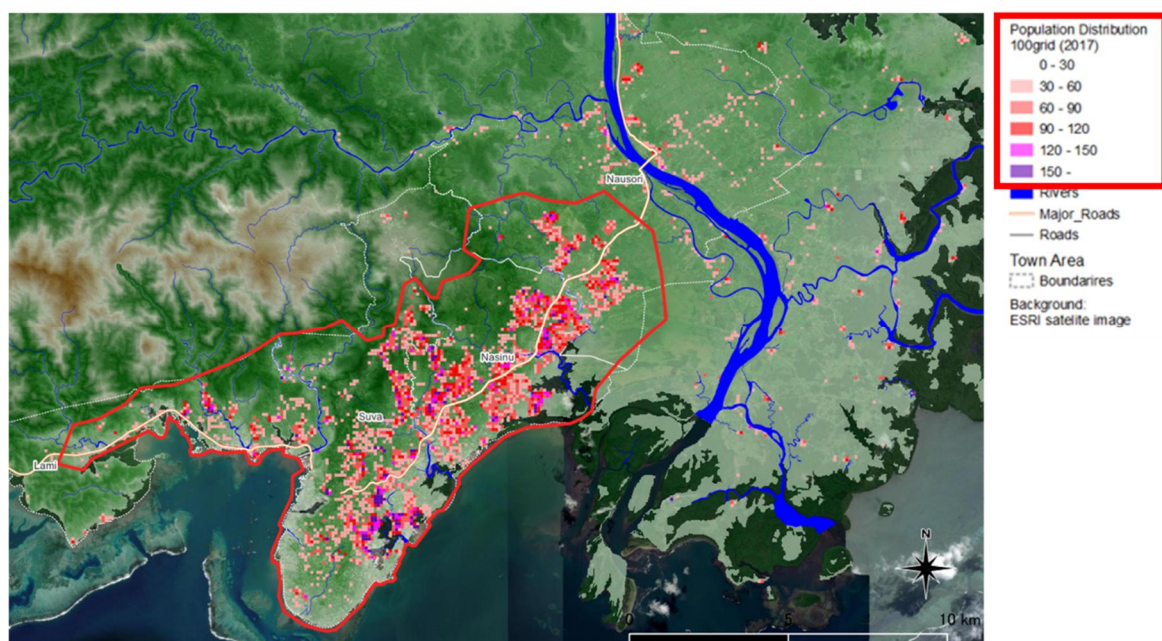


Figure 6 Population Distribution and Area to Consider Priority Area Plan

Unlike in the Western Division, the Divisional Development Plan is not developed in the Central Division. Therefore, individual consultation was conducted to agencies in responsible for each sector and Provincial Administrator in each Province in collecting the information such as challenges and planned projects by each sector, and development projects and projects related in DRR by each areas. The challenges and solutions confirmed is summarized (shown in table 4 and table 5).

Table 4 Challenges and Solutions Identified in each Sector

Sector	Challenges	Solution
Road	- High traffic volume in greater Suva - Insufficient drainage, Forest degradation and upstream development to increase run-off - Riverbank/Coastal erosion cause major impact	- Road network improvement in greater Suva - Resilient design for approach of bridges - Recovery for riverbank/coastal erosion and landslide measures implemented
Housing	- Improvement of Informal Settlement - Relocation of community in high-risk area	Pilot project for informal settlement improvement and public housing
Town & Country Planning	Update of the risk information in case to include hazard perspective to town and urban planning	- Advisory policy may be utilized for risk-informed development - Suva planning scheme under revision
Seismic	- Update of the Tsunami risk area (20m - 10m) - Lack in data and information for details Tsunami analysis	- Tsunami Ready activity to be continued - Tsunami Database to be developed including LiDAR observation

The Project for Mainstreaming Disaster Risk Reduction
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Table 5 Challenges and Solutions Identified in each Area

Area	Challenges	Solution
Rewa	- Salinization in Rewa delta area impacting agricultural productivity - Access to villages in Rewa delta in flooding situation and flood gate is not functioning	- Improving access to villages in Rewa delta and in the islands - Improvement of drainage and flood gate in the Rewa delta area (consultation on-going)
Naitasiri	- Flooding from Wainimala river - Landslides damaging access roads - Providing relief items to mountain villages	- Relocation of houses damaged by flood - Construction of access roads for evacuation and response, evacuation centers.
Serua	- Landslide and coastal erosion impacting Queens road and villages - Flood in major rivers including Navua river - Island and coastal villages in high-risk area	- Improvement of seawalls - Dredging in major river (Navua river etc.) - Floodgate to prevent coastal disaster - Relocation of island and coastal villages

NDRMO officers summarized the information and GIS data to understand the risk profile in the Central Division. Moreover, the individual consultation to the Provincial Administrator were conducted to collect information on specific issues in the local level (shown in the Figure 7, Figure 8 and Figure 9).

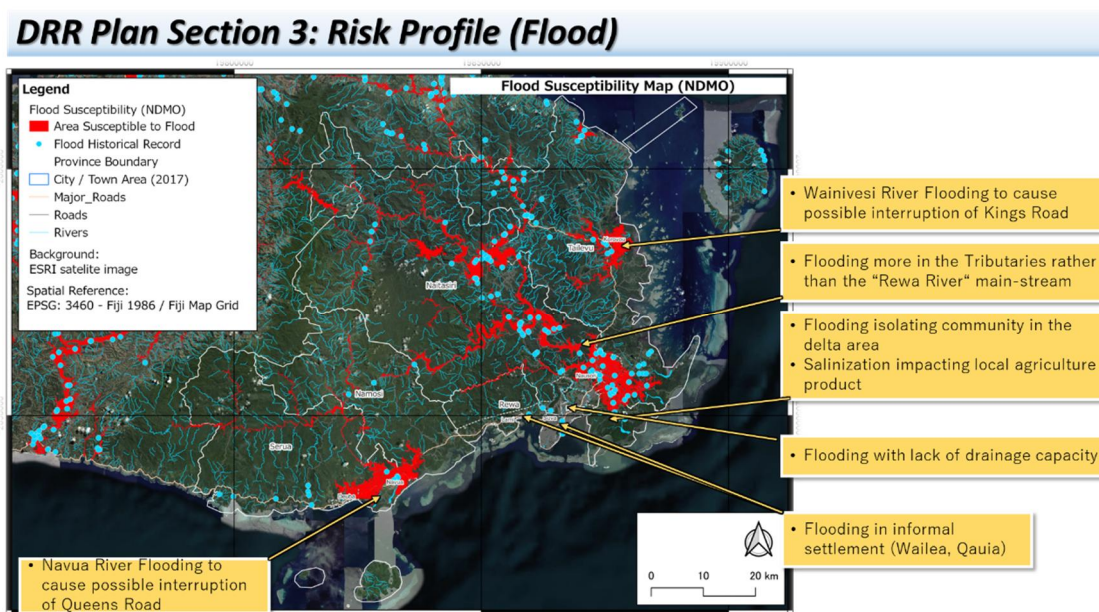


Figure 7 Risk Profile for Central Division for Flood

DRR Plan Section 3: Risk Profile (Landslide)

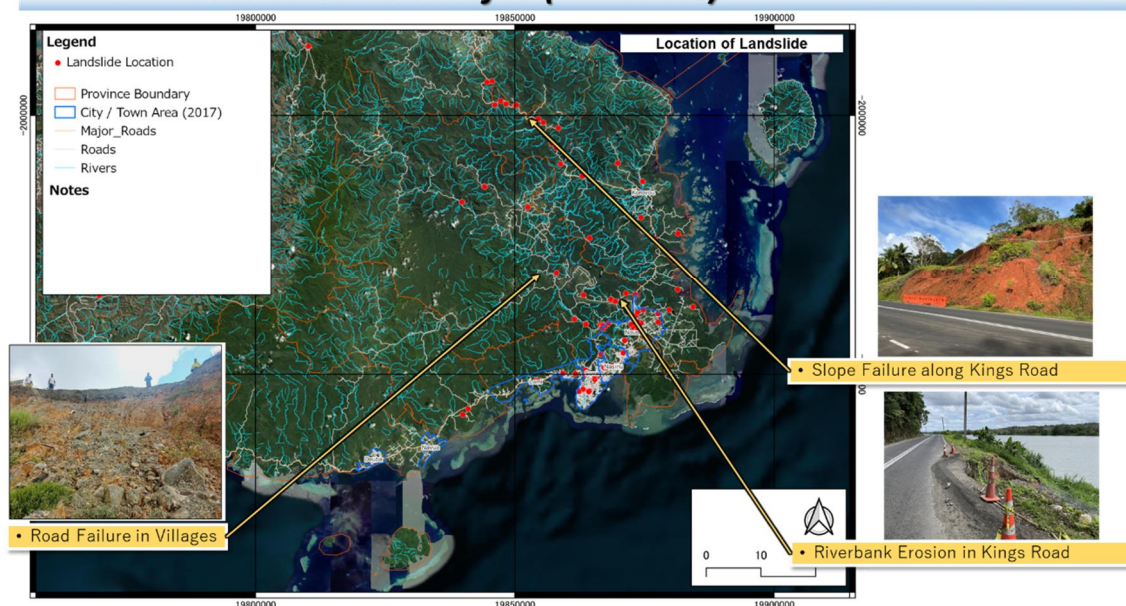


Figure 8 Risk Profile for Central Division for Landslide

DRR Plan Section 3: Risk Profile (Coastal Disaster)

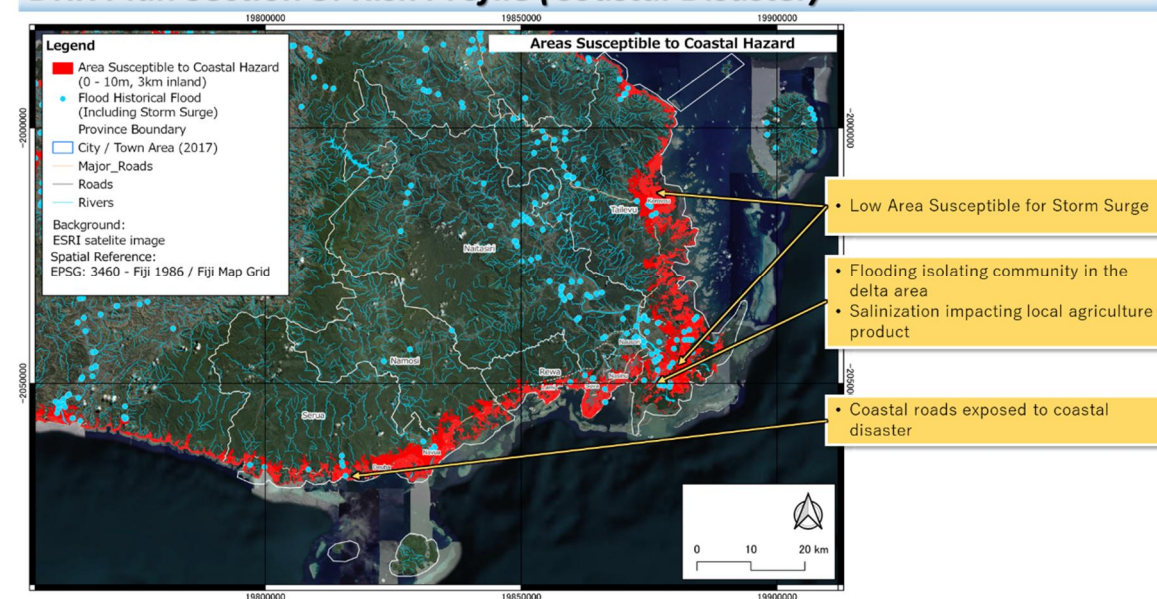


Figure 9 Risk Profile for Central Division for Coastal Disaster

Considering the above different situations, different approaches that prioritize the effective DRR activities were taken.

Based on the challenges and solutions identified from the individual consultation, NDMRO have determined the DRR direction in the Central Division. Considering the expanding urbanization in greater Suva metropolitan area, the importance of risk-informed development to avoid future development in high-risk areas was identified as DRR direction.

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In addition, with increasing intensity of rainfall and changing land use, flood management with focus on urban expansion area was also identified as DRR direction.

Specific DRR activities will be organized in line with the DRR Direction and divided into existing urban areas, newly developing urban areas, and village areas. The content of the Priority Area Plan was discussed with the Planning Officers of the Cities and Towns.



Figure 10 DRR Direction Identified in the Central Division

[Output 2/Task-7] Provide technical support to implement priority DRR measures identified in the Local DRR Plans developed in pilot areas (PDM Activity 2-3)

Discussions on specific disaster prevention infrastructure measures in the Priority Areas of the Central Division were considered. Based on consultations with the NDRMO and the discussion in the local level, the countermeasure proposals were considered.

The Project for Mainstreaming Disaster Risk Reduction PM Form 3-1 Monitoring Sheet Summary

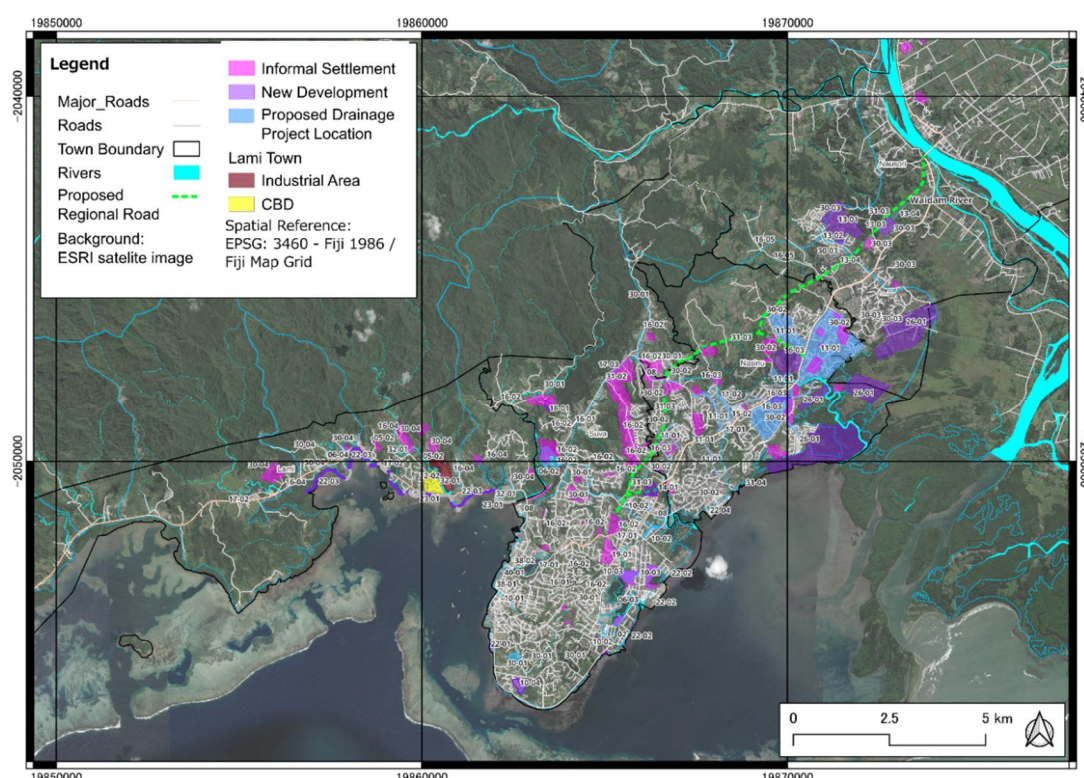
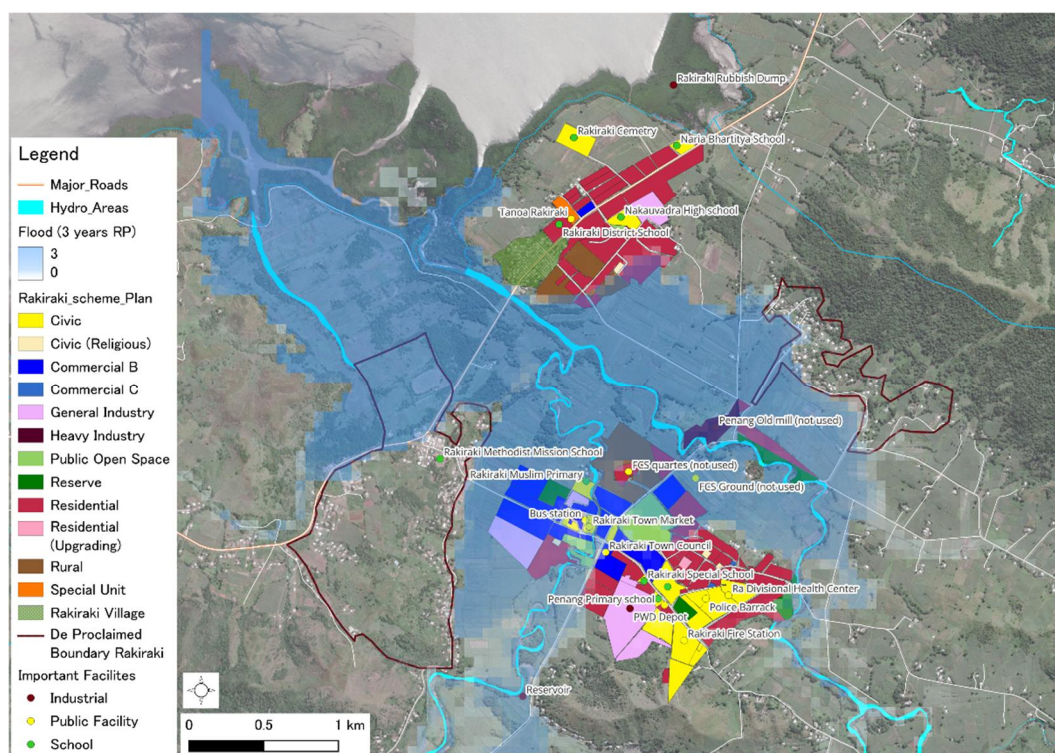


Figure 11 Countermeasure Proposals in the Greater Suva Metropolitan Area

[Output 2/Task-8] Provide technical assistance to implement the action plan and the monitoring and evaluation procedures in order to ensure the nationwide formulation, implementation and revision of Local DRR plans (PDM Activity 2-5)

The formulation of the DRR plan in the divisional level has been included in the Fiji National Development Plan 2025 – 2029 and Vision 2050 (NPDP) which was endorsed in November 2024. In the National Development Plan, it is targeted to develop 2 divisional DRR plan by 2027 and to cover all the division DRR plan by 2029. NDRMO is currently leading the activity to formulate the Divisional DRR plan for the Central Division, it is expected for NDRMO to continue this activity. In addition, in the Western Division, as an expansion of DRR plan in the Priority Area, the NDRMO targeted Rakiraki and have conducted consultations with the town council.

Based on the National Development plan, it is expected for NDRMO and the divisional office to secure the budget for the formulation, implementation and revision of the local DRR plans. The “Guide on the DRR Plan Formulation in Fiji” was updated based on the lessons from the DRR plan formulation activity in the Central Division.



**Figure 12 Overlay of Flood Inundation Risk with Facilities
to be Protected and Land Use Plan in Rakiraki Town**

(4) Output 3

[Output 3/Task-7] Assess and upgrade the system to plan, implement, monitor and review DRR activities (PDM Activity 3-3)

As a result of the first period of the project, one of the goals in the National Development Plan 2025-2029 (NDP), which was reviewed by the new administration due to strong advocacy from NDRMO, is "Building resilience through risk informed socioeconomic development". A specific indicator for this goal is the development of DRR Divisional Plans across all divisions.

In the first half of the roadmap, titled "NDRRP Roadmap for LDP Development," NDRMO addresses this indicator and have decided to monitor the development status of Division DRR Plans and Priority Area DRR Plans. The methods and responsible parties for conducting monitoring will be outlined in the forthcoming monitoring guidelines. Here, WG3 also refer to the NDRRP M&E conducted separately by NDRMO and its implementation guidelines, proposing ways to minimize the burden on both NDRMO and implementing agencies as much as possible.

In the latter part of the roadmap, titled "NDRRP Roadmap for LDP Implementation," WG3 are considering a method to aggregate the monitoring results of each LDP's implementation

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status. The monitoring system is being discussed by WG2 and Commissioner Offices, with WG3 also joining this discussion to create synergy.

[Output 3/Task-8] Conduct inter-organizational meetings under NDRMC on the planning, implementation and monitoring of DRR activities (PDM Activity 3-4)

The National Disaster Risk Management Act, which was reformed in October 2024, determines that the NDRMC must meet at least twice a year. The act establishes the function of the Disaster Risk Reduction Committee guided by the NDRMC.

NDRMO is proposing discussion subjects to the Committee to endorse the outputs of the project.

As stated above, while the NDRMC is mandated by law, its actual scheduling depends on the minister's availability. To facilitate regular meetings, both NDRMO and the project will make efforts to frequently provide input to the minister and the PS regarding the importance of these councils and DRR-related proposals that they wish to discuss. The DRR Committee was held instead of the NDRMC.

[Output 3/Task-9] Support the mainstreaming of DRR into activities implemented by related organizations (PDM Activity 3-5)

WG3 have held consultations with the following organizations to concretize the DRR related activities outlined in the roadmap. WG3 visited Commissioner Office Western for the endline survey and revealed that one-third of the projects listed in the Western Division DRR Plan and Priority Area DRR Plan are in progress. WG3 will reflect these contents and update both the roadmap and monitoring guidelines accordingly.

The following table shows outlines of discussion for DRR project promotion.

Table 6 Outlines of Discussion for DRR Project Promotion

Date	Agencies and Organizations	Main Subjects
Mar. 14, 2025	MRMDDM	• Discussion on Local DRR Plans and Promotion of Implementation
May 13-29, 2025	NDRMO	• Discussion on Local DRR Plans and Promotion of Implementation
May 14, 2025	MRMDDM	• Discussion on Local DRR Plans and Promotion of Implementation
May 15, 2025	MFSPNDS	• Discussion of DRR Fund
June 6, 2025	NDRMO	• Discussion on Local DRR Plans and Promotion of Implementation
June 27, 2025	MRD	• Discussion on Promotion of Implementation
June 30, 2025	NDRMO	• Discussion on Promotion of Implementation
July 1, 2025	Commissioner Office Central	• Discussion on Promotion of Implementation

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Date	Agencies and Organizations	Main Subjects
July 2, 2025	Commissioner Office Western	• Discussion on Promotion of Implementation
July 4, 2025	FMS	• Discussion on Promotion of Implementation

[Output 3/Task-10] Organize a system for the publication of the DRR white paper (PDM Activity 3-6)

DRR White Paper was renamed to DRR Annual Report for Fiji. Contents and function of the document were kept.

NDRMO prepared a council paper for DRR Annual Report FY22-23 to submit the report to the DRR Committee and NDMC. In the council paper, NDRMO highlighted that Annual Report is to be published annually.

Annual Report FY23-24 is currently being drafted. There are some difficulties to collect required information within the Ministry.

1.3 Achievement of Output

Following table shows the objectively verifiable indicators to evaluate the achievement of each Output based on the PDM, and the progress of each achievement.

Table 7 Achievement of each Outputs

Outputs	Objectively verifiable indicators	Progress
Output 1	The hazard assessment guideline and the expansion plan are developed	The guidelines to assess flood, sediment disasters, coastal disasters and earthquakes were developed. Draft nationwide explanation plan was developed.
	Hazard assessments are conducted with technical agencies at pilot areas	Preliminary assessments and Enhanced assessments have been conducted for the Central Division.
	The results of hazard assessments are shared at meetings under NDRMC structure	The Central Division DRR Plan consisting of the results of hazard assessments was endorsed in the DRR Committee under NDRMC.
Output 2	Local DRR plans based on the results of hazard assessments at pilot areas with the assistance of JICA experts and NDRMO are developed	Local DRR Plan in the Western Division (Divisional Plan and the Priority Area Plan in selected areas (Nadi, Ba)) was developed and endorsed in the DRR Committee. Local DRR Plan in the Central Division is now being formulated.
	A guideline to develop, implement and review a local DRR plan is developed, revised based on lessons learned and uploaded on the website of NDRMO	A guideline for DRR planning was drafted, but has not yet been uploaded on the website of NDRMO.
	A plan to expand local DRR plan nationwide is developed	A plan to expand local DRR Plan nationwide was drafted.
Output 3	A road map to implement prioritized actions of NDRRP (NDRRP road map) is developed	NDRRP Roadmap with 2 sections, one for LDP development and the other for LDP implementation was drafted.
	DRR-related meetings under NDRMC structure are held	The DRR Committee was held in March 2025.
	A guideline to plan, implement, monitor and revise the NDRRP road map is developed	- Initial idea of Monitoring & Evaluation method has been proposed. - DRR Annual Report was endorsed.

1.4 Achievement of Project Purpose

Following table shows the objectively verifiable indicators to evaluate the achievement of project purpose based on the PDM, and the progress of each achievement.

Table 8 Achievement of Project Purpose

No.	Objectively verifiable indicators	Progress
1	A DRR white paper is issued every year (from the second year of the project) and referred to in reports, speeches, websites and so on.	The DRR White Paper (The DRR Annual Report for Fiji) FY2022-2023 was endorsed in the DRR Committee held in March. And it is introduced in the World Bosai Forum. The FY2023-2024 is now being drafted.
2	The prioritized actions in the NDRRP road map are implemented and monitored.	Partially achieved. Some DRR related activities listed in the plan for the Western Division were implemented and monitored by Commissioner Office Western or related agencies. However, formulation of the DRR plans in the Northern and Eastern Divisions are prioritized in the NDRRP road map, and they have been included as one of the Key Performance Indicator (KPI) in Fiji National Development Plan.
3	Local DRR plans for 2 divisions are developed based on the results of hazard assessments with the assistance of NDMO and related agencies.	Local DRR plan for the Western Division was developed and the plan for the Central Division is about to finalized.

1.5 Changes of Risks and Actions for Mitigation

N/A

1.6 Progress of Actions undertaken by JICA

N/A

1.7 Progress of Actions undertaken Gov. of Fiji

N/A

1.8 Progress of Environmental and Social Consideration (if applicable)

N/A

1.9 Progress of Considerations on Gender/Peace Building/Poverty Reduction (if applicable)

N/A

1.10 Other remarkable/considerable issues related/affect to the project (such as other JICA's projects, activities of counterparts, other donors, private sectors, NGOs etc.)

N/A

2. Delay of Work Schedule and/or Problems (If any)

2.1 Details

Delay in work due to the retirement of the DRR Officer at the Commissioner Central Office.

2.2 Cause

Written in 2.1.

2.3 Actions to be taken

The NDRMO officer in charge of the Western Division will share his experiences and explain the achievements, history of past activities and future activities with the newly assigned NDRMO officer in charge of the Central Division to ensure the continuity of the project. Increase the input of Japanese Experts to support the activities.

2.4 Roles of responsible Persons/Organization (JICA, Government of Fiji, etc.)

Appropriate personnel allocation and support from the Government of Fiji.

3. Modification of the Project Implementation Plan

3.1 Plan of Operation (PO)

Due to the suspension of the Project in the COVID19 pandemic, extension of the Project period was agreed in a JCC meeting in the first period and R/D was updated. The current PO was modified based on the R/D.

3.2 Other Modifications on Detailed Implementation Plan

N/A

4. Preparation of the Government of Fiji toward after the Completion of the Project

N/A

II. Project Monitoring Sheet I & II

as Attached

The Project for Mainstreaming Disaster Risk Reduction
PM Form 3-1 Monitoring Sheet Summary

Abbreviations

Abbreviations	English
a/~	Acting ~ (ex. a/PS stands for Acting Permanent Secretary)
BCP	Business Continues Plan
CCA	Climate Change Adaptation
C/P	Counterpart
DBGA	Department of Building and Government Architect
DDM	Director for Disaster Management
DoE	Department of Energy
DLG	Department of Local Government
DRR	Disaster Risk Reduction
DWS	Department of Water and Sanitation
EFL	Energy Fiji Limited
EMS	European Macroseismic Scale
FAL	Fiji Airports Limited
FMS	Fiji Meteorological Service
FNBC	Fiji National Building Code
FNU	Fiji National University
FPCL	Fiji Ports Corporation Limited
FRA	Fiji Road Authority
GEM	Global Earthquake Model
GIS	Geographic Information System
HQs	Headquarters
IFRC	International Federation of Red Cross and Red Crescent Societies
JCC	Joint Coordination Committee
JICA	Japan International Corporation Agency
JMA	Japan Meteorological Agency
M&E	Monitoring and Evaluation
MAW	Ministry of Agriculture and Waterways (former MAWE)
MAWE	Ministry of Agriculture, Waterways and Environment
MCTTT	Ministry of Commerce Trade, Tourism and Transport
MDNP	Ministry of Defense, National Security and Policing
M&E	Monitoring and Evaluation
MEPIR	Ministry of Employment, Productivity and Industrial Relations
MFSPNDS	Ministry of Finance, Strategic Planning, National Development and Statistics (former MoE)
MHCD	Ministry of Housing and Community Development
MHLG	Ministry of Housing and Local Government (former Dept. of Housing, MHCD and DLG)
MHMS	Ministry of Health and Medical Services
MIMS	Ministry of Infrastructure and Meteorological Services
Min.iTaukei	Ministry of iTaukei Affairs
MLIT	Ministry of Land, Infrastructure, Transport and Tourism of Japan
MLMR (MoLand)	Ministry of Lands and Mineral Resources
MLGEHA	Ministry of Local Government, Education, Heritage and Arts
M/M	Meeting Minutes
MoC	Ministry of Communication
MoE	Ministry of Economy
MoFA	Ministry of Foreign Affairs
MoYS	Ministry of Youth and Sports

The Project for Mainstreaming Disaster Risk Reduction
PM Form 3-1 Monitoring Sheet Summary

Abbreviations	English
MPWMST	Ministry of Public Works, Meteorological Services and Transport (former MIMS)
MRD	Mineral Resources Department
MRMDDM	Ministry of Rural and Maritime Development and Disaster Management (former MRMD)
MRMD	Ministry of Rural and Maritime Development
MTCA	Ministry of Tourism and Civil Aviation
MWCPA	Ministry of Women, Children and Poverty Alleviation
NDMC	National Disaster Management Council
NDMO	National Disaster Management Office
NDRMO	National Disaster Risk Management Office (former NDMO)
NDRRP	National Disaster Risk Reduction Policy
NRW	Non-Revenue Water
OCG	Oriental Consultants Global
OCW	Office of Commissioner Western
OPM	Office of the Prime Minister
PGA	Peak Ground Acceleration
PS	Permanent Secretary
PSIP	Public Sector Investment Programme
R/D	Record of Discussion
RMR	Policy, Research and Risk Management Unit
RRI model	Rainfall-Runoff-Inundation model
SAO	Senior Administrative Officer
SPC	The Pacific Community (former the South Pacific Commission)
TAF	Telecommunication Authority of Fiji
UNDRR	United Nations Office for Disaster Risk Reduction
USGS	United States Geological Survey
USP	University of South Pacific
WAF	Water Authority of Fiji
WG	Working Group

Project Design Matrix

Project Title: Project for Mainstreaming Disaster Risk Reduction
Implementing Agency: National Disaster Management Office
Target Group: Officials of NDMO and relevant agencies
Period of Project: December 2020 - November 2025
Project Site: Suva
Model Site: Western Division and Central Division

Version 2.0 (2nd Period)
Dated 31 August 2025

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumption	Achievement	Remarks
Overall Goal DRR activities in the NDRRP roadmap are implemented under the coordination of NDMO.	- A DRR white paper is issued every year - NDRRP roadmap is regularly monitored at meetings under NDMC structure - Number of local DRR plans are increased	- DRR white papers - Reports, media articles, press releases, speeches, websites - NDRRP monitoring sheet - Local DRR plans		Partially achieved.	
Project Purpose Capacity of NDMO is strengthened to implement and promote DRR activities in line with the international, regional and national policies.	- A DRR white paper is issued every year (from the 2nd year of the project) and referred to in reports, speeches, websites and so on. - The prioritized actions in the NDRRP roadmap are implemented and monitored - Local DRR plans for 2 divisions are developed based on the results of hazard assessments with the assistance of NDMO and related agencies	- DRR white papers - NDRRP monitoring sheet - Reports, media articles, press releases, speeches, websites - Local DRR plans		Partially achieved.	
Outputs 1. The capacity to assess hazards scientifically is strengthened in collaboration with technical agencies	- The hazard assessment guideline and the expansion plan are developed - Hazard assessments are conducted with technical agencies at pilot areas -The results of hazard assessments are shared at meetings under NDMC structure	- The hazard assessment guideline - The expansion plan - Hazard maps - Meeting minutes		-Draft guidelines to assess Flood, Sediment disasters, Tsunami, Storm surge an earthquake are developed. -Some assessments in the pilot areas have been conducted on Flood, Sediment disasters, Tsunami and Storm surge. -After some online assessment, desktop based assessments to Western division was conducted. -Scenario-based earthquake mapping was examined as enhanced assessment and population exposure was mapped to for Local DRR plans. -The assessments are completed and shared to the relevant agencies.	
2. The implementation system is established to develop practical local DRR plans nationwide.	- Local DRR plans based on the results of hazard assessments at pilot areas with the assistance of JICA experts and NDMO are developed - A guideline to develop, implement and review a local DRR plan is developed, revised based on lessons learned and uploaded on the website of NDMO - A plan to expand local DRR plan nationwide is developed	- The guideline on local DRR plans - The plan to expand local DRR plans nationwide - Local DRR plans at pilot areas		-Divisional Plan in the Western Division and the priority area plan in selected areas (Nadi, Ba) was formulated and awaiting for the official approvalment by the council. -Formulation of the DRR plan have been included as one of the Key Performance Indicator (KPI) in Fiji National Development Plan -Divisional Plan in the Central Division including the priority area plan and priority area plan for the Rakiraki town in Western division has been initiated leaded by NDRMO.	
3. The functions to promote DRR investment are enhanced at a national level in consideration with CCA	- A roadmap(*) to implement prioritized actions of NDRRP (NDRRP roadmap) is developed - DRR-related meetings under NDMC structure are held - A guideline to plan, implement, monitor and revise the NDRRP roadmap is developed	- The NDRRP roadmap - Meeting minutes - The guideline on the NDRRP roadmap		-NDRRP Roadmap was developed. -The DRR Committee was held in March 2025. -Initial idea of Monitoring & Evaluation method has been proposed. -DRR Annual Report was developed and approved.	
Activities	Inputs		Important Assumption		
1-1 Conduct a survey on the present status of hazard assessments (including roles and responsibilities among agencies) in Fiji and identify issues 1-2 Examine methodologies to assess hazards based on the present status in Fiji 1-3 Conduct hazard assessments of targeted disasters at pilot areas 1-4 Develop a guideline to assess hazards and a plan to expand the assessments nationwide	The Japanese Side	The Fijian Side	- Huge disasters which negatively affect project implementation do not happen during the project period		
	(1) Assignments of Experts 1) Leader/ DRR Governance 2) DRR Activity Management 1 3) Deputy Team Leader / Local DRR Planning 4) Disaster Risk Assessment 1 5) Disaster Risk Assessment 2 (Coastal Disaster / Climate Change) 6) Earthquake Disaster 7) Building Standards 8) Infrastructure Design Standards 9) Topographic Map / GIS 1 10) Project Coordination / Capacity Development 11) DRR Activity Magagement 3	(1) Assignments of Counterparts (2) Cooperation of relevant agencies (3) Office space with facilities necessary for the Project (4) Running expenses for project activities (salary, travel/daily allowance, etc.)			
	(2) Short-term Training in Japan 1) DRR Governance 2) Local DRR Planning (3) Provision of equipment Referral data for hazard assessments (4) Local operational costs				
	2-1 Examine the optimal way to implement local DRR planning and expand them nationwide based on the present conditions in Fiji 2-2 Develop local DRR plans of pilot areas in accordance with a practical development process 2-3 Conduct technical supports to implement prioritized DRR measures in the plans 2-4 Prepare a guideline to develop and implement local DRR plans based on the results and the lessons learned from pilot activities 2-5 Develop an implementation plan to expand Local DRR plans, and its monitoring and evaluation procedures				
3-1 Conduct a survey on the system and capacity to plan, implement, monitor and review DRR activities at a national level, and identify issues.					
3-2 Develop a practical road map(*) to invest in DRR activities based on related national DRR/CCA plans and policies.					
3-3 Establish a system to plan, implement, monitor and review DRR activities implemented by related agencies					
3-4 Conduct meetings under NDMC structure among related organizations to implement the above activities					
3-5 Support mainstreaming DRR into activities implemented by related organizations					
3-6 Organize a system to issue a DRR white paper					

*Roadmap is defined as an implementation plan of prioritized activities of NDRRP including the expected budget allocation with time frame

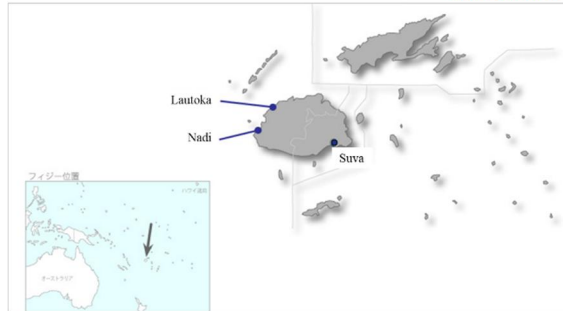
The Project for Mainstreaming Disaster Risk Reduction

Keywords; NDRMO, Divisional DRR Plan, Priority Area Plan,
DRR Annual Report for Fiji



1. Project Outline

- The Project for Mainstreaming Disaster Risk Reduction
- Implementation Period of the Project
The First Period: From December 2020 to July 2024 (44 M)
The Second Period: From August 2024 to November 2025 (16 M)
- Project Area: Republic of Fiji
- Counterparts:



Implementation Organization:

National Disaster Risk Management Office (NDRMO)

Related Agencies:

Ministry of Rural and Maritime Development and Disaster Management (MRMDDM)
Ministry of Public Works, Meteorological Services and Transport (MPWMST)
Ministry of Finance, Strategic Planning, National Development and Statistics (MFSPNDS)
Ministry of Housing and Local Government (MHLG)
Ministry of Agriculture and Waterways (MoAW)
Fiji Meteorological Services (FMS)
Mineral Resources Department (MRD)

- Targeted disasters in this project;

Flood, cyclone, storm surge, landslide, earthquake, tsunami

- Background of the Project and Issues

In Fiji, flooding occurs almost every year due to cyclone and rain front. There is also a risk of tsunami due to earthquakes frequently occurring in the surrounding ocean. In addition to these hazards, vulnerabilities brought about by living in small, reclusive and remote island countries, increase the disaster risk in Fiji. This is why **Disaster Risk Reduction (DRR)** is an urgent issue in promoting the sustainable development of Fiji.

The National Disaster Risk Management Office (NDRMO) has the responsibility to develop and monitor the implementation of DRR plan and to coordinate related agencies based on the National Disaster Management Plan (NDMP) developed in 1995 and the National Disaster Management Act (NDMA) passed in 1998.

However, there are several challenges in the institutional framework for the development of national and local DRR plans, and for the implementation of DRR projects, in hazard assessment, etc. Given this situation, **Japan International Cooperation Agency (JICA)** received the request to implement the “Project for Mainstreaming DRR” which will enhance the capacity of NDRMO.

Overall Goal

DRR activities in the NDRRP roadmap re implemented under the coordination of NDRMO.

Project Purpose

Capacity of NDRMO is strengthened to implement and promote DRR activities in line with the international, regional and national policies. Three Outputs are targeted to achieve this Project Purpose.

Outputs

Output 1: The capacity to assess hazards scientifically is strengthened in collaboration with technical agencies.

Output 2: The implementation system is established to develop practical local DRR plans nationwide.

Output 3: The functions to promote DRR investment are enhanced at a national level in consideration with CCA.

2. Overall of the Project Progress

In the 1st period, NDRMO, FMS and MRD collaboratively conducted the hazard risk assessment (WG1). NDRMO and Commissioner Western Office conducted the formulation of **the Divisional DRR Plan** for Western Division (WG2). To promote the above DRR activities at the national level, NDRMO has formulated **a Roadmap** for the planning, implementation, monitoring, and revision of DRR activities. NDRMO has published **the DRR Annual Report for Fiji 2022-2023**, the first comprehensive report on DRR activities in Fiji (WG3). Both achievements have been approved by the DRR Committee for the 2024-2025 fiscal year. **Guidelines** for implementing DRR activities are developed.

In the 2nd period, **led by the NDRMO**, efforts are underway to **horizontally expand** the formulation of the above-mentioned plans to the Central Division by utilizing the guidelines. In addition, the implementation status of the roadmap formulated during the 1st period was monitored, along with an assessment of the adequacy of the mechanisms for planning, implementation, monitoring, and revision of the project.

Study Programs in Japan

As part of this Project, Fijian national government officers joined a training program in Japan for six practitioners including DRR Officers in August 2023. A high-level invitation program to Japan was conducted for senior officials of MRMDDM including the Minister, in October 2024. Through site visits and discussions with **JICA**, and Japanese relevant agencies, participants learned about the history of disasters in Japan, DRR policies, the importance of pre-disaster measures, the formulation and promotion of DRR policies, as well as practical challenges and strategies for implementation. They also explored ways to apply these insights to the promotion of DRR in Fiji.

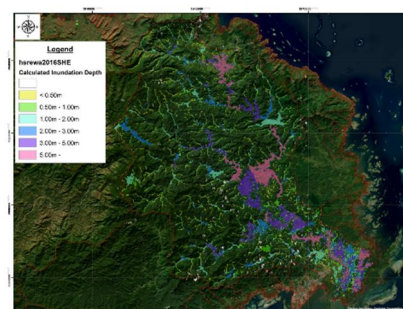


Site visit in Japan

3. Activities of Output 1

Working Group 1 (WG1) including NDRMO, FMS, MRD and JICA Project Team members for Output 1 conducted preliminary hazard assessments for targeted disasters, and developed and improved guidelines for the assessments.

In the 1st period, the current status and challenges of hazard assessment in Fiji were organized, hazard assessment methods were examined, and hazard assessments for targeted disaster were conducted in the Western Division. First, a **preliminary hazard assessment** was conducted for the entire Western Division. Next, risk assessments were carried out by WG2, and priority areas were selected (as described later in the activities of Output 2): **Ba Town for floods** and **Nadi Town for coastal disasters** (storm surge and tsunami). WG1 then conducted more **enhanced hazard assessments** for these priority areas, completing detailed evaluations. Additionally, guidelines for hazard and risk assessments and a nationwide expansion plan were developed.



Preliminary hazard assessment result for flood in Central Division

In the 2nd period, hazard assessments are being conducted in the Central Division. Additionally, as a continuation of development for Priority Area Plan in the Western Division, enhanced hazard assessments are conducted in **Rakiraki**.

There are challenges in **recording disaster histories** which are necessary to calibrate the results of hazard assessments. Recommendations to promote on-site damage surveys as well as collaborative field surveys have also been made.

4. Activities of Output 2

WG2 (JICA Project Team members for Output 2) formulates the "**Divisional DRR Plan**" to establish fundamental DRR strategies and the "**Priority Area DRR Plan**" to concretize DRR measures.

In the 1st period, the Western Division DRR Plan was formulated. After organizing and analyzing basic data and development policies of the Western Division and reviewing the basic concept and activity plan of the Western Division DRR Plan, priority areas were selected, and Priority Area Plans were developed as mentioned above.

In the plan formulation, NDRMO and the Commissioner Western Office took the lead, involving division officers from line ministries and town councils in the discussions. Divisional DRR Plans were approved by the **DRR committee**, and the implementation of disaster prevention infrastructure measures is anticipated.

In the 2nd period, the Central Division DRR Plan is being formulated. NDRMO consulted with relevant technical agencies, the Commissioner Central Office, and city and town authorities, and collected development plans from various sectors, and **the Greater Suva Area** was designated as the Priority Area for Priority Area Plan. In the Central Division DRR Plan, **the DRR Direction**, which considers **long-term urban expansion** and **land use changes** in the Greater Suva Area and increased rainfall intensity due to **climate change**, was also organized.



Consultation with relevant agencies

5. Activities of Output 3

WG3 (JICA Project Team members for Output 3) aims to **promote the implementation of DRR projects** by reviewing and improving the disaster activity plans and the mechanisms for their implementation and monitoring, through consultations with relevant agencies.

In the 1st period, they finalized a draft roadmap to promote the implementation of the National Disaster Risk Reduction Policy (NDRRP) and prepared **the DRR Annual Report for Fiji**. Based on

NDRMO's efforts in this project, DRR was addressed as a separate chapter in the revised **National Development Plan 2025-2029 (NDP)** updated in 2024, highlighting the increased importance of DRR within Fiji.

Furthermore, within the NDP, the number of Divisional DRR Plans formulated was established as one of the Key Performance Indicators (KPIs), creating a system to monitor the progress of plan formulation.

In the 2nd period, the progress of the roadmap formulated in the 1st period is being monitored, and the DRR Annual Report for Fiji is published. Moreover, consultations with domestic and international organizations are being conducted to promote the implementation of DRR projects.

6. Ways forward

NDRMO is expected to carry out the following tasks after the end of this project.

- Enhancement of hazard maps and leading preliminary surveys for that purpose.
 - Implementation of rapid assessments after disasters, particularly recording flood depths.
- **Monitoring and promoting the implementation** of established Divisional DRR Plans and Priority Area Plans.
 - Effective monitoring implementation requires cooperation from the implementing ministries in providing relevant information for monitoring, and reference to DRR Plans in their business plans.
- **Promoting the formulation of the Divisional DRR Plans in the Eastern and Northern Divisions** in accordance with the National Development Plan.
- **Promoting the formulation of the Priority Area DRR Plans in the Western and Central Divisions.**
- **Establishment of an annual publication mechanism** for the DRR Annual Report for Fiji, and **prompt reporting and approval** by the National Disaster Management Council.
- **Implementation of promotion and monitoring of DRR activities** in accordance with the Local DRR Plan's Roadmap.



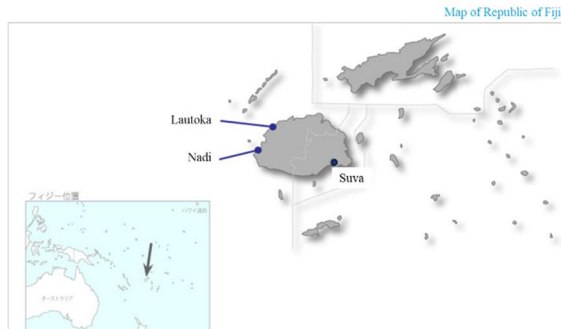
The Project for Mainstreaming Disaster Risk Reduction

Keywords; DRR, NDRMO, Divisional DRR Plan, Priority Area Plan, DRR Annual Report for Fiji, Climate Change, Risk-informed Development



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Mineral Resources Department (MRD)

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- Background of the Project and Issues

In Fiji, flooding occurs almost every year due to cyclone and rain front. There is also a risk of tsunami due to earthquakes frequently occurring in the surrounding ocean. In addition to these hazards, vulnerabilities brought about by living in small, reclusive and remote island countries, increase the disaster risk in Fiji. This is why **Disaster Risk Reduction (DRR)** is an urgent issue in promoting the sustainable development of Fiji.

The National Disaster Risk Management Office (NDRMO) has the responsibility to develop and monitor the implementation of DRR plan and to coordinate related agencies based on the National Disaster Management Plan (NDMP) developed in 1995 and the National Disaster Management Act (NDMA) passed in 1998.

However, there are several challenges in the institutional framework for the development of national and local DRR plans, and for the implementation of DRR projects, in hazard assessment, etc. Given this situation, **Japan International Cooperation Agency (JICA)** received the request to implement the “Project for Mainstreaming DRR” which will enhance the capacity of NDRMO.

Overall Goal

DRR activities in the NDRRP roadmap re implemented under the coordination of NDRMO.

Project Purpose

Capacity of NDRMO is strengthened to implement and promote DRR activities in line with the international, regional and national policies. Three Outputs are targeted to achieve this Project Purpose.

Outputs

Output 1: The capacity to assess hazards scientifically is strengthened in collaboration with technical agencies.

Output 2: The implementation system is established to develop practical local DRR plans nationwide.

Output 3: The functions to promote DRR investment are enhanced at a national level in consideration with CCA.

2. Overall of the Project Progress

In the 1st period, NDRMO, FMS and MRD collaboratively conducted the hazard risk assessment (WG1). NDRMO and Commissioner Western Office conducted the formulation of **the Divisional DRR Plan** for Western Division (WG2). To promote the above DRR activities at the national level, NDRMO has formulated **a Roadmap** for the planning, implementation, monitoring, and revision of DRR activities. NDRMO has published **the DRR Annual Report for Fiji 2022-2023**, the first comprehensive report on DRR activities in Fiji (WG3). Both achievements have been approved by the DRR Committee for the 2024-2025 fiscal year. **Guidelines** for implementing DRR activities are developed.

In the 2nd period, **led by the NDRMO**, efforts are underway to **horizontally expand** the formulation of the above-mentioned plans to the Central Division by utilizing the guidelines. In addition, the implementation status of the roadmap formulated during the 1st period was monitored, along with an assessment of the adequacy of the mechanisms for planning, implementation, monitoring, and revision of the project.

Study Programs in Japan

As part of this Project, Fijian national government officers joined a training program in Japan for six practitioners including DRR Officers in August 2023. A high-level invitation program to Japan was conducted for senior officials of MRMDDM including the Minister, in October 2024. Through site visits and discussions with **JICA**, and Japanese relevant agencies, participants learned about the history of disasters in Japan, DRR policies, the importance of pre-disaster measures, the formulation and promotion of DRR policies, as well as practical challenges and strategies for implementation. They also explored ways to apply these insights to the promotion of DRR in Fiji.



Site visit in Japan

3. Activities of Output 1

Working Group 1 (WG1) including NDRMO, FMS, MRD and JICA Project Team members for Output 1 conducted preliminary hazard assessments for targeted disasters, and developed and improved guidelines for the assessments.

In the 1st period, the current status and challenges of hazard assessment in Fiji were organized, hazard assessment methods were examined, and hazard assessments for targeted disaster were conducted in the Western Division. First, a **preliminary hazard assessment** was conducted for the entire Western Division. Next, risk assessments were carried out by WG2, and priority areas were selected (as described later in the activities of Output 2): **Ba Town for floods** and **Nadi Town for coastal disasters** (storm surge and tsunami). WG1 then conducted more **enhanced hazard assessments** for these priority areas, completing detailed evaluations. Additionally, guidelines for hazard and risk assessments and a nationwide expansion plan were developed.

In the 2nd period, hazard assessments are being conducted in the Central Division. Additionally, as a continuation of development for Priority Area Plan in the Western Division, hazard assessments are conducted in **Rakiraki**. The "**Nationwide expansion plan of hazard and risk assessments**" is about to finalize to help the continuation of development.

There are challenges in **recording disaster histories** which are necessary to calibrate the results of hazard assessments. Recommendations to promote on-site damage surveys as well as collaborative field surveys have also been made.

4. Activities of Output 2

WG2 (JICA Project Team members for Output 2) formulates the "**Divisional DRR Plan**" to establish fundamental DRR strategies and the "**Priority Area DRR Plan**" to concretize DRR measures.

In the 1st period, the Western Division DRR Plan was formulated. After organizing and analyzing basic data and development policies of the Western Division and reviewing the basic concept and activity plan of the Western Division DRR Plan, priority areas were selected, and Priority Area Plans were developed as mentioned above.

In the plan formulation, NDRMO and the Commissioner Western Office took the lead, involving division officers from line ministries and town councils in the discussions. Divisional DRR Plans were approved by the **DRR committee**, and the implementation of disaster prevention infrastructure measures is anticipated.

In the 2nd period, the Central Division DRR Plan is being formulated. NDRMO consulted with relevant technical agencies, the Commissioner Central Office, and city and town authorities, and collected development plans from various sectors, and **the Greater Suva Metropolitan Area** was selected as the Priority Area for Priority Area Plan, considering its concentrated population and the current situation of urban area expansion. Individual consultations were conducted to agencies responsible for each sector and Provincial Administrator in each Province in collecting the information such as challenges and planned projects by each sector, and development projects and projects related in DRR by each area. The challenges and solutions confirmed are summarized.



Consultation with relevant agencies

Challenges and Solutions Identified in each Sector

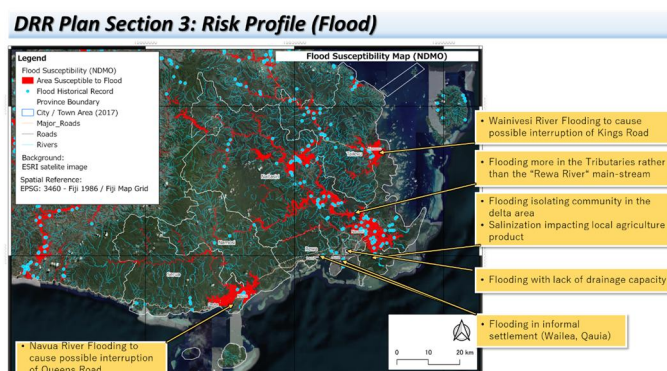
Sector	Challenges	Solution
Road	• High traffic volume in greater Suva • Insufficient drainage, Forest degradation and upstream development to increase run-off • Riverbank/Coastal erosion cause major impact	• Road network improvement in greater Suva • Resilient design for approach of bridges

		• Recovery for riverbank/coastal erosion and landslide measures implemented
Housing	• Improvement of Informal Settlement • Relocation of community in high-risk area	• Pilot project for informal settlement improvement and public housing
Town & Country Planning	• Update of the risk information in case to include hazard perspective to town and urban planning	• Advisory policy may be utilized for risk-informed development • Suva planning scheme under revision
Seismic	• Update of the Tsunami risk area (20m - 10m) • Lack in data and information for details Tsunami analysis	• Tsunami Ready activity to be continued • Tsunami Database to be developed including LiDAR observation

Challenges and Solutions Identified in each Area

Area	Challenges	Solution
Rewa	• Salinization in Rewa delta area impacting agricultural productivity • Access to villages in Rewa delta in flooding situation and flood gate is not functioning	• Improving access to villages in Rewa delta and in the islands • Improvement of drainage and flood gate in the Rewa delta area (consultation on-going)
Naitasiri	• Flooding from Wainimala river • Landslides damaging access roads • Providing relief items to mountain villages	• Relocation of houses damaged by flood • Construction of access roads for evacuation and response, evacuation centers.
Serua	• Landslide and coastal erosion impacting Queens road and villages • Flood in major rivers including Navua river • Island and coastal villages in high-risk area	• Improvement of seawalls • Dredging in major river (Navua river etc.) • Floodgate to prevent coastal disaster • Relocation of island and coastal villages

Based on the challenges and solutions, WG2 have determined the **DRR direction** in the Central Division. Considering the **long-term urban expansion** and **land use changes** in greater Suva metropolitan area and increased rainfall intensity due to **climate change**, the importance of **risk-informed development** to avoid future development in high-risk areas was identified as **DRR Direction**.



Risk Profile for Central Division for Flood



DRR Direction Identified in the Central Division

The “**Guide on the DRR Plan Formulation in Fiji**” was updated based on the lessons from the DRR plan formulation activity in the Central Division.

5. Activities of Output 3

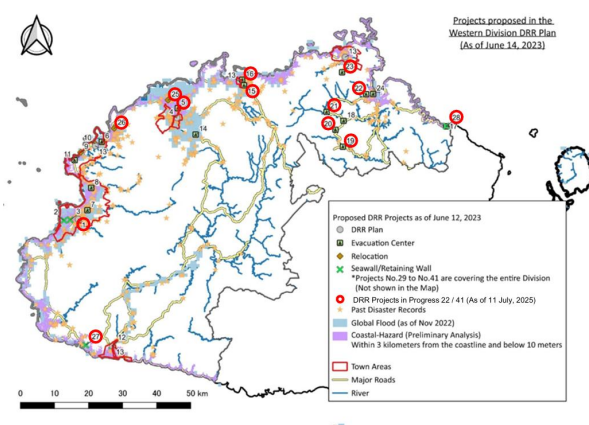
WG3 (JICA Project Team members for Output 3) aims to **promote the implementation of DRR projects** by reviewing and improving the disaster activity plans and the mechanisms for their implementation and monitoring, through consultations with relevant agencies.

In the 1st period, they finalized a draft roadmap to promote the implementation of the National Disaster Risk Reduction Policy (NDRRP) and prepared **the DRR Annual Report for Fiji**. Based on NDRMO’s efforts in this project, DRR was addressed as a separate chapter in the revised **National Development Plan 2025-2029 (NDP)** updated in 2024, highlighting the increased importance of DRR within Fiji.

Furthermore, within the NDP, the number of Divisional DRR Plans formulated was established as one of the Key Performance Indicators (KPIs), creating a system to monitor the progress of plan formulation.

In the 2nd period, the progress of the roadmap formulated in the 1st period is being monitored. According to our endline survey, it was revealed that 22 DRR Projects out of 41 Projects in the Western Division were in progress.

The DRR Annual Report for Fiji is published. Moreover, consultations with domestic and international organizations are being conducted to promote the implementation of DRR projects.



Status of the DRR Projects in the Western Division

6. Ways forward

NDRMO is expected to carry out the following tasks after the end of this project.

- Enhancement of hazard maps and leading preliminary surveys for that purpose.
 - Implementation of rapid assessments after disasters, particularly recording flood depths.
- **Monitoring and promoting the implementation** of established Divisional DRR Plans and Priority Area Plans.
 - Effective monitoring implementation requires cooperation from the implementing ministries in providing relevant information for monitoring, and reference to DRR Plans in their business plans.
- **Promoting the formulation of the Divisional DRR Plans in the Eastern and Northern Divisions** in accordance with the National Development Plan.
- **Promoting the formulation of the Priority Area DRR Plans in the Western and Central Divisions.**
- **Establishment of an annual publication mechanism** for the DRR Annual Report for Fiji, and **prompt reporting and approval** by the National Disaster Management Council.
- **Implementation of promotion and monitoring of DRR activities** in accordance with the Local DRR Plan's Roadmap.





Republic of Fiji

PROJECT for Mainstreaming of Disaster
Risk Reduction Project

Guideline on
Tsunami Hazard / Risk
Enhanced Assessment
~Enhanced Assessment~

December 2025

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

ORIENTAL CONSULTANTS GLOBAL
YACHIYO ENGINEERING CO., LTD
PACIFIC CONSULTANTS CO., LTD



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Chapter 1. Introduction

1.1 Introduction

Fiji is located in disaster prone area due to its geographical, geological and demographic conditions. Flood occurs almost every year due to cyclone and front. There is also a risk of tsunami due to earthquake frequently occurring in the surrounding ocean. In addition to these hazards, vulnerabilities brought about by living in small, reclusive, and remote island countries increase the disaster risk in Fiji. According to the World Risk Index 2018 released by UN University, Fiji is the 10th high-risk country among 171 countries in the world.

Fiji has a certain level of capacity for disaster response based on its experience with past disasters by coordinating related agencies from national to local levels. Furthermore, some efforts have been taken already for mainstreaming DRR and promoting the pre-investment for DRR by developing the “Fiji National Disaster Risk Reduction Plan (NDRRP) 2018-2019” based on international framework such as the Sendai Framework.

However, there are several challenges in the institutional framework for the development of national and local DRR plans, and for the implementation of DRR projects, in the hazard assessment, etc.

Based on this situation, the followings from the “Sendai Framework for Disaster Risk Reduction / SFDRR” are very important in Fiji.

- 1) Understanding disaster risk
- 2) Strengthening disaster risk governance to manage disaster risk
- 3) Investing in disaster risk reduction for resilience
- 4) Enhancing disaster preparedness for effective response, and to “Build Back Better” in recovery, rehabilitation, and reconstruction

As mentioned above, it is necessary to clarify the hazards in order to understand the actual situation of the disasters and to implement appropriate measures against disasters that are causing great damage.

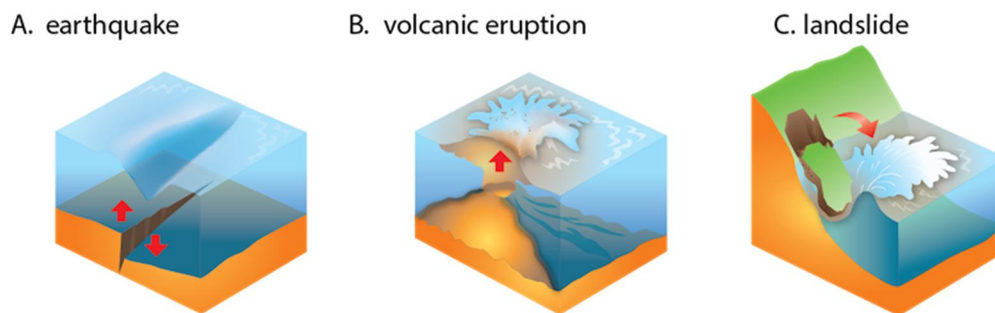
1.2 Major Types of Coastal Disaster

Coastal disasters are damage that happens at coastal area, mainly water related disaster. For example, tropical cyclone induces storm surge if it passes through coastal area and strong wind causes high wave, resulting in overtopping at coast. High wave also causes coastal erosion and sedimentation at coastal and river mouth. Not only meteorological phenomena, geological one (e.g., earthquake, land slide and eruption) can cause tsunami, which induces coastal inundation at coastal area.

This part will explain the coastal disasters in Fiji, referencing the technical reports and papers.

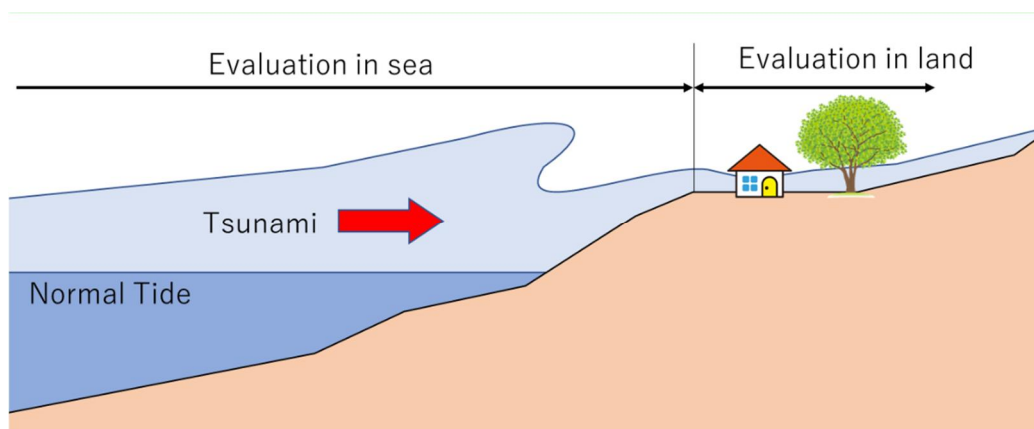
1.2.1 Tsunami

Tsunami is a large-scale wave propagation phenomenon in the ocean caused by sudden changes in seabed and coastal topography, and its main factors are earthquakes, landslides (sector collapse), volcanic activities, etc as shown in Figure 1-1. Tsunami caused by a sudden change in topography arrives at the coastal area, as shown in Figure 1-2, and when it exceeds the ground height or facility height, inundation to the land area occurs. Therefore, it is very important to appropriately estimate tsunami heights in coastal areas. Similar to storm surges, tsunamis are mainly caused by sudden changes in topography on the seaside of the shoreline as physical phenomena, and the behaviour of tsunamis in accordance with the bathymetry is determined. However, in land areas, inside of the shoreline, the extent of inundation and the behaviour of inundation flows are determined by land use conditions such as ground height, houses, commercial facilities, and agricultural lands. Therefore, this section outlines each method from a simplified method to a detailed method by dividing it into a hazard evaluation method on the seaside and on the land side as with tsunami.



Source: University of Hawaii website

Figure 1-1 Sources of tsunami



Source: JICA Survey Team

Figure 1-2 Image of tsunami in the coastal area

Chapter 2. Overall Method

2.1 Outline of Method

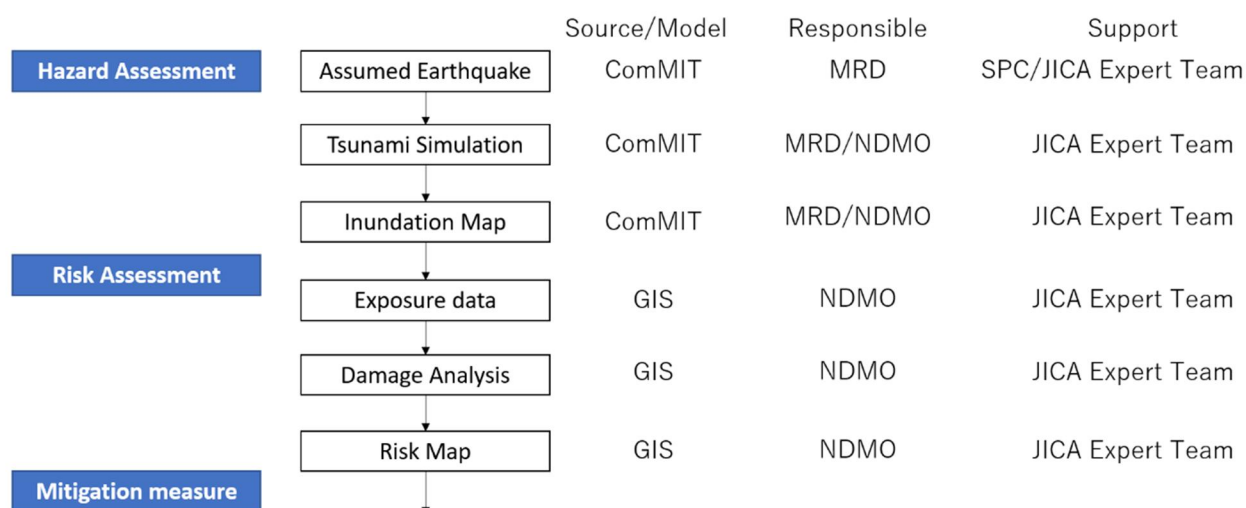
2.1.1 Purpose

The objective of this guideline is to conduct performance calculations for the initial condition of a tsunami and estimate tsunami height at coastal areas using the ComMIT tsunami model. This approach serves as a method for analysing simplified Tsunami Hazard and Risk Assessment in Fiji.

2.1.2 Tsunami Hazard & Risk Assessment

(1) Roles and responsibilities

MRD has conducted several tsunami simulations by using Tsunami Modelling, “ComMIT” developed by NOAA, from PTWC (Pacific Tsunami Warning Center). Using open-source ComMIT & GIS models after selection of the priority area, NDRMO & MRD jointly conduct simplified hazard and risk assessment under the support of SPC & JICA Expert Team in this DRR mainstreaming project.



Source: JICA Expert Team

Figure 2-1 Roles and Responsibilities of Hazard and Risk assessment: Tsunami

(2) Tsunami Hazard Map Related Projects

Figure 2-2 indicates three activities related to tsunami hazard map which depend on the detailed and simplified analysis.

The first activity, Tsunami Ready Program was conducted for target area, Cuvu with the support of UNESCO. The tsunami simulation and height were analyzed with ComMIT model, inundation was also analyzed by simulation. The target level of Hazard Map for Cuvu is observed less than MSL+5meters.

The third Former Method was conducted for Suva under NDRMO/MRD with the consideration of tsunami height experience of 10m/20m in the past. Inundation analysis was not conducted. The target level of Hazard Map for Suva is observed less than 10/20m.

The second activity is involved in the present DRR mainstreaming project with the support of JICA. The target area is Nadi. Similar to the first activity, tsunami simulation and estimation of tsunami height can be conducted by ComMIT model. The inundation analysis is supposed to be conducted with Fill Level Method and target level of Hazard Map of Nadi will be implemented later.

	Detailed		Simplified
	1. Tsunami Ready Program	2. DRR Mainstreaming	3. Former Method
Supporter	UNESCO	JICA	- (NDMO/MRD)
Target Area	<u>Cuvu</u>	<u>Nadi</u>	e.g., Suva
DEM	High resolution 10 m With LiDAR & Bathymetric data by SPC	SRTM (3s) or LiDAR	Mesh from 20 m contour (<u>MoL</u>)
Tsunami Source	Trench Earthquake(-M9.3) Inland Earthquake(-M7.9)	Trench Earthquake(M9.0) Inland Earthquake	No (experience)
Tsunami Height	By <u>ComMIT</u> simulation	By <u>ComMIT</u> simulation	10m/20m (experience)
Inundation	By simulation	Fill Level Method (tsunami height + HWL)	-
Hazard Map	Less than MSL+5m	???	Less than 10/20m

Source: JICA Expert Team

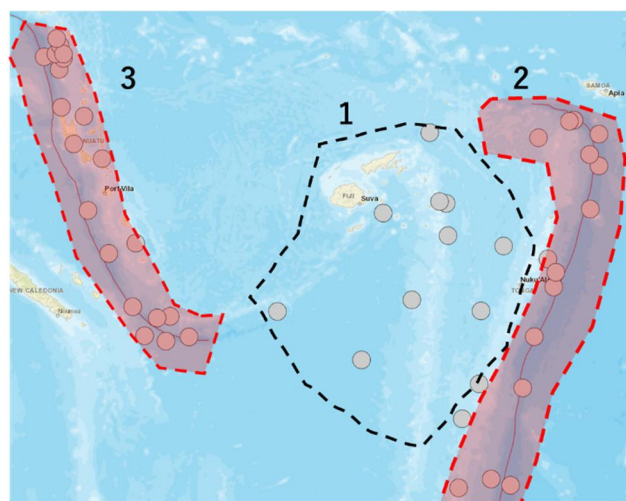
Figure 2-2 Activities related to the creation of Tsunami Hazard Map

(3) Assumed Earthquakes and Tsunamis

The following summarized the locations of Earthquakes around Fiji Islands from USGS database.

Table 2-1 Largest Earthquakes around Fiji Islands more than Magnitude 8.0

Date	Depth (km)	Magnitude
2018-08-19	600	8.2
1919-04-30	25	8.1
2009-09-29	18	8.1
1920-09-20	25	8.09
1917-06-26	15	8.0
1976-01-14	33	8.0
2006-05-03	55	8.0



Source: USGS Earthquake location map, more than Magnitude 7.5 around Fiji islands

Figure 2-3 Groups of Earthquakes around Fiji islands

The locations of earthquakes are categorized into 3 groups as follows:

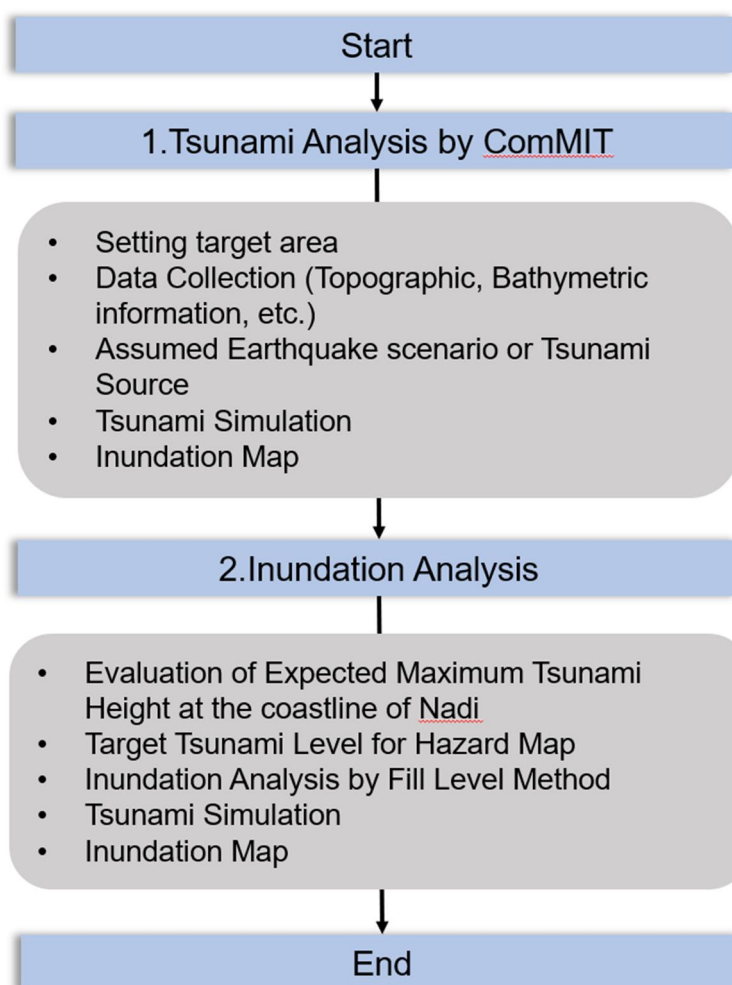
1. Inland
2. Tonga Trench
3. Vanuatu Trench

However, because it is difficult to assume the size and location of inland earthquake and tsunami, this guideline focuses on the earthquakes located in Tonga and Vanuatu Trench, namely group 2 and 3.

2.1.3 Analysis Flow

The enhanced hazard and risk analysis for tsunami disaster proposed in this project is following. The enhanced assessment applied the numerical simulation called “ComMIT model” by NOAA to evaluate tsunami height along coast line for various earthquakes and tsunamis. After these simulations, Inundation analysis will be conducted by using the results of tsunami heights from the simulations.

1. Tsunami Analysis by ComMIT
2. Inundation Analysis



Source: JICA Expert Team

Figure 2-4 Analysis Flow

2.2 Analysis Procedures

2.2.1 Tsunami Analysis by ComMIT

The first step in the analysis flow is to analyze the tsunami hazard that needs to estimate the tsunami height at coastal target area in Fiji. By considering the factors such as topographic & bathymetric information and assumed earthquake scenarios or tsunami source, a tsunami simulation by using open-source ComMIT model developed by NOAA can be conducted. Furthermore, the simulation results help to identify the potential tsunami impact on vulnerable areas.

2.2.2 Inundation Analysis

Following the hazard analysis, the next step is to conduct the inundation analysis by Fill Level Method that can access the inundated area/inundation depth of the target coastal area. This involves considering the maximum tsunami level (maximum tsunami height resulted in consideration of worst-case scenarios, highest astronomical tides) and ground elevation of target area.

Chapter 3. Tsunami Analysis by ComMIT

3.1 General Description of ComMIT

Tsunami models require information on: (1) bottom and coastal topography; (2) initial and boundary conditions; and (3) model run specific information such as time-step, spatial resolution, and length of model run.

ComMIT is an interface around NOAA's Method of Splitting Tsunamis (MOST) tsunami model. ComMIT is designed for ease of use and allows the dissemination of results to the community while addressing concerns associated with proprietary issues of bathymetry and topography. It uses initial conditions from a pre-computed propagation database, has an easy-to-interpret graphical interface, and requires only portable hardware. ComMIT was initially developed for Indian Ocean countries with support from the United Nations Educational, Scientific, and Cultural Organization (UNESCO), the United States Agency for International Development (USAID), and the National Oceanic and Atmospheric Administration (NOAA). ComMIT is written in the Java Programming languages and uses NetCDF format for model input and output parameters.

3.2 Purpose of Analysis

In the present tsunami study, the objective is to use the ComMIT software as a research tool to access potential tsunami sources from the New Hebrides Subduction Zone Earthquake and analyze the bathymetric data which generate predictions of tsunami wave height and expected inundation for the target coastal area, and identify the largest impact of the tsunami by representing the extremities of estimated maximum wave height over time arrival.

3.3 Analysis Flow

The analysis flow involves a systematic approach of tsunami simulation in order to identify the tsunami hazard map for a target coastal area. The general outline of the analysis flow of simulation by ComMIT model is as follows.

1. Setting Target Area
2. Setting Bathymetry for calculation
3. Setting Assumed Earthquake and Tsunami Source
4. Run ComMIT model
5. Confirmation of Results of Tsunami Simulation

The following parts will explain the details of tsunami analysis methodology, taking Nadi study and Suva study as an example.

3.3.1 Setting Target Area

The target area should be focused on by the simulation. This section focuses on assessing hazards in the coastal regions of Nadi and Suva as example, it encompasses analyzing earthquake risk, conducting tsunami simulations, and generating inundation maps utilizing the ComMIT model developed by NOAA.

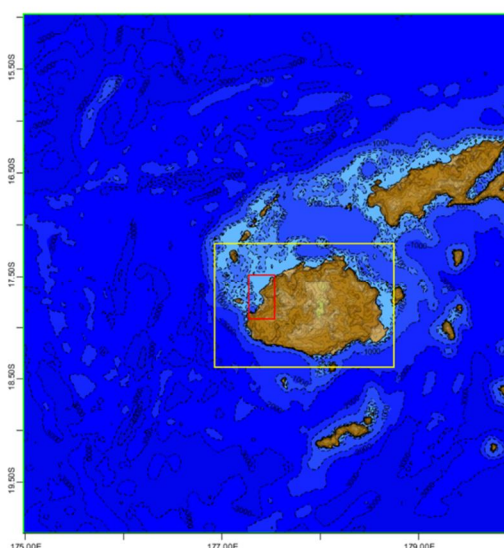


Source: OpenStreetMap

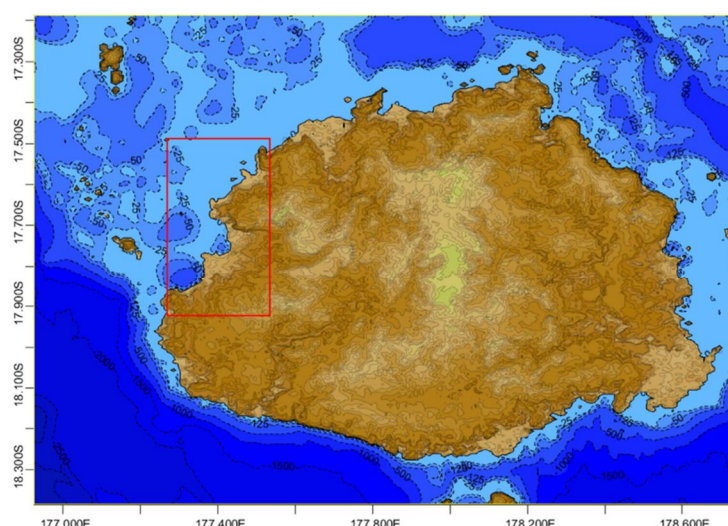
Figure 3-1 Setting Target Area (example of Nadi, Fiji)

3.3.2 Setting Bathymetry for calculation

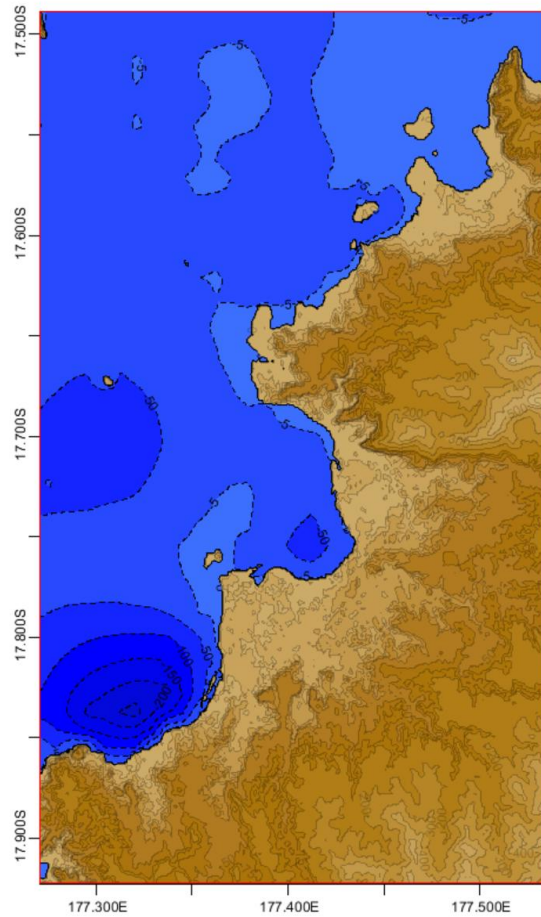
The bathymetry or topographic conditions of the target country, Fiji, can be downloaded from the ComMIT server. The procedures for conducting ComMIT simulations, including the method for downloading the bathymetry data, can be found in section 3.3.4. The bathymetric conditions near Fiji for this study are as follows.



Low resolution A-grid



Medium resolution B-grid



High resolution C-grid

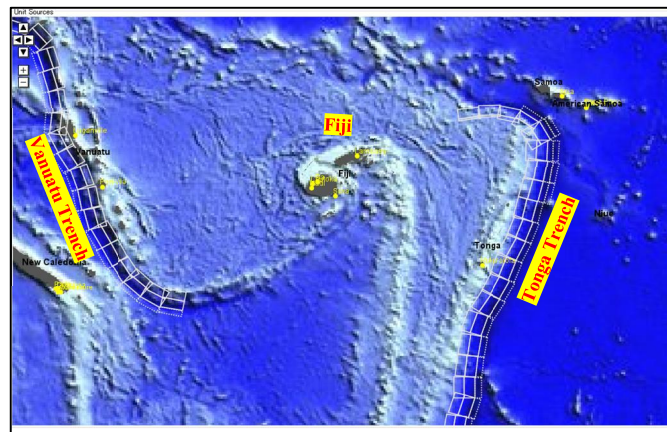
Figure 3-2 Bathymetric data for Tsunami Analysis

Bathymetry is from NOAA ETOPO1 INTERPOLATED FROM 60 ARC-SECONDS TO 3 ARC-SECONDS to match the topography data set. Topography is from the CGIAR SRTM 90m version 4 digital elevation model produced by the CGIAR Consortium for Spatial Information.

3.3.3 Setting Assumed Earthquake and Tsunami Source

(1) Purpose

This study focuses on the assumption of significant earthquake magnitudes resulting from the movement of fault plates, particularly along the Vanuatu Trench and Tonga Trench shown in below, situated in the north-western part of Fiji.



Source: ComMIT Model

Figure 3-3 Location of Vanuatu Trench, Tonga Trench, and Fiji

Setting the bottom and coastal topography and assuming earthquake magnitude to generate tsunami waves are necessary steps to conduct the tsunami simulation using the ComMIT program. Therefore, the simplified assumption of earthquake magnitude capable of generating tsunami waves that impact the coastline of the Fiji island, particularly focusing on the Nadi region, is considered as follows:

(2) Scenario of Tsunami Source Setting

Based on five largest earthquakes in the recorded history since 1950 (see Table 3-1), tsunami source scenarios along the Vanuatu Trench and Tonga Trench are set as shown in Table 3-2. The sources of the scenario tsunami include several shifted cases from South to North along the Vanuatu Trench. Additionally, tsunami cases from Tonga Trench will also be calculated for a reference in this study.

Table 3-1 Five Largest Earthquakes since 1950

No.	Magnitude	Location	Date	Rupture Zone (Length)	Rupture Zone (Width)
1	9.5	Puerto Montt, Valdivia, Chile	1960/05/22	800-1000km	130-150km
2	9.2	Prince William Sound , Alaska	1964/03/28	700-800km	150-250km
3	9.1	Sumatra, Indonesia	2004/12/26	700-1300km	100-150km
4	9.0	Sendai, Japan	2011/03/11	400-500km	100-200km
5	9.0	Kamchatka, Russia	1952/11/04	500-700km	150-240km

Source: JICA Expert Team

Table 3-2 Scenario Tsunami Source Setting

Magnitude	Rupture Zone (Length)	Rupture Zone (Width)
9.5	1000km	150km
9.2	800km	150km
9.1	700km	150km
9.0	500km	150km

Source: JICA Expert Team

3.3.4 Run ComMIT Simulation

Here is an example case study model simulation of Magnitude 9.0 with 500km unit source from Vanuatu Trench. The following steps outline the process of creating a new model from scratch, adding unit sources, conducting a model run, generating result animation, and examining an extreme case maximum wave condition:

Step 1) Open the ComMIT model. Click the New Model Run or Site from the Model menu item

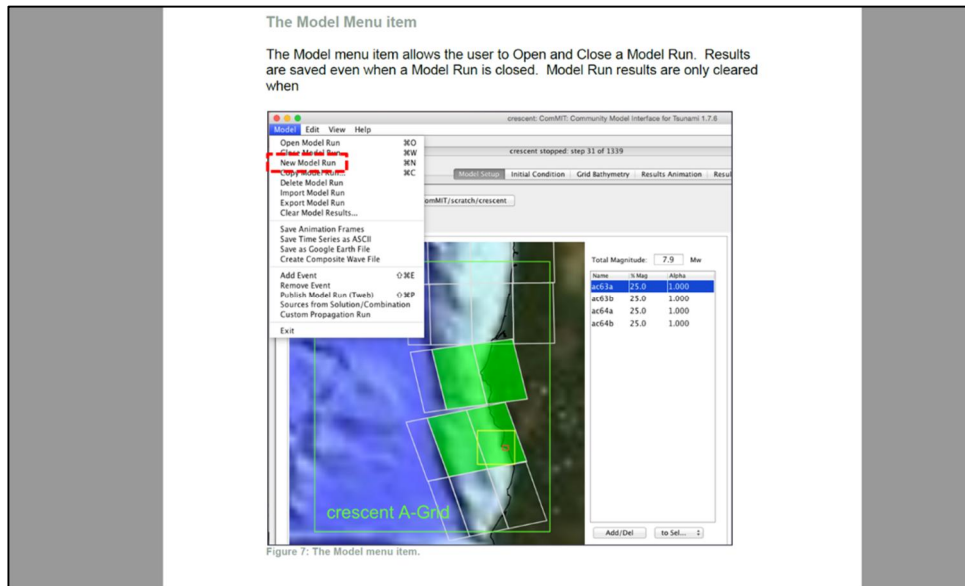


Figure 3-4 The Model menu item

Step 2) Type the name to create a new Model site, then click 'Next' button.

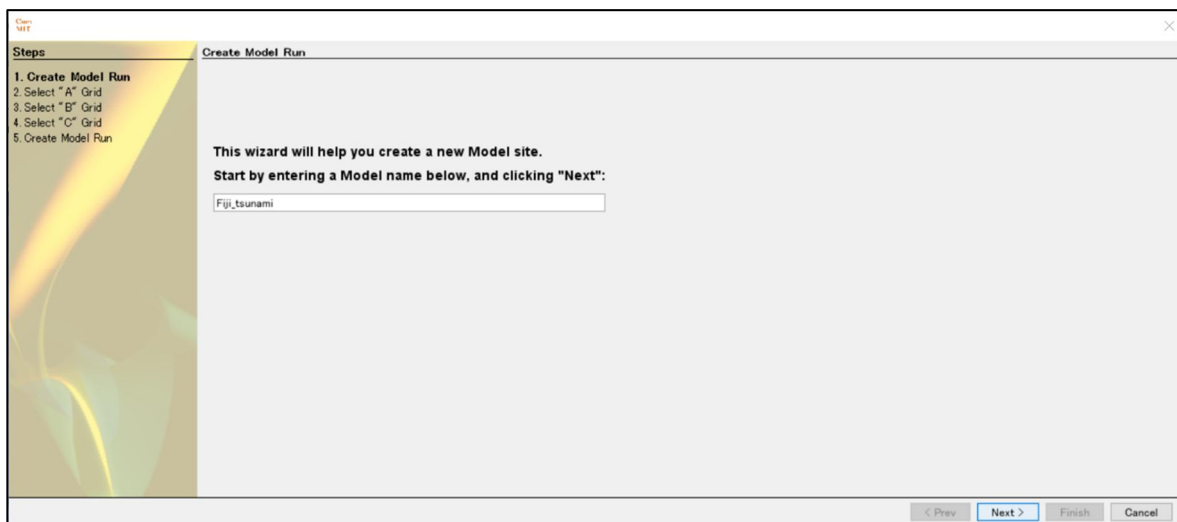


Figure 3-5 Model name creation

Step 3) Select the A-grid extent by holding SHIFT and drag, then click 'Next' button.

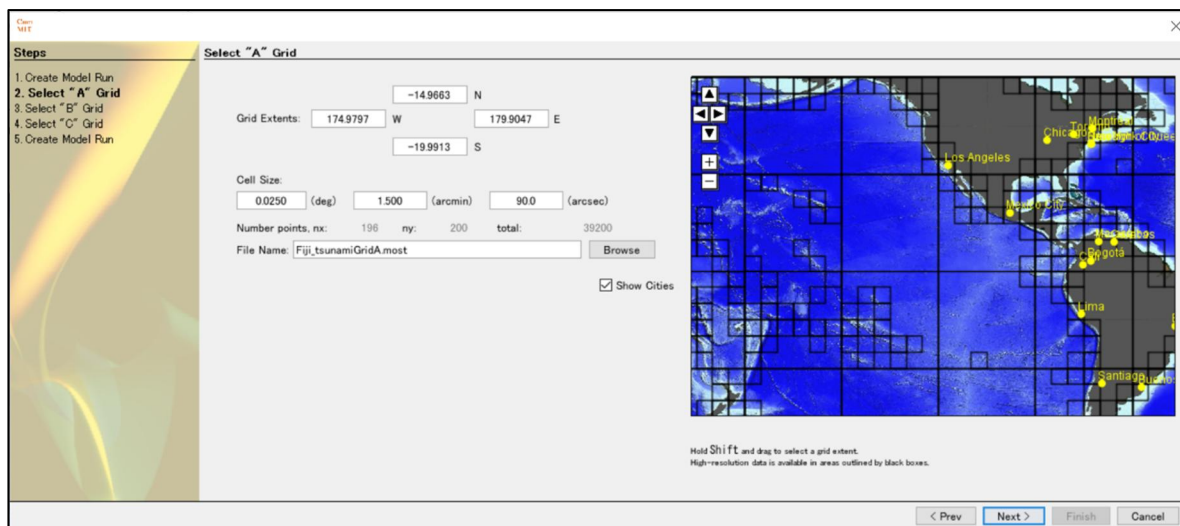


Figure 3-6 Select 'A' Grid

Step 4) Carry out the same procedure for selecting 'B' and 'C' grid.

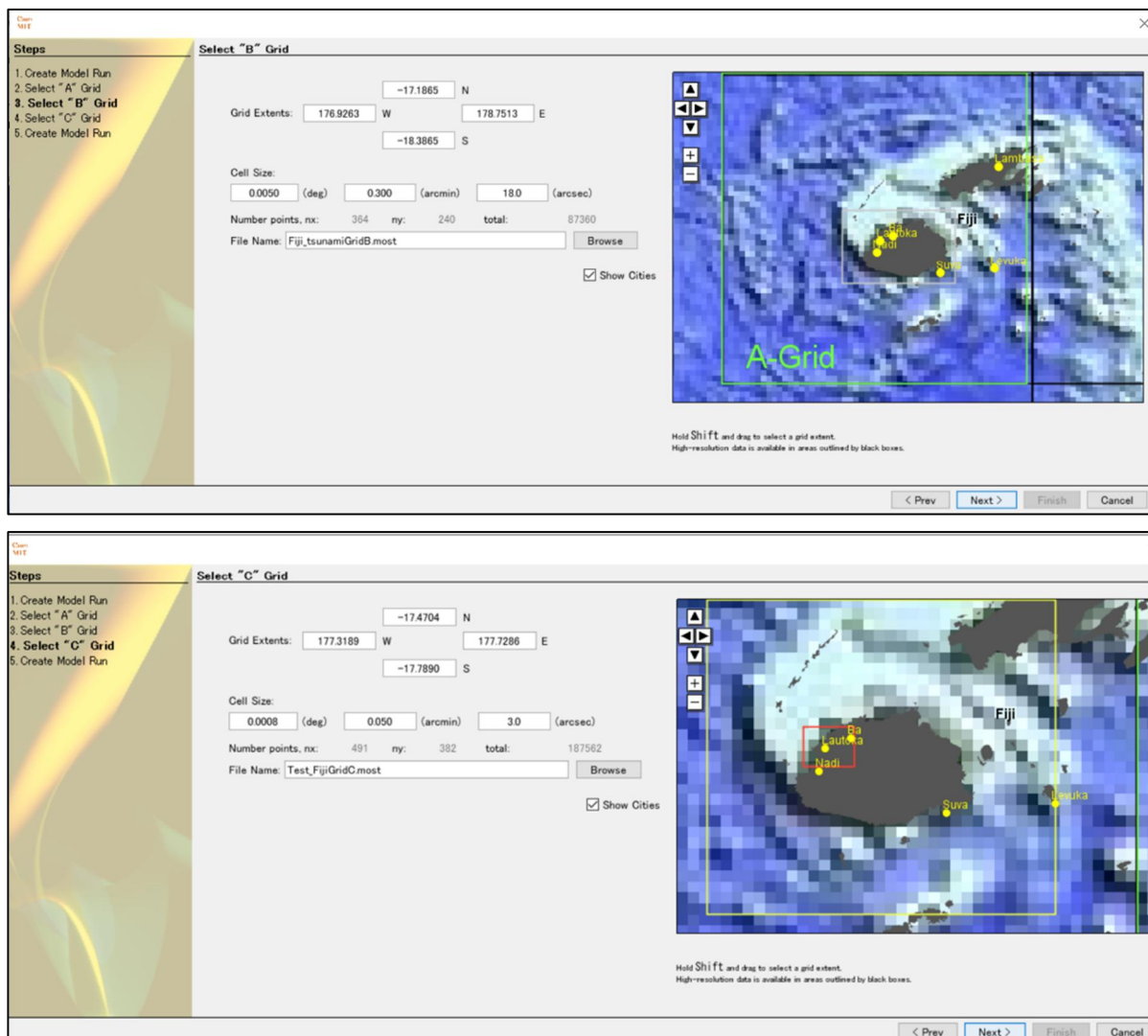


Figure 3-7 Select 'B' & 'C' Grid

Step 5) After the completion of selecting of Grid A, B & C, click 'Finish' button.

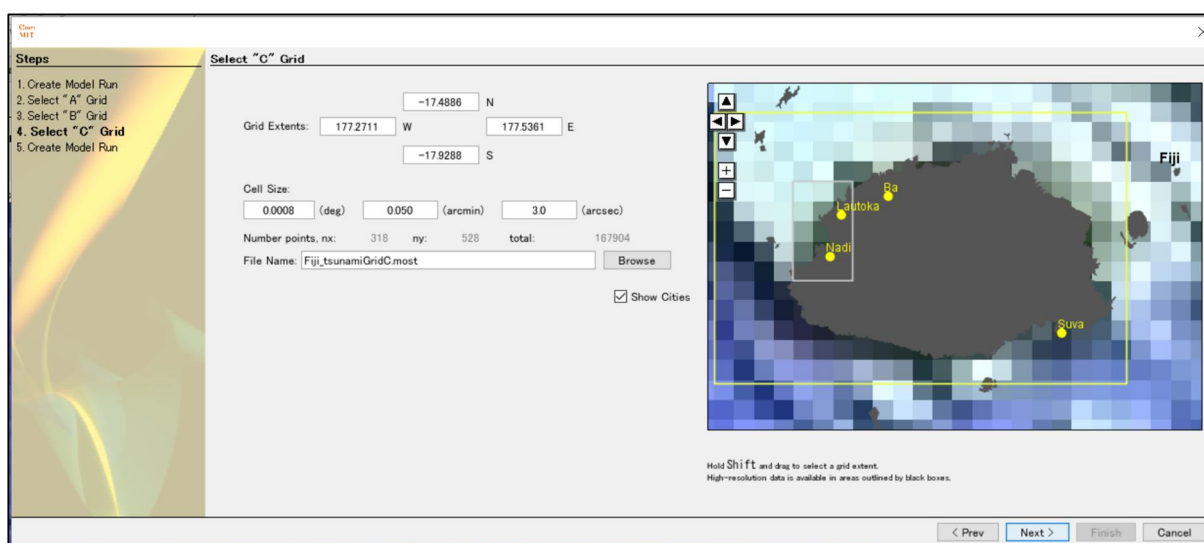
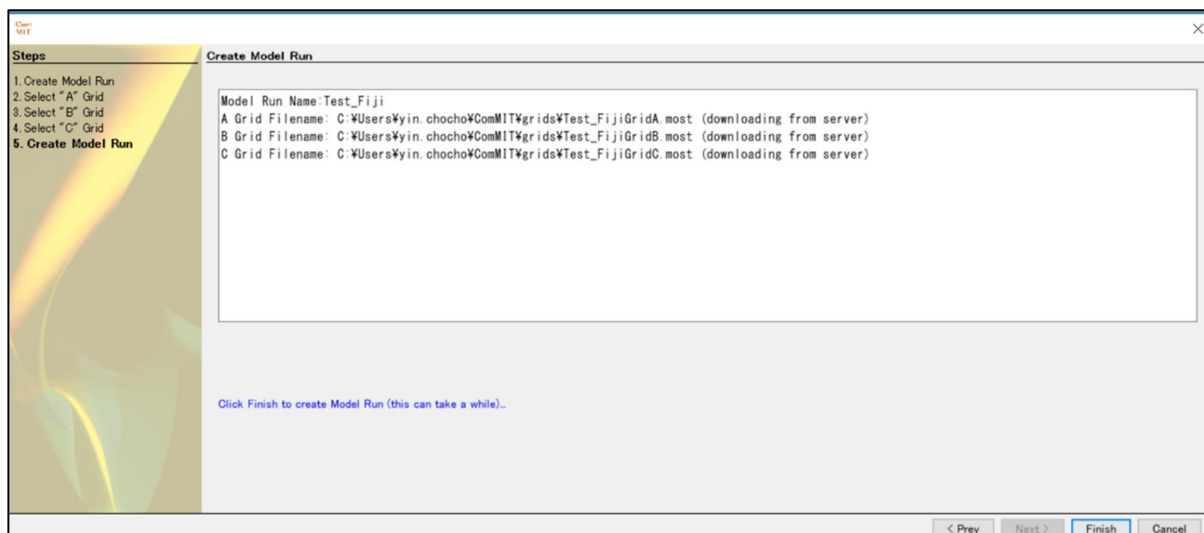


Figure 3-8 Select 'B' & 'C' Grid

Step 6) The model will contact to ComMIT server for creating the grid. Click 'Close' Button when the model is successfully created.

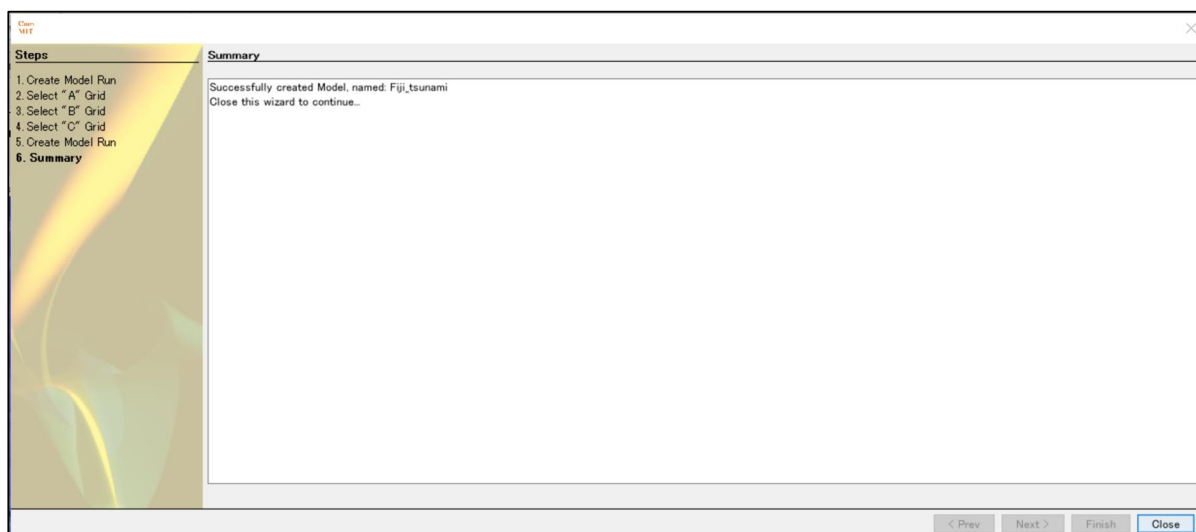
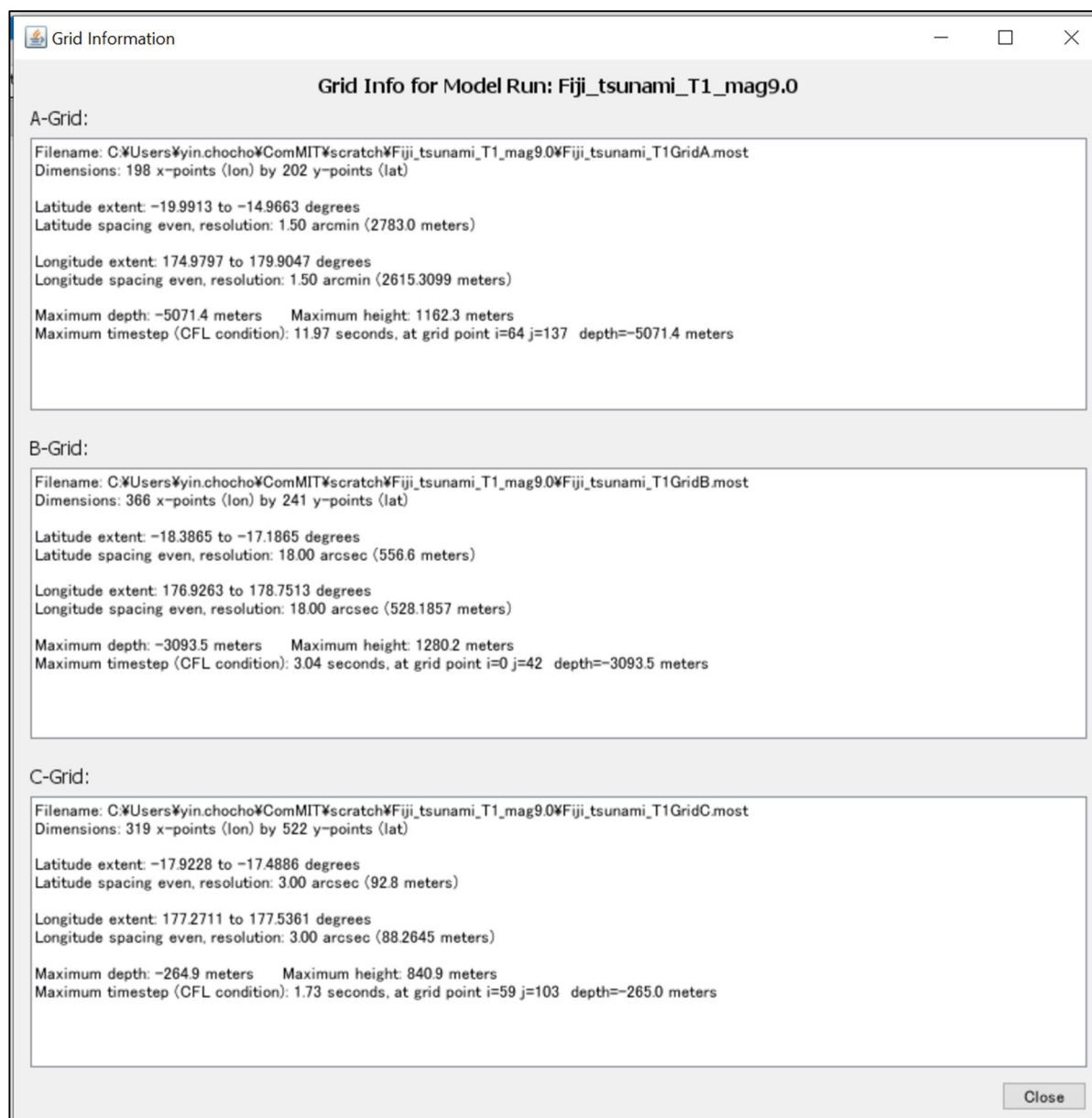


Figure 3-9 Summary

※ The grid information can be checked in the 'View' tab as follows.



[illegible]

Step 8) Zoom out the model output log in the window until we see the seismic unit sources, then select the necessary unit sources (seismic fault plates) to create the scenario by double clicking the white frame rectangles.

15

Step 9) Click ‘Start model’ button, and the model will run automatically by time steps.

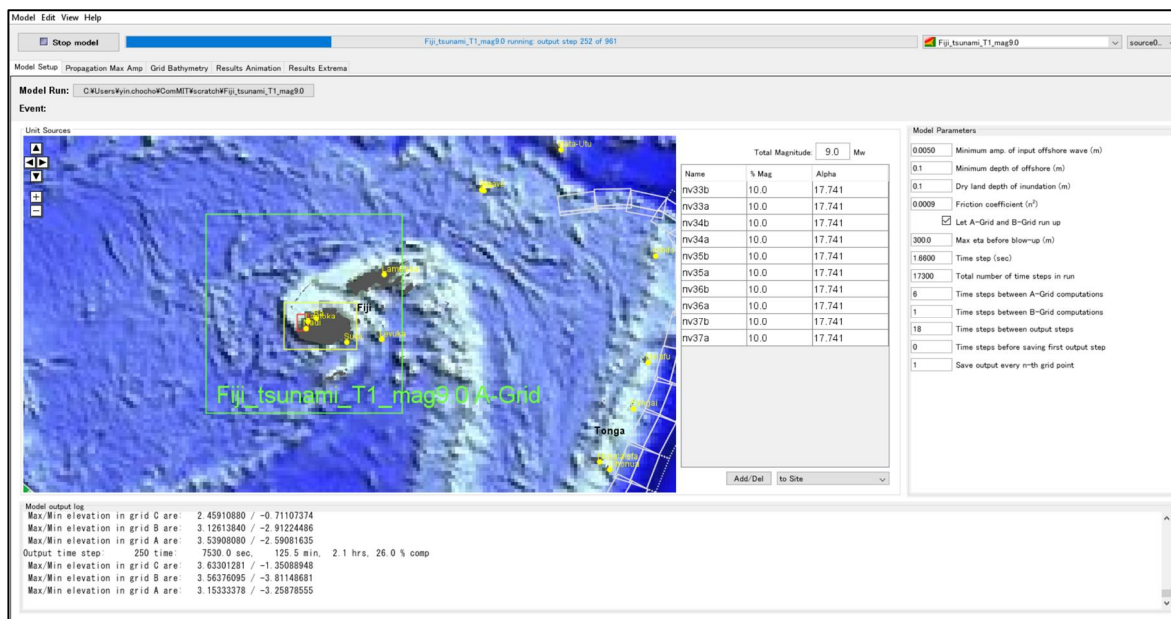


Figure 3-12 Run the Model

Step 10) Click ‘Propagation Max.Amp’ tab. The initial Condition Maximum Amplitude will be shown as follows.

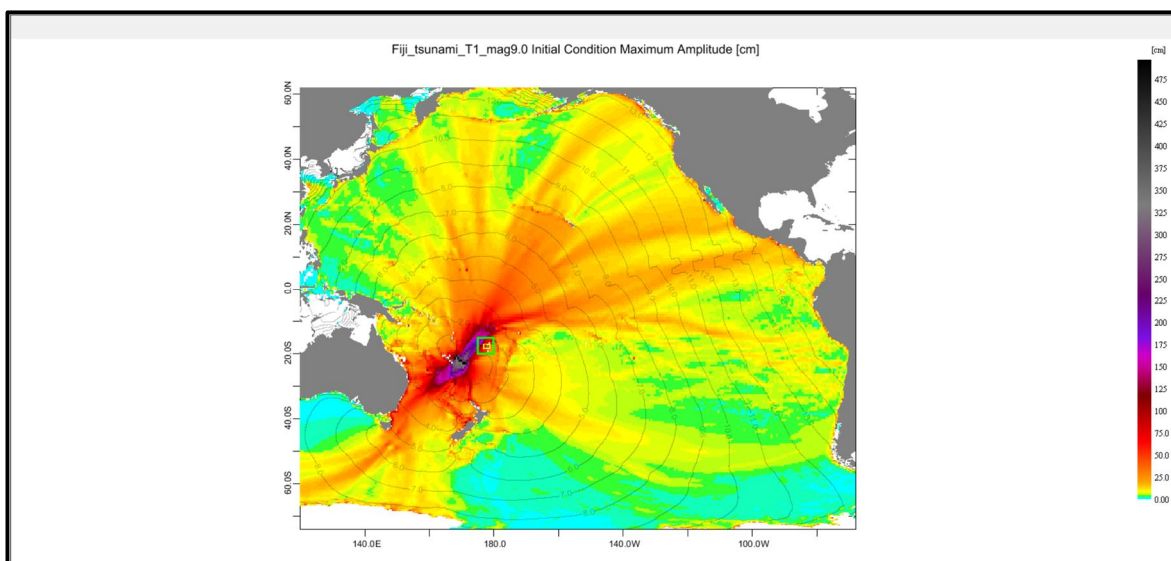


Figure 3-13 Propagation Max Amp Window

Step 11) Click ‘Grid Bathymetry’ tab. The user can change the views by clicking grid A-B-C button.

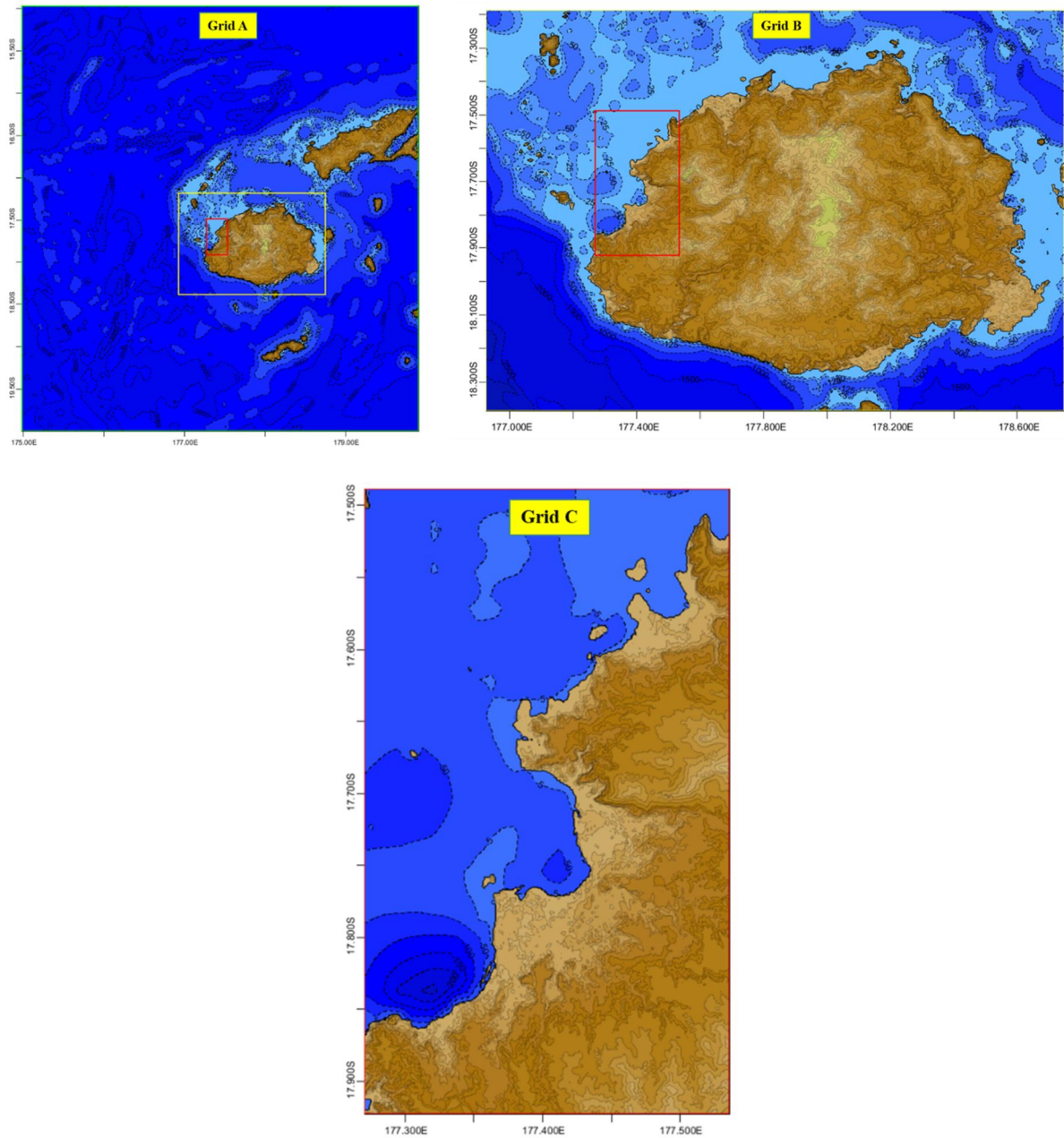


Figure 3-14 Grid Bathymetry

Step 12) Click ‘Results Animation’ tab. The user can also change the views by clicking grid A-B-C button.

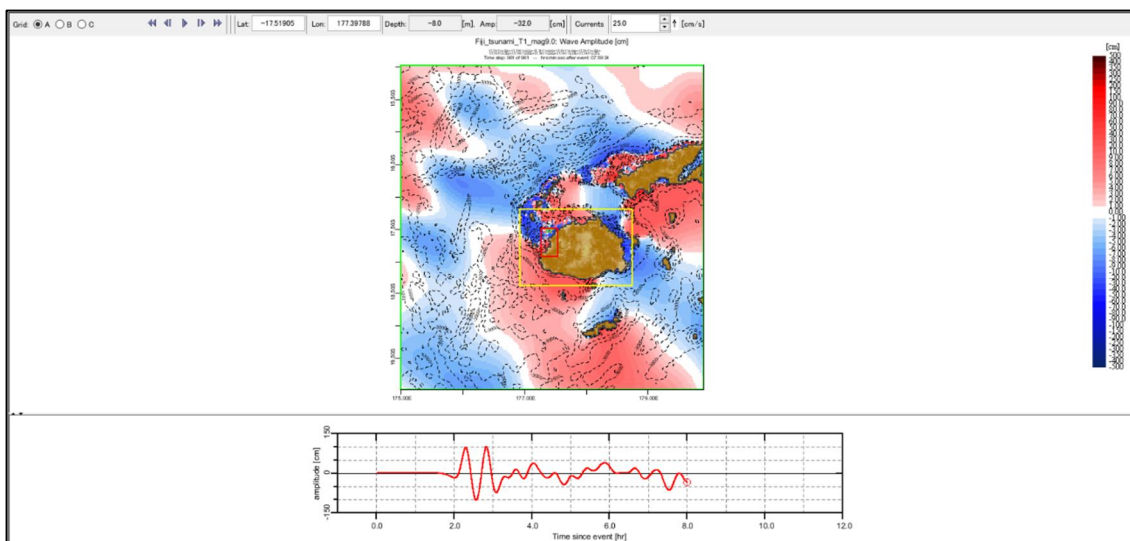


Figure 3-15 ‘A’ Grid Result Animation

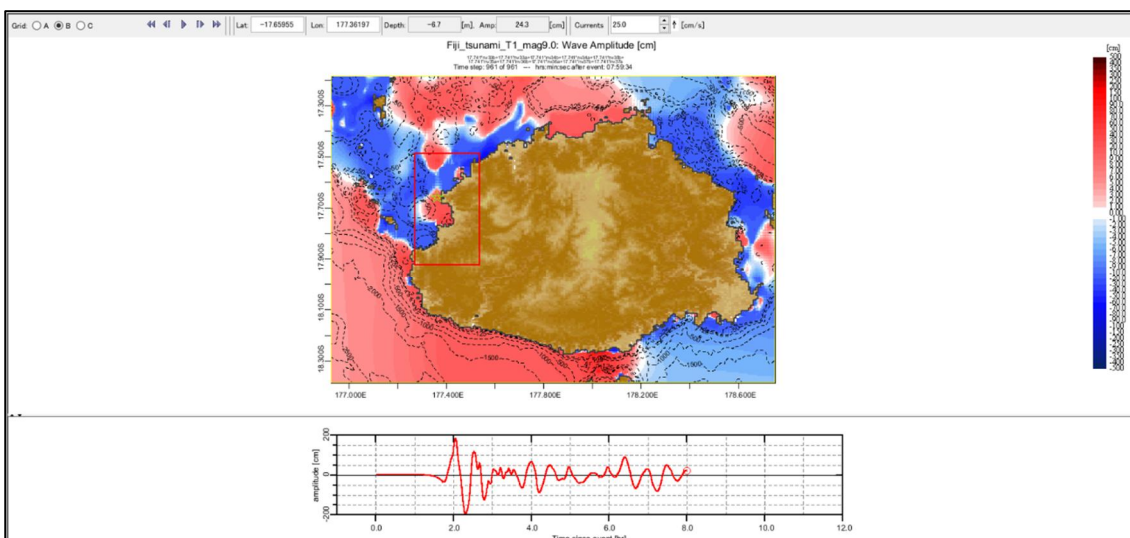


Figure 3-16 ‘B’ Grid Result Animation

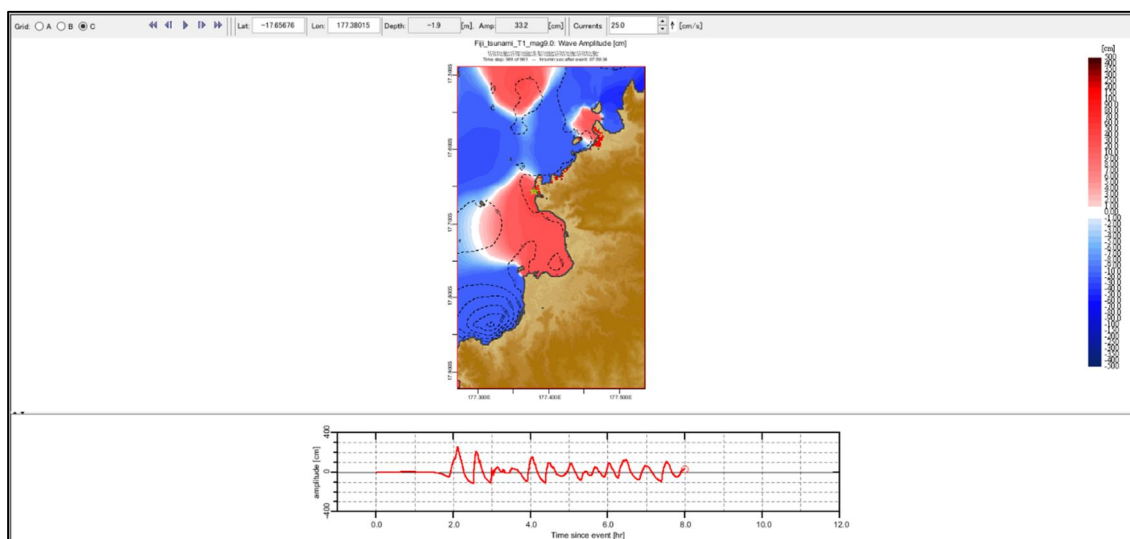


Figure 3-17 ‘C’ Grid Result Animation

※The result animation shows the wave amplitude per time series event (hour). The graph shows the wave amplitude per time since event occurred for the desired location (green star as shown in above plot) and the user can change the view of the target point by clicking anywhere in the window).

Step 13) Click 'Result Extrema' tab. The user can also change the views by clicking grid A-B-C button.

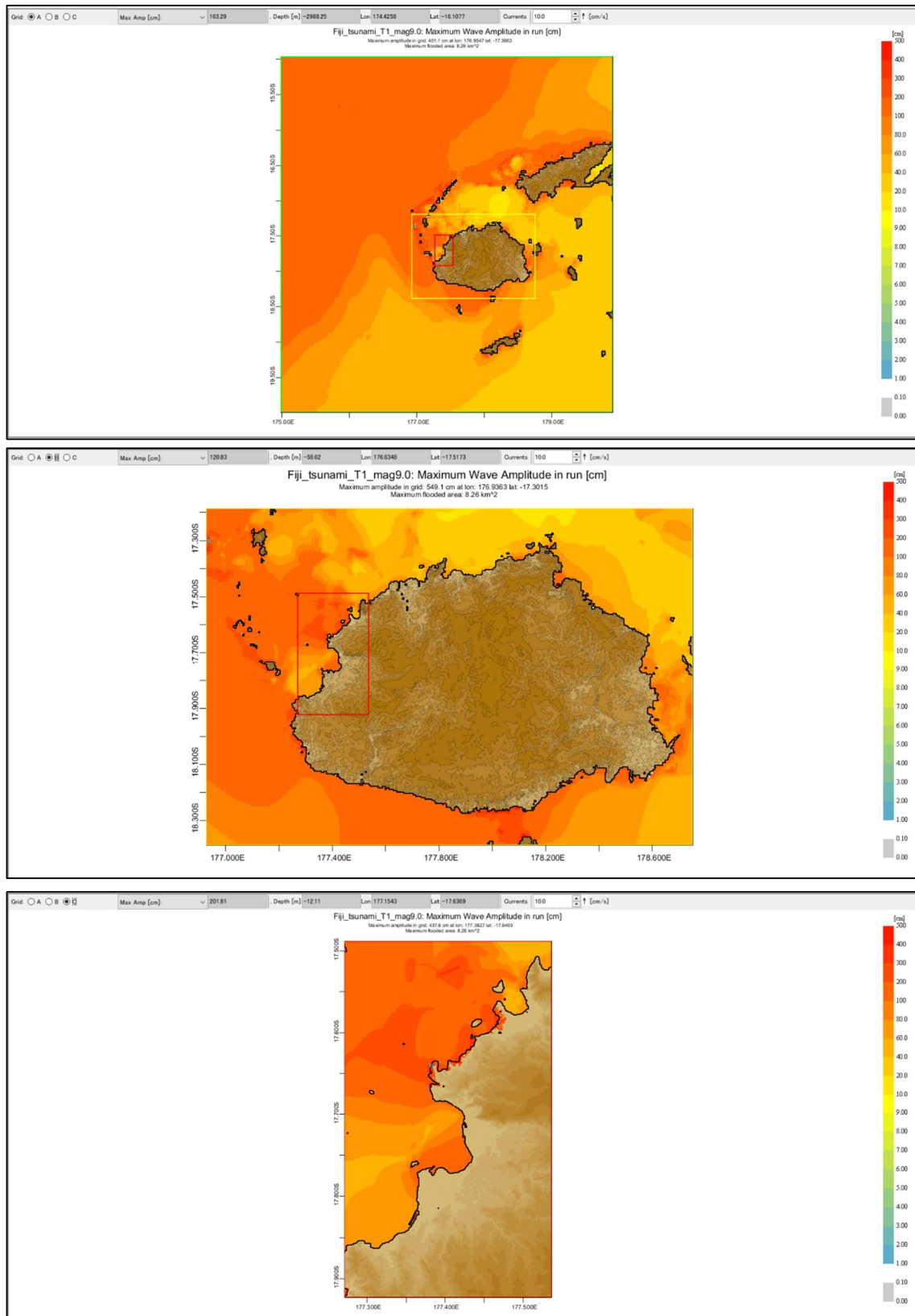


Figure 3-18 Result Extrema for 'A', 'B' & 'C' Grid

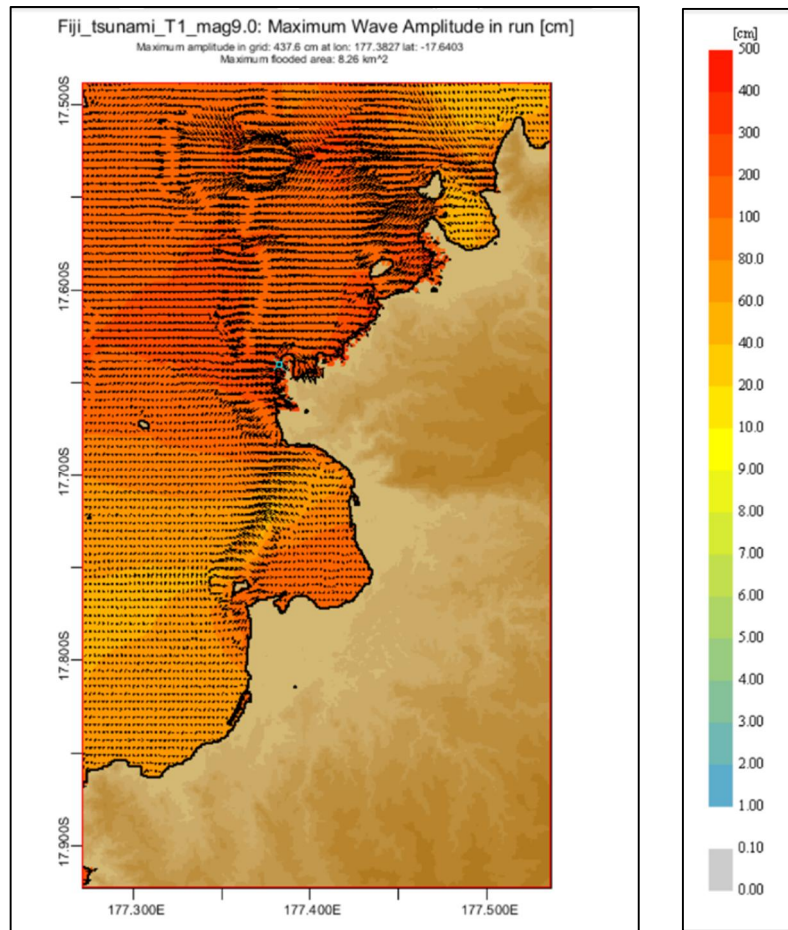


Figure 3-19 Result Extrema with Current Vector

3.3.5 Confirmation of Results of Tsunami Simulation

The results of tsunami simulation by ComMIT should be confirmed by exposing the results to GIS format. The major outputs of the simulations are following.

- Tsunami Height
- Tsunami Flow Velocity
- Tsunami Flow Depth (Inundation depth)

Chapter 4. Inundation Analysis

4.1 Purpose

Inundation analysis in this guideline involves studying the potential extent and impact of flooding caused by tsunami. It encompasses the assessment of areas likely to be affected by floodwaters, including determining the depth and flow velocity of water, and mapping out the potential flood zones. The results of inundation analysis provide crucial information for disaster risk reduction efforts, enabling authorities to identify high-risk areas, enhance preparedness, evaluate infrastructure vulnerability, inform insurance decisions, support land-use planning, and guide climate change adaptation strategies.

4.2 Analysis Flow

The flow of inundation analysis is as follows. The case of Nadi is used as reference. At first, the tsunami height at the coastline of Nadi is estimated, followed by setting the target tsunami level at the target site. By using the fill level method, tsunami inundation map will be developed.

1. Evaluation of Expected Tsunami Height at the coastline of Nadi
2. Target Tsunami Level for Hazard Map
3. Inundation Analysis by Fill Level Method
4. Tsunami Hazard Map

4.3 Evaluation of Expected Tsunami Height at the coastline

The maximum tsunami height would be obtained by a series of simulations from the above simulations.

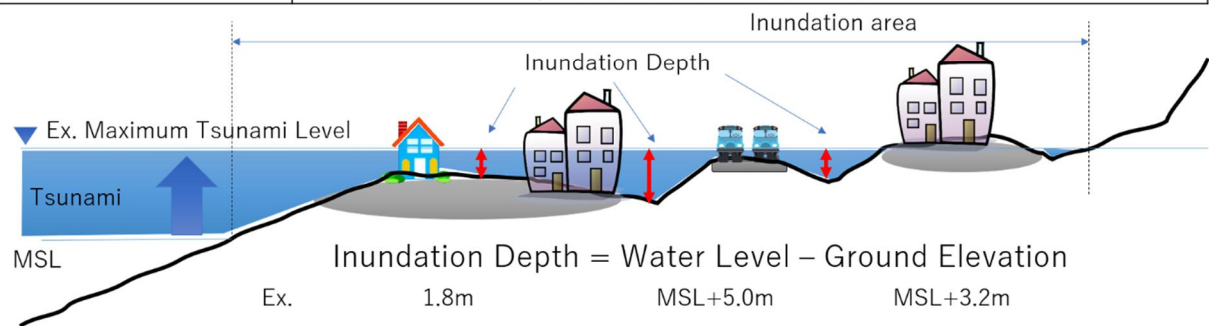
4.4 Target Tsunami Level for Hazard Map

By accumulating the estimated maximum tsunami height obtained by Simulation from the above evaluations and highest astronomical tide (e.g., Lautoka tide station: MSL + 1.142m), total estimated tsunami elevation of target coast can be evaluated.

4.5 Inundation Analysis by Fill Level Method

Following the estimated maximum tsunami level (target level for hazard map), inundation analysis can be evaluated by using different ways of approach. It involves predicting the extent and depth of flooding or inundation caused by a tsunami event. In the present project, inundation analysis (see Figure 4-1) is performed by Fill Level Method to access the inundated area or depth of the target zones.

	Contents
Items can be assessed	➤ Inundated area/ Inundation depth
Major Necessary Data	➤ <u>Sea side target level/ DEM</u>
Characteristics (●Pros, × Cons)	● If there is a water level between DEM and the <u>sea side</u>, it can be easily evaluated. ● The inundation depth in each mesh of DEM can be evaluated. × The effect of detailed topography, etc. cannot be considered. × Influences caused by structures cannot be considered.



Source: JICA Expert Team

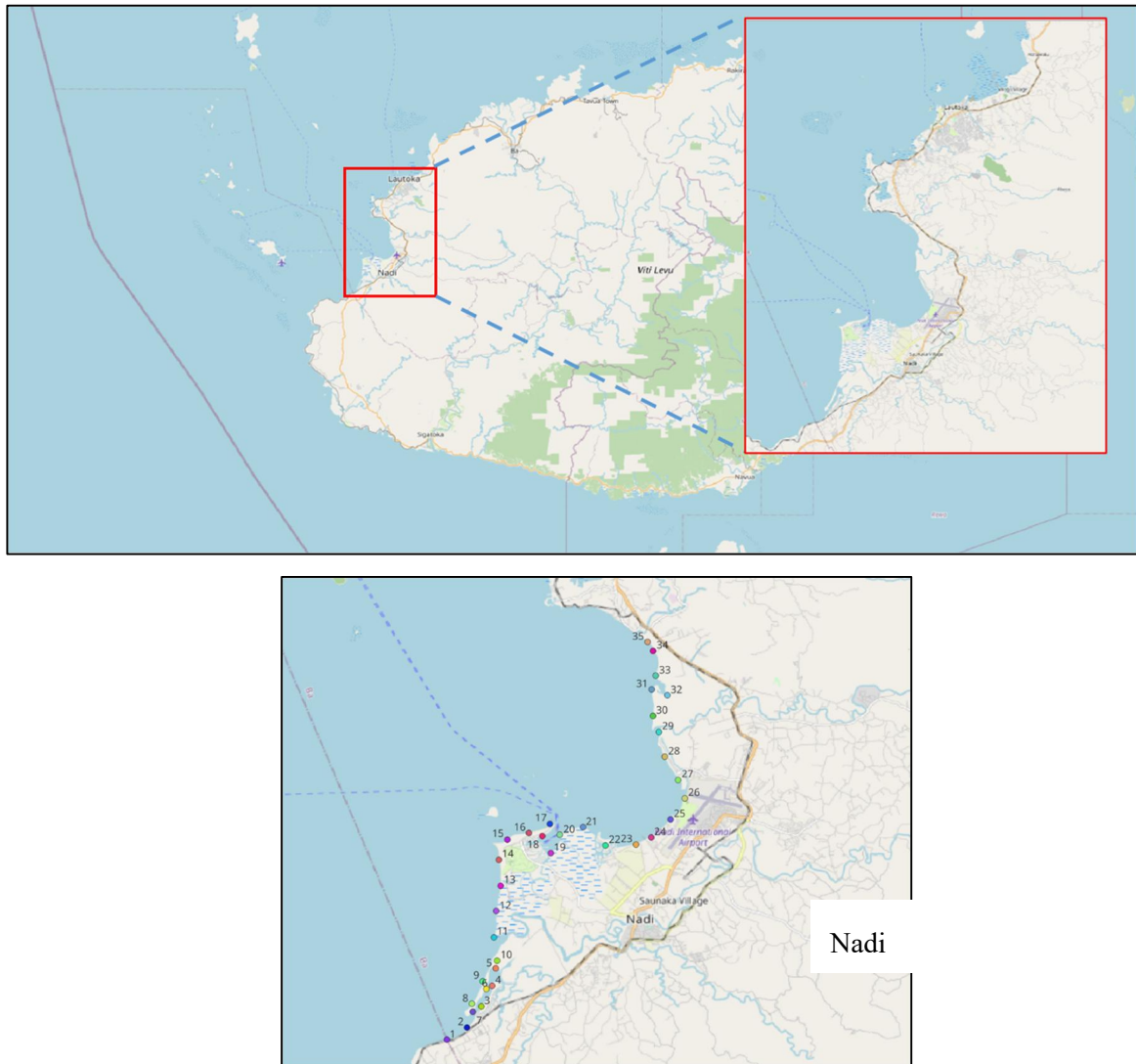
Figure 4-1 Inundation Analysis by Fill Level Method

Chapter 5. Case Study in Nadi

5.1 Tsunami Analysis

5.1.1 Setting Target Area

This case study focuses on assessing hazards in the coastal regions of Nadi which is located on the western side of the main Viti Levu Island in Fiji as an example. It encompasses analyzing earthquake risk, conducting tsunami simulations, and generating inundation maps utilizing the ComMIT model developed by NOAA.



Source: OpenStreetMap

Figure 5-1 Area of Interest for present study (Nadi, Fiji)

The target output points in the figure represent the coastline of Nadi, where the estimated maximum tsunami heights may be observed to reach.

5.1.2 Setting Bathymetry for calculation

Bathymetry is the same as the above section in 3.3.2.

5.1.3 Setting Assumed Earthquake and Tsunami Source

This study conducted the following cases of scenarios of tsunami.

Table 5-1 Scenario Tsunami Source Setting

Case No.	Trench	Magnitude	Rupture Zone (Length)	Rupture Zone (Width)	No. of Cases
1	Vanuatu	9.0	500km	150km	T1-T10
2	Vanuatu	9.1	700km	150km	T1-T10
3	Vanuatu	9.2	800km	150km	T1-T10
4	Vanuatu	9.5	1000km	150km	T1-T11
5	Tonga	9.0	500km	150km	T1-T2

Source: JICA Expert Team

(1) M9.0 from Vanuatu Trench

The 1st case study earthquake is assumed to be magnitude 9.0 and is anticipated to occur along the Vanuatu Trench. Considering 11 different unit source combinations, each combination is assumed to have a focal length of 500km, focal width of 150km, and focal depth of 25km, as illustrated in Figure 5-2.

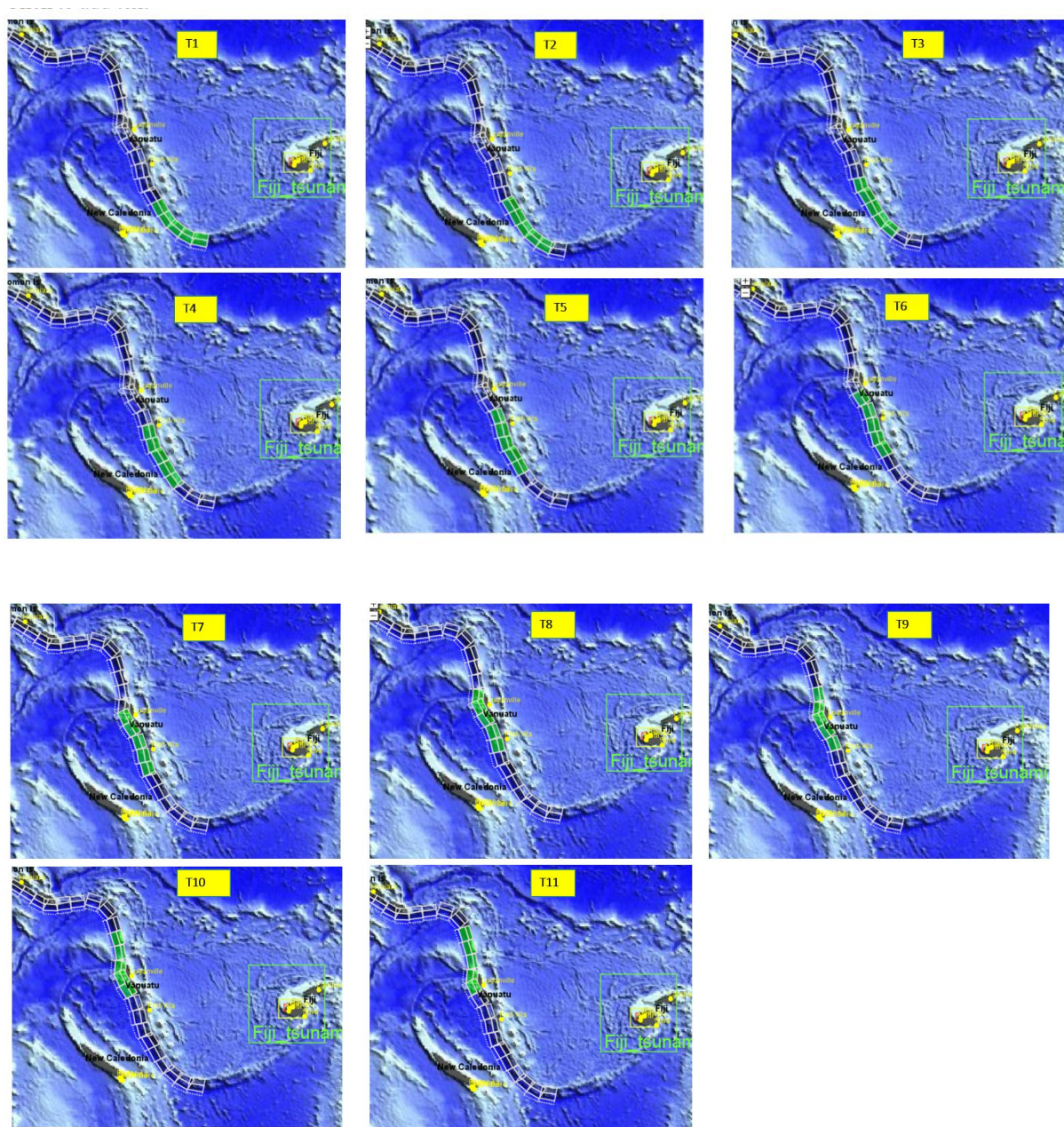


Figure 5-2 Unit source combinations: M9.0 from Vanuatu Trench

(2)M9.1 from Vanuatu Trench

The 2nd case study earthquake is assumed to have a magnitude of 9.1 and is expected to occur along the Vanuatu Trench. Considering 10 different unit source combinations, each combination is assumed to have a focal length of 600km, focal width of 150km, and focal depth of 25km, as depicted in Figure 5-3.

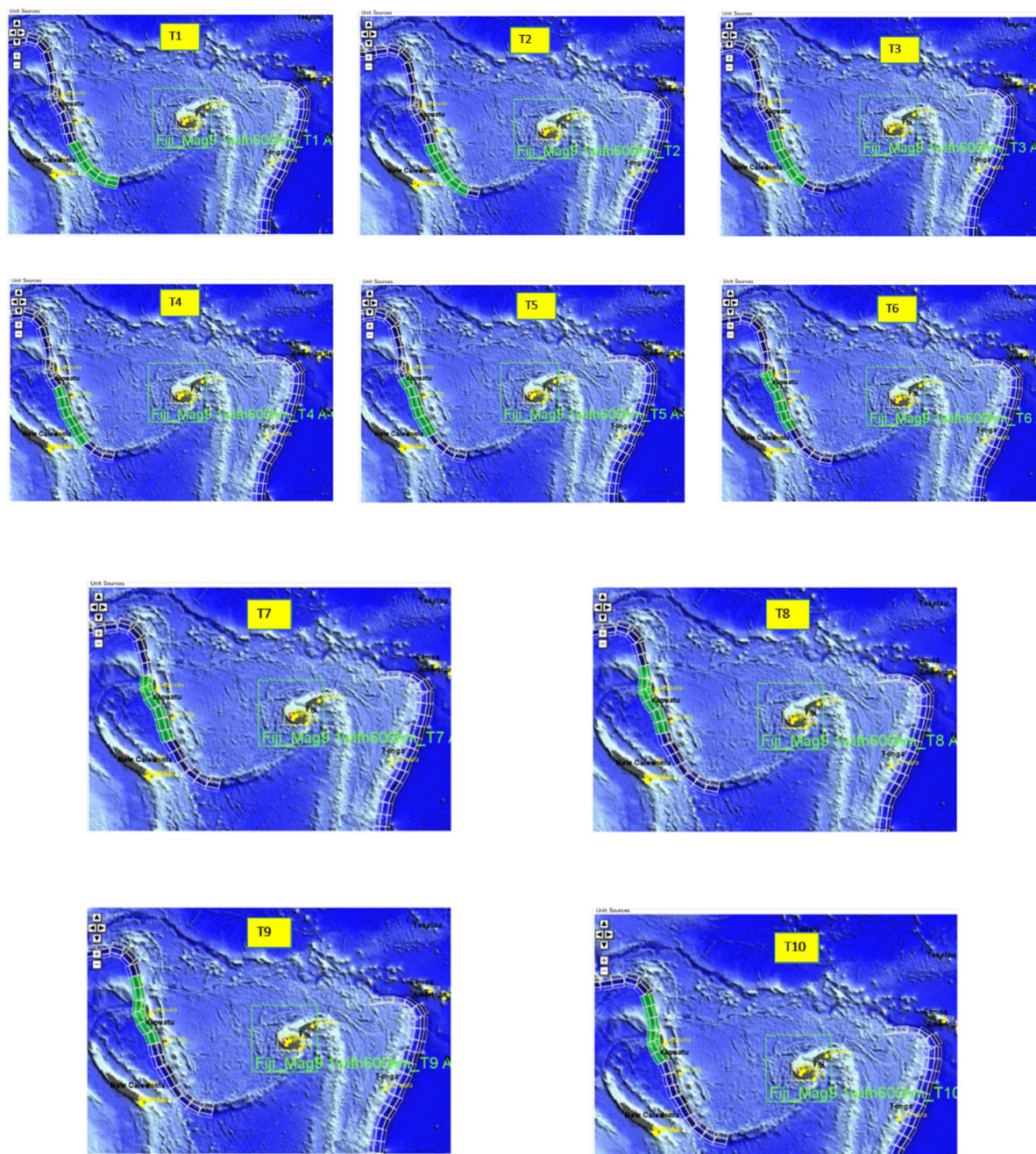


Figure 5-3 Unit source combinations: M9.1 from Vanuatu Trench

(3)M9.2 from Vanuatu Trench

The 3rd case study earthquake is assumed to have a magnitude of 9.2 and is expected to occur along the Vanuatu Trench. Considering 10 different unit source combinations, each combination is assumed to have a focal length of 700km, focal width of 150km, and focal depth of 25km, as illustrated in Figure 5-4.

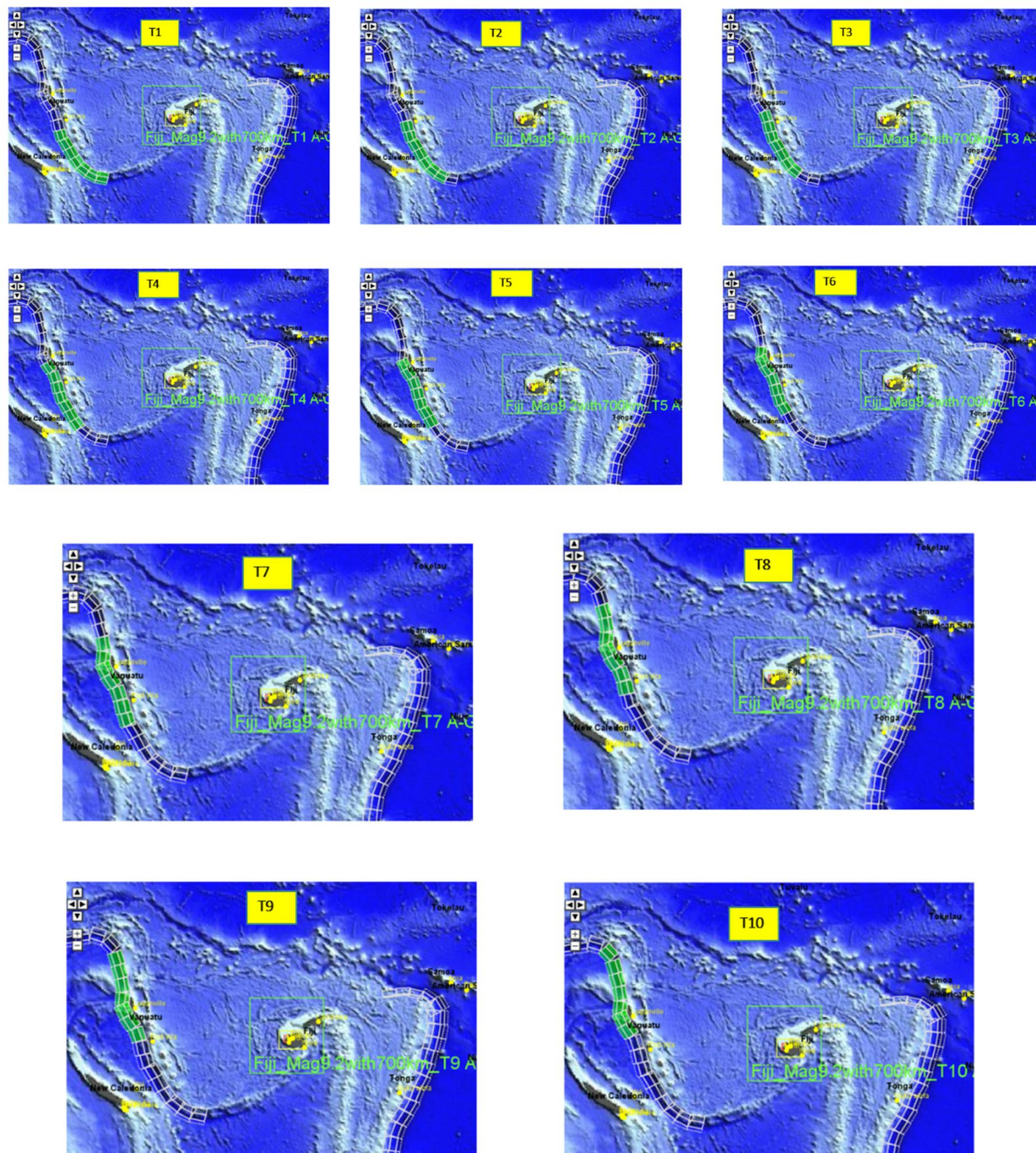


Figure 5-4 Unit source combinations: M9.2 from Vanuatu Trench

(4)M9.5 from Vanuatu Trench

The 4th case study earthquake is assumed to have a magnitude of 9.5 and is expected to occur along the Vanuatu Trench. Considering 10 different unit source combinations, each combination is assumed to have a focal length of 1000km, focal width of 150km, and focal depth of 25km, as depicted in Figure 5-5.

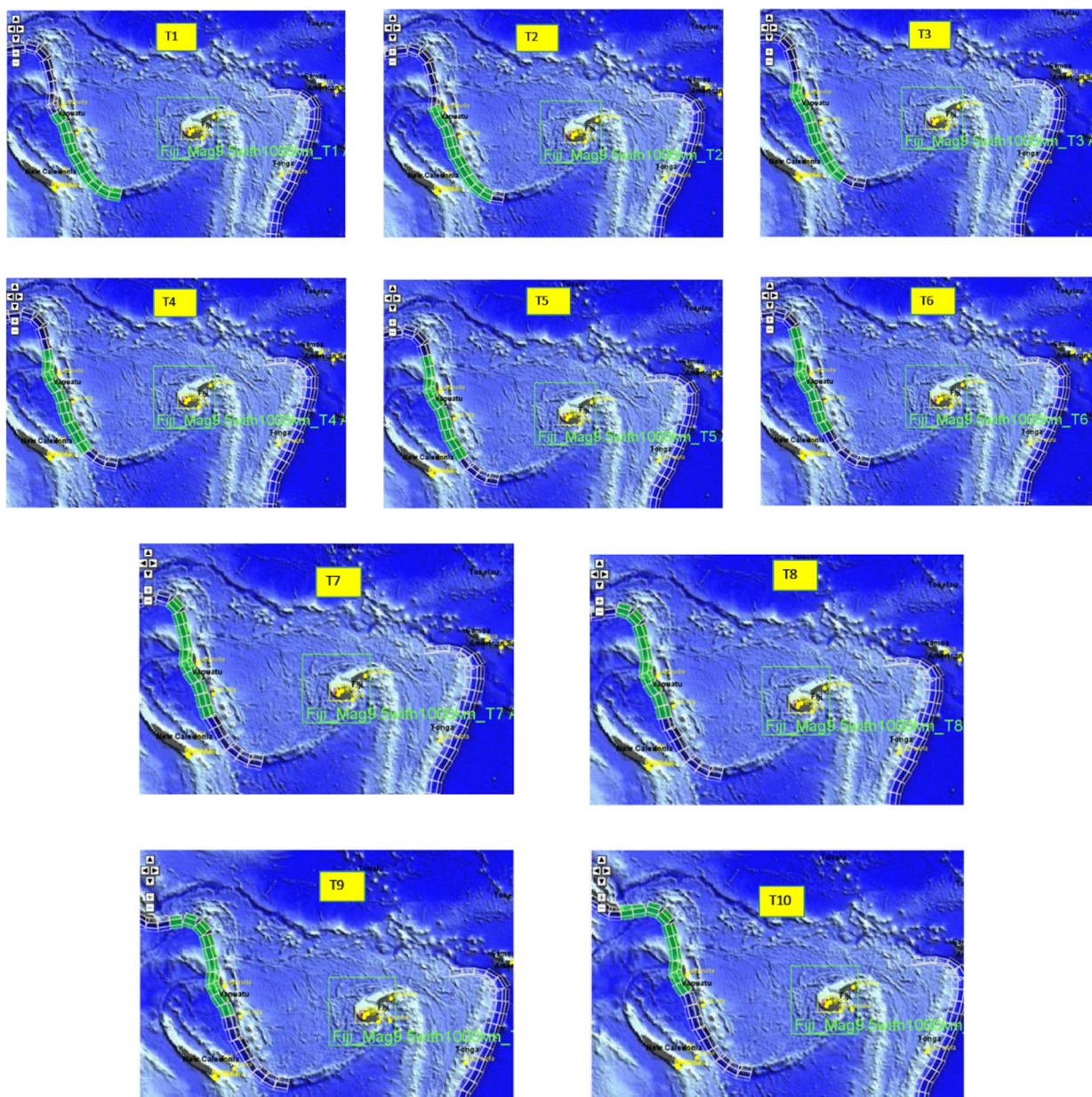


Figure 5-5 Unit source combinations: M9.5 from Vanuatu Trench

(5) M9.0 from Tonga Trench

The 5th case study earthquake is assumed to have a magnitude of 9.0 in consideration of the Tonga Trench as a tsunami source. Considering 2 different unit source combinations, each combination is assumed to have a focal length of 1000km, focal width of 150km, and focal depth of 25km, as depicted in Figure 5-6.

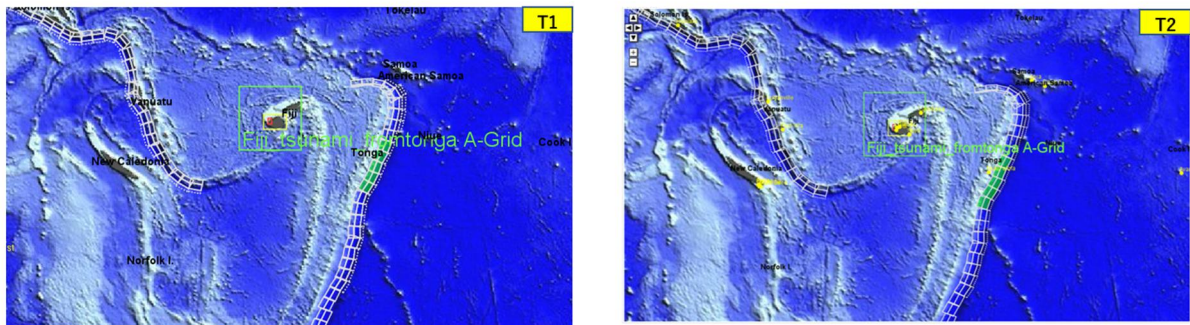


Figure 5-6 Unit source combinations: M9.0 from Tonga Trench

5.1.4 Results of Tsunami Simulation

Expected maximum inundated results from the ComMIT model simulation of the above case scenarios are as follows.

(1) M9.0 from Vanuatu Trench

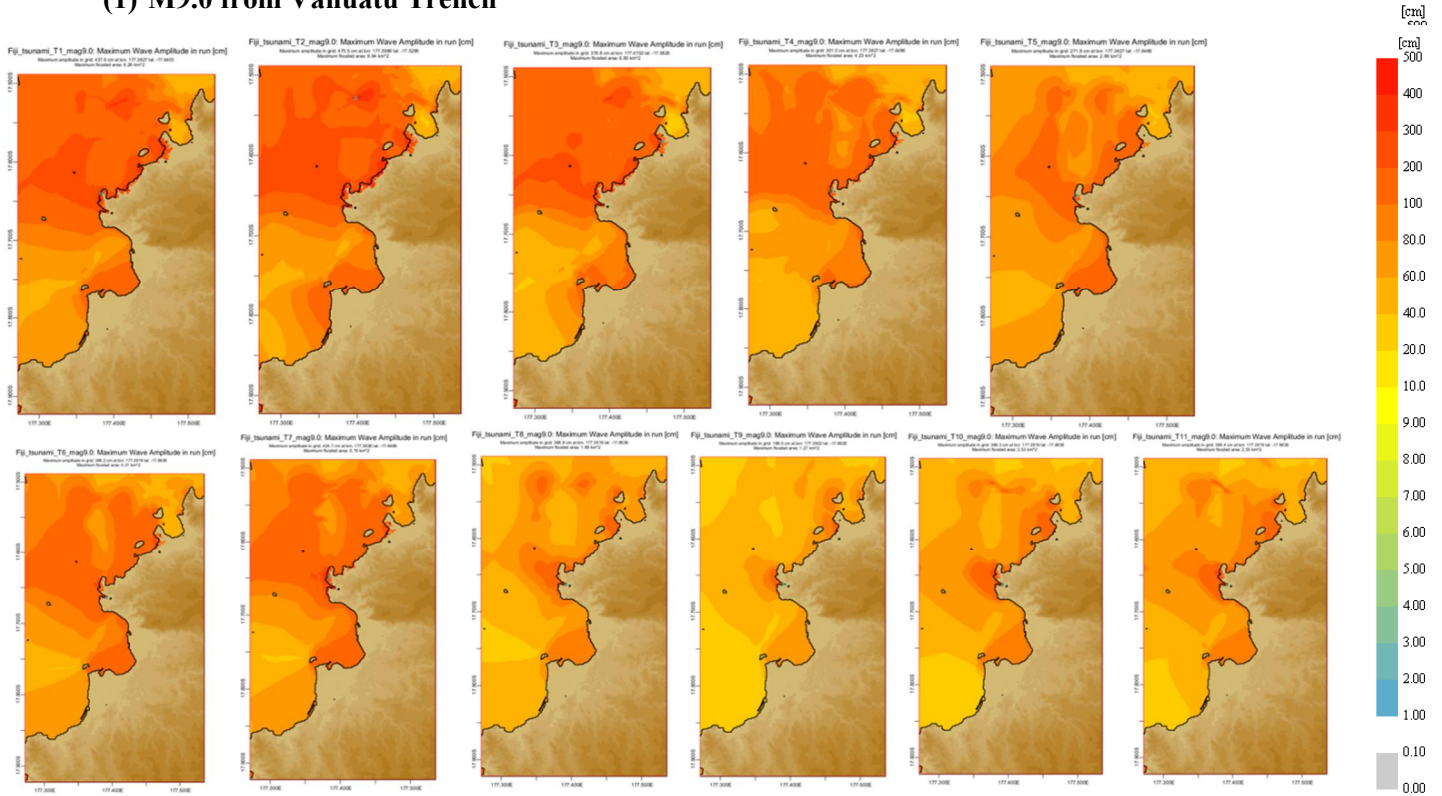


Figure 5-7 Results of Tsunami Simulation -Tsunami Height (M9.0) in cases T1-11

(2) M9.1 from Vanuatu Trench

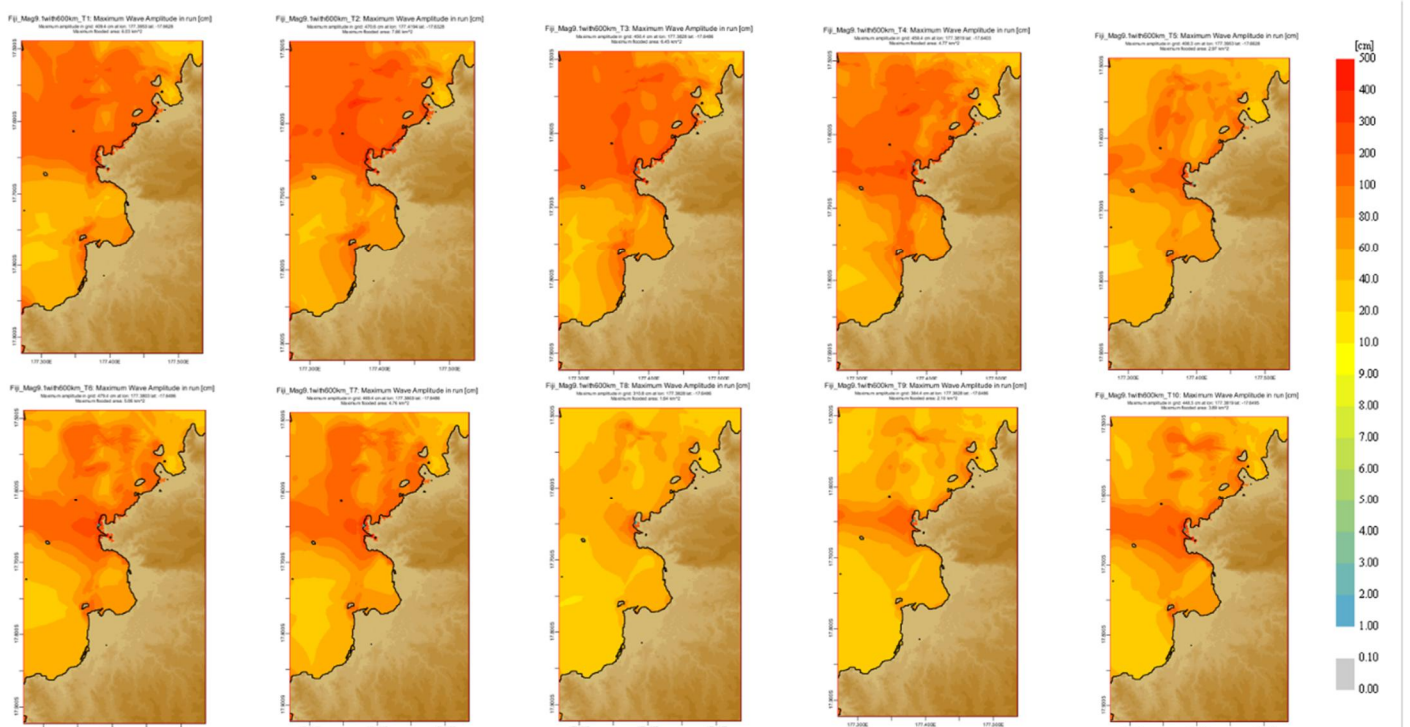
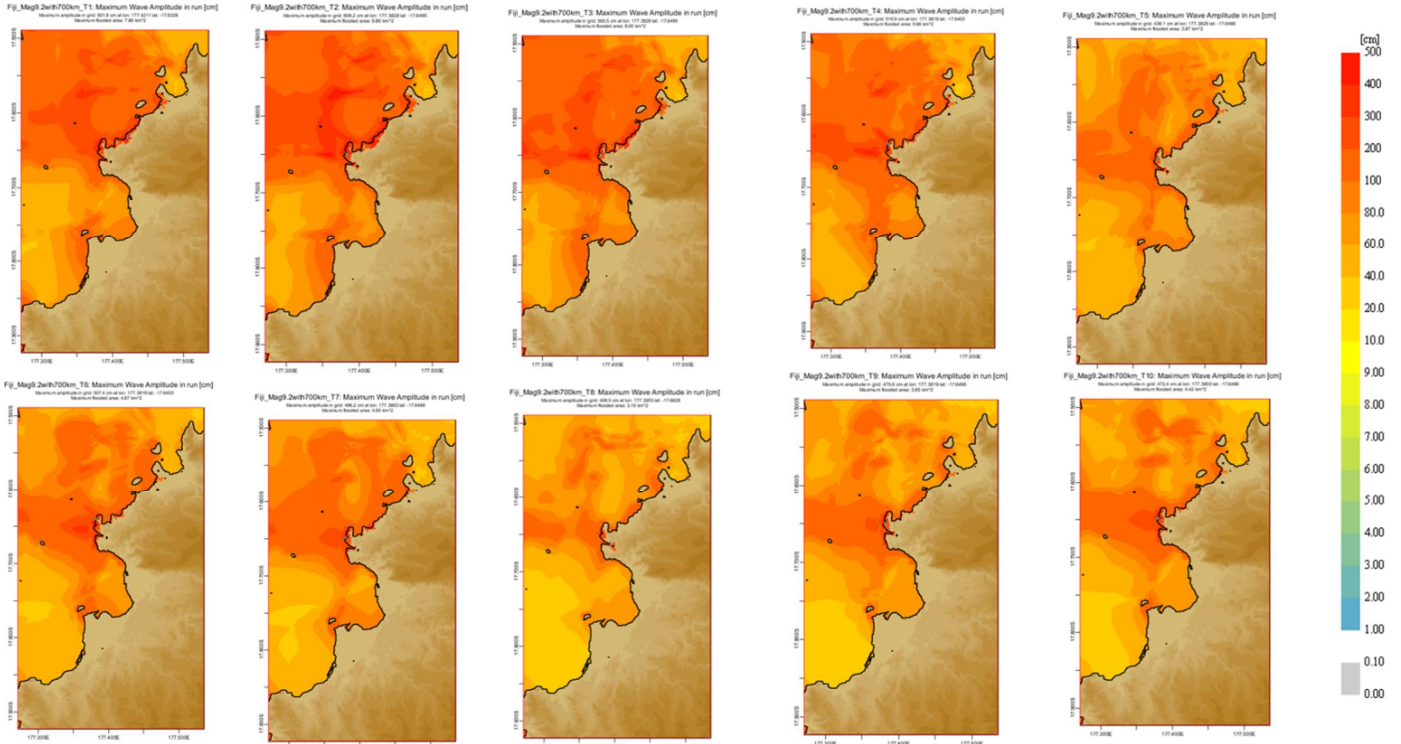
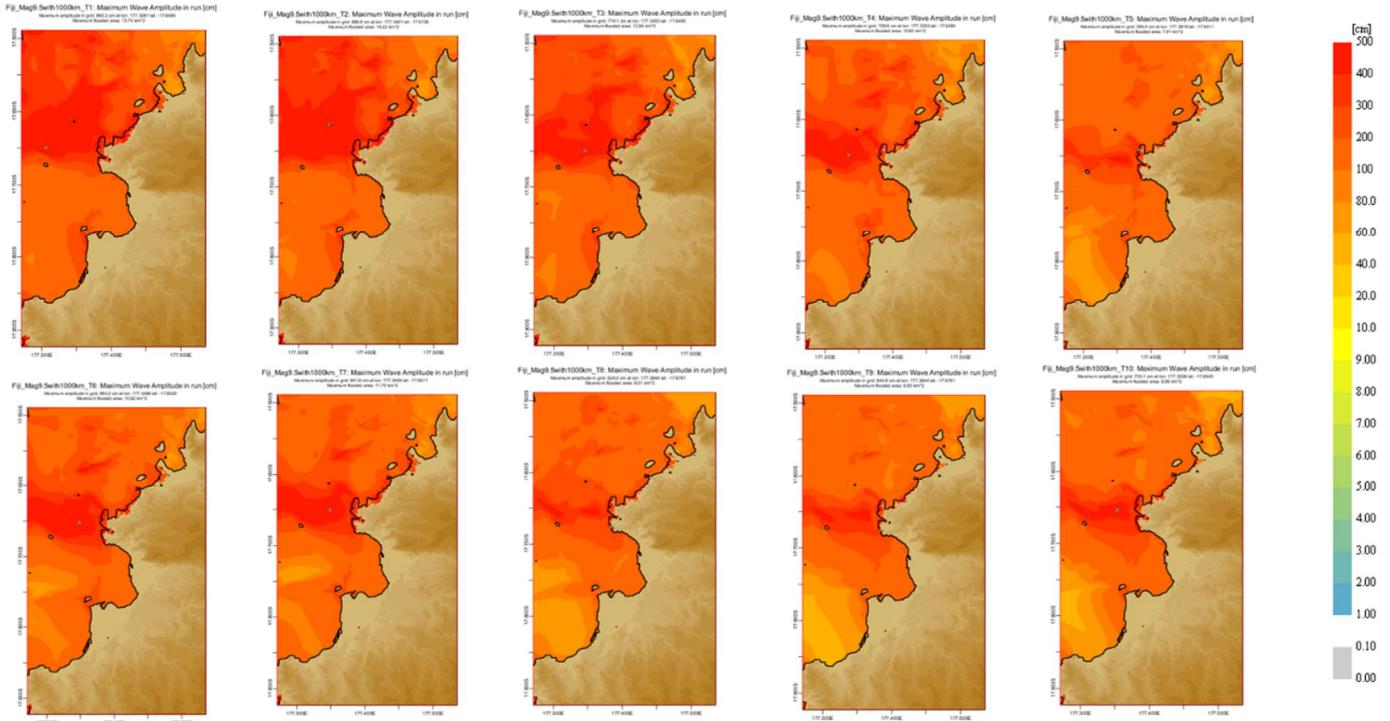


Figure 5-8 Results of Tsunami Simulation -Tsunami Height (M9.1) in cases T1-10

(3) M9.2 from Vanuatu Trench



(4) M9.5 from Vanuatu Trench



(5)M9.0 from Tonga Trench

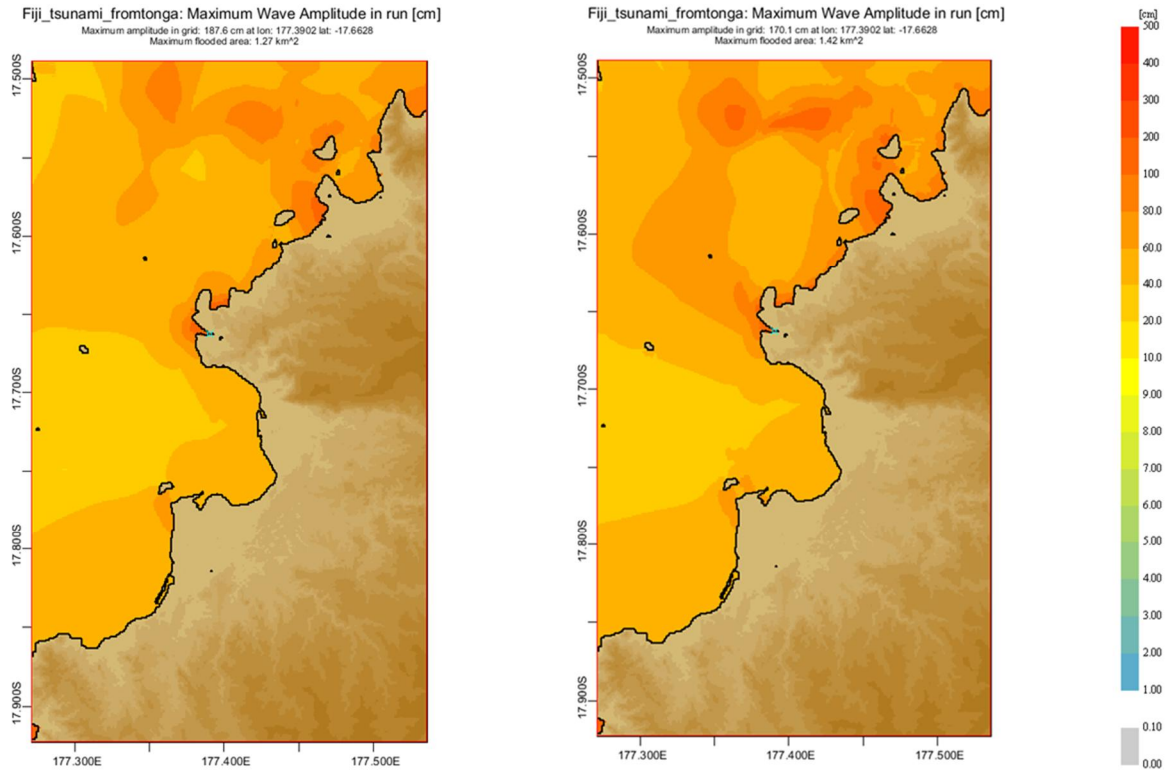


Figure 5-11 Results of Tsunami Simulation -Tsunami Height (M9.0) in cases T1-2

5.1.5 Evaluation of Expected Maximum Tsunami Height at the coastline of Nadi

After obtaining the extremal values from the ComMIT simulation results, the maximum wave amplitudes (tsunami wave heights) can be extracted in ASCII file format. By combining this ASCII file with the extraction of target points in the coastline of Nadi using open-source QGIS software, the maximum tsunami wave heights which may reach the target points are evaluated and presented as follows.

(1) M9.0 from Vanuatu Trench

cal_pt	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	Max
pt1	70.9	85.9	62.4	56.6	64.1	70.5	66.1	54.9	29.9	35.9	40.6	85.9
pt2	70.8	91.3	66.0	57.1	64.3	71.8	66.6	55.5	30.5	36.0	41.0	91.3
pt3	83.3	113.8	85.4	62.2	66.2	73.9	68.2	58.9	33.8	37.9	44.3	113.8
pt4	112.5	151.9	115.1	78.9	68.2	77.2	70.7	64.1	38.0	59.6	47.2	151.9
pt5	105.1	146.6	106.6	73.2	70.1	78.9	72.6	61.7	35.5	50.0	45.4	146.6
pt6	105.9	145.7	108.2	73.0	68.5	78.3	70.2	62.6	35.3	54.7	46.9	145.7
pt7	79.2	110.8	81.8	61.1	64.9	71.9	67.1	57.0	31.6	37.4	42.4	110.8
pt8	69.2	90.1	65.9	56.5	64.2	70.8	66.4	55.0	30.5	36.2	40.9	90.1
pt9	69.6	98.5	72.0	57.1	64.6	71.8	67.3	55.5	30.6	36.7	41.4	98.5
pt10	75.9	110.7	78.9	57.6	63.4	71.0	67.1	55.6	31.0	37.3	42.2	110.7
pt11	80.0	112.9	82.3	58.2	64.9	72.5	68.6	56.9	31.6	37.7	42.6	112.9
pt12	101.2	143.6	104.5	66.5	65.0	76.3	71.6	61.2	34.3	39.3	45.3	143.6
pt13	105.7	150.2	109.7	74.7	68.7	78.8	75.5	63.4	44.9	50.4	56.8	150.2
pt14	128.3	166.4	129.6	90.9	69.1	78.1	93.6	71.2	44.0	77.1	68.5	166.4
pt15	116.2	91.9	105.7	84.5	90.7	113.3	114.6	78.2	64.9	94.4	92.6	116.2
pt16	117.4	119.3	103.3	112.5	110.7	121.6	113.0	93.3	77.4	92.8	95.3	121.6
pt17	113.6	111.1	103.8	106.5	110.1	117.1	111.6	93.8	77.2	89.6	92.0	117.1
pt18	146.4	134.1	119.5	101.2	114.5	124.0	117.1	95.2	81.1	94.4	90.6	146.4
pt19	168.3	145.8	135.2	109.7	119.9	128.6	121.3	99.8	84.6	96.3	91.2	168.3
pt20	135.8	125.1	114.8	100.3	111.1	119.9	114.1	93.9	78.3	91.7	89.6	135.8
pt21	116.7	106.9	100.2	98.4	106.5	109.3	109.4	93.9	74.8	90.0	88.1	116.7
pt22	124.7	114.0	106.6	106.0	108.5	116.7	122.4	97.4	75.1	91.4	89.6	124.7
pt23	120.1	110.6	107.0	104.2	107.5	113.1	114.8	96.0	74.7	92.0	89.6	120.1
pt24	120.4	110.5	103.0	100.1	107.0	111.8	114.9	95.8	74.5	91.6	89.1	120.4
pt25	121.3	111.8	104.5	103.0	106.3	112.8	112.4	97.2	74.7	91.6	89.1	121.3
pt26	119.6	111.4	103.8	99.8	106.5	110.8	111.2	96.0	74.5	91.4	88.8	119.6
pt27	120.0	107.6	105.3	98.4	105.7	110.3	110.6	95.2	74.1	91.1	88.6	120.0
pt28	114.9	100.9	101.8	94.2	103.9	106.3	107.0	90.5	72.3	88.7	85.8	114.9
pt29	105.5	98.4	101.4	96.4	102.8	103.8	103.6	86.1	70.3	86.3	83.0	105.5
pt30	98.4	96.1	98.3	95.2	102.4	100.5	101.5	82.9	68.5	83.9	80.7	102.4
pt31	89.5	95.2	90.5	97.6	101.5	100.8	101.8	77.0	66.9	81.2	78.7	101.8
pt32	120.2	138.2	136.5	139.6	123.0	133.7	131.8	86.2	76.9	90.3	113.3	139.6
pt33	89.4	98.8	104.3	108.0	103.7	106.5	105.6	75.3	67.3	81.6	80.3	108.0
pt34	86.9	108.6	106.9	106.7	116.9	114.3	110.7	74.7	67.6	82.1	86.1	116.9
pt35	93.2	120.6	106.1	106.3	103.7	113.3	108.4	73.1	66.8	80.5	88.6	120.6
Max	168.3	166.4	136.5	139.6	123.0	133.7	131.8	99.8	84.6	96.3	113.3	168.3

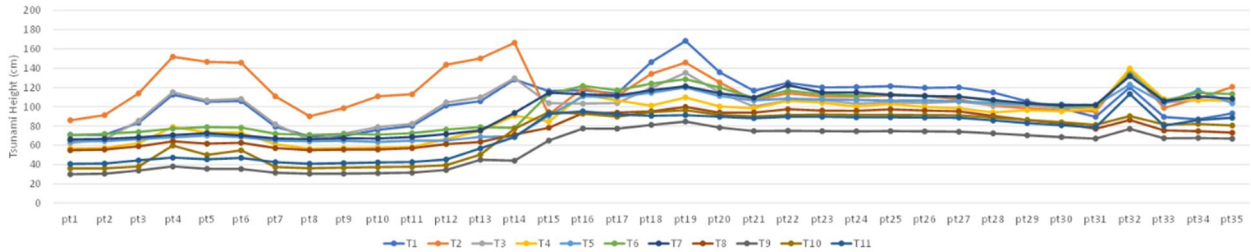
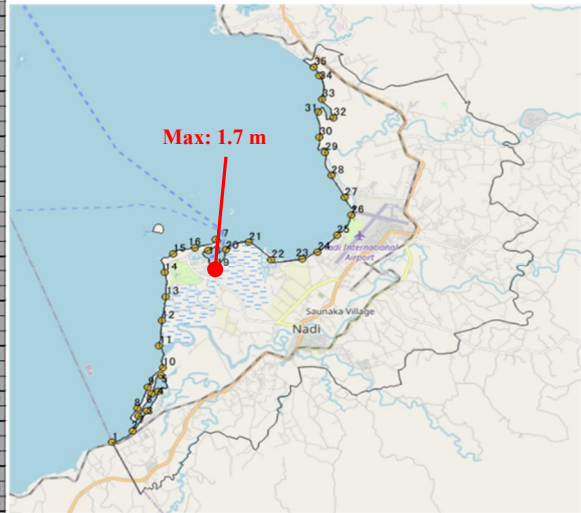
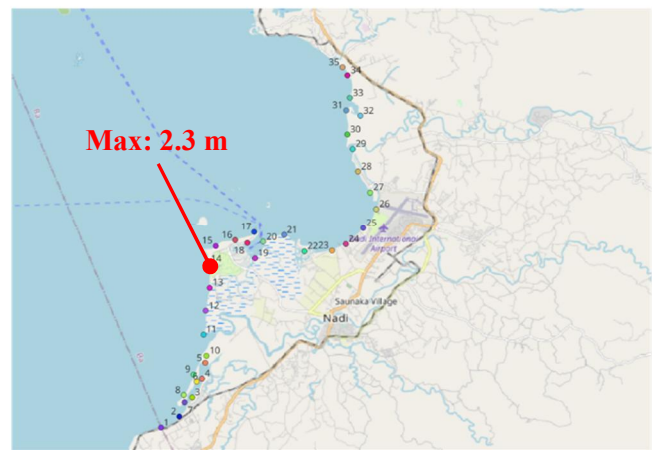


Figure 5-12 Maximum Tsunami Height- Nadi (M9.0)

(2) M9.1 from Vanuatu Trench

cal_pt	HT1	HT2	HT3	HT4	HT5	HT6	HT7	HT8	HT9	HT10	Max
pt1	60.43	64.59	64.08	44.81	49.25	49.09	42.76	33.50	30.30	30.35	64.69
pt2	67.00	68.05	68.03	47.40	49.63	49.25	44.36	34.57	31.43	32.47	68.05
pt3	87.50	83.12	83.73	53.41	51.07	51.18	55.58	34.53	35.54	36.60	87.50
pt4	101.00	78.97	86.00	55.33	51.60	48.51	51.65	35.88	32.85	34.55	101.00
pt5	68.77	64.06	58.50	58.82	64.40	63.46	55.37	46.78	43.40	40.01	68.77
pt6	111.01	96.04	100.78	65.21	52.26	54.95	60.20	38.04	37.39	44.52	111.01
pt7	91.14	83.13	85.08	54.56	50.90	51.80	51.98	36.37	36.43	40.14	91.14
pt8	64.87	67.86	69.44	48.86	49.39	48.93	43.10	34.79	30.16	34.25	69.44
pt9	72.17	73.97	76.95	56.76	49.32	49.00	45.12	34.84	29.88	36.45	76.95
pt10	83.12	81.73	86.58	48.85	49.40	49.75	50.15	34.70	30.30	42.43	86.58
pt11	90.36	90.62	93.23	76.31	50.11	50.90	52.87	35.63	31.07	45.75	93.23
pt12	128.37	118.57	123.37	103.72	58.16	57.34	68.31	42.93	38.28	55.90	128.37
pt13	205.74	150.20	154.01	104.13	59.83	61.25	61.76	40.53	55.86	63.58	205.74
pt14	233.49	169.90	173.88	154.14	89.29	96.10	92.79	54.57	60.92	96.79	233.49
pt15	129.39	118.04	124.43	95.69	95.71	113.24	100.55	58.73	67.54	101.37	129.39
pt16	97.05	83.75	74.16	100.38	83.15	110.05	84.01	57.73	56.91	81.94	100.38
pt17	80.73	78.18	76.47	106.31	76.82	93.14	75.31	56.37	56.85	67.88	106.31
pt18	103.18	87.06	98.09	88.57	83.80	82.29	79.24	70.18	64.32	66.21	103.18
pt19	130.32	111.36	143.88	124.73	109.41	113.34	93.05	93.71	75.82	89.11	143.88
pt20	85.69	75.72	87.79	84.23	79.50	80.37	74.09	59.86	58.05	67.35	87.79
pt21	71.23	72.95	72.60	76.89	70.69	78.45	68.40	57.41	55.31	65.47	76.89
pt22	97.34	89.82	106.81	126.54	128.76	101.29	85.23	66.07	76.03	67.50	128.76
pt23	85.51	87.07	77.43	85.73	79.55	73.95	66.36	61.74	66.46	65.83	87.07
pt24	83.05	74.43	78.11	87.14	82.47	74.83	66.95	62.30	62.09	67.21	87.14
pt25	86.28	78.12	74.01	83.97	77.78	75.75	67.78	63.42	60.94	67.25	86.28
pt26	90.37	76.08	72.60	83.68	77.00	72.87	64.24	65.79	57.81	67.37	90.37
pt27	89.24	74.14	69.54	82.54	83.54	72.98	65.40	61.88	57.77	66.94	89.24
pt28	72.65	66.81	65.74	73.31	70.99	67.11	59.36	56.43	54.73	65.24	73.31
pt29	66.63	64.86	69.20	72.81	68.90	62.96	54.36	54.82	53.93	65.22	72.81
pt30	59.15	64.75	69.74	66.81	65.74	62.97	50.07	55.60	53.74	61.71	69.74
pt31	50.02	70.06	76.93	80.38	71.11	61.82	51.06	51.28	55.55	60.57	80.38
pt32	93.44	102.99	143.01	191.45	139.04	147.30	138.07	73.92	74.36	118.83	191.45
pt33	52.04	84.83	92.04	125.71	77.94	84.42	74.45	50.64	58.57	61.28	125.71
pt34	66.92	100.85	117.30	162.34	104.53	119.16	112.74	59.89	64.61	95.58	162.34
pt35	84.14	192.03	119.82	209.60	115.48	133.77	125.07	63.44	71.28	114.28	209.60
Max	233.49	169.90	173.88	209.60	139.04	147.30	138.07	93.71	76.03	118.83	233.49



Location = Nadi
Earthquake Magnitude = 9.1
unit source = 600km x 150 km

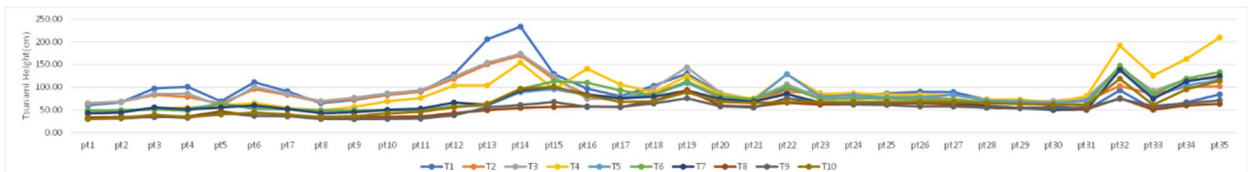


Figure 5-13 Maximum Tsunami Height- Nadi (M9.1)

(3) M9.2 from Vanuatu Trench

cal pt	HT1	HT2	HT3	HT4	HT5	HT6	HT7	HT8	HT9	HT10	Max
pt1	77.28	90.30	83.80	60.53	60.50	53.62	43.66	37.20	33.77	42.40	90.28
pt2	80.81	93.94	88.35	61.79	61.08	54.19	44.76	37.74	34.17	45.28	93.94
pt3	104.69	120.51	112.29	67.14	63.23	57.72	58.31	40.06	36.73	55.24	120.51
pt4	103.70	115.42	112.56	71.13	60.12	52.05	57.06	39.54	36.17	54.27	115.42
pt5	69.66	81.74	77.61	74.08	74.31	67.16	56.24	48.89	43.95	39.69	81.74
pt6	121.72	136.77	128.50	84.35	68.60	60.30	66.94	45.30	40.28	64.83	136.77
pt7	105.32	121.44	113.10	68.03	66.23	60.40	55.18	41.41	35.85	55.23	121.44
pt8	81.77	95.08	89.62	60.38	60.45	54.01	47.13	38.19	34.71	47.15	95.08
pt9	89.99	105.27	99.74	70.81	60.14	54.18	50.93	38.45	35.08	51.71	105.27
pt10	101.41	117.54	111.29	87.15	60.33	54.95	55.85	38.98	37.85	57.74	117.54
pt11	110.57	127.51	119.57	95.51	61.66	55.75	60.58	39.46	40.20	63.04	127.51
pt12	139.30	163.62	157.34	130.47	70.25	67.45	74.10	45.49	52.63	77.01	163.62
pt13	184.88	184.59	159.46	129.62	74.47	74.90	81.34	63.14	65.20	84.95	184.88
pt14	183.81	199.89	180.38	157.46	108.67	110.47	118.44	74.24	88.79	119.30	199.89
pt15	149.86	145.63	141.18	109.32	109.34	128.75	117.61	71.99	134.30	123.55	149.86
pt16	105.46	95.85	98.06	161.77	98.45	129.39	102.30	72.91	74.15	103.08	161.77
pt17	86.61	61.61	101.45	120.75	91.37	110.55	91.56	69.76	70.17	85.75	120.75
pt18	116.35	108.15	118.37	97.47	98.72	94.73	101.29	85.83	85.97	81.10	118.37
pt19	144.92	154.36	160.57	132.20	126.27	125.51	117.39	90.48	118.64	111.53	160.57
pt20	97.79	95.50	108.89	96.87	95.20	91.56	94.08	76.24	75.44	78.74	108.89
pt21	84.41	83.91	91.81	88.96	84.41	87.83	85.44	66.60	68.97	76.58	91.81
pt22	113.57	126.87	137.78	129.83	130.38	112.90	103.70	100.08	97.34	78.90	137.78
pt23	95.75	104.47	108.02	104.03	87.94	86.51	87.45	70.50	69.32	78.74	108.02
pt24	92.96	97.15	91.13	101.43	89.92	82.77	84.55	75.07	69.04	78.45	101.43
pt25	97.12	100.88	98.43	99.96	84.91	82.36	83.37	72.55	72.37	78.89	100.88
pt26	100.51	101.18	92.83	96.37	83.97	81.18	83.63	73.06	73.28	78.80	101.18
pt27	99.78	100.86	88.35	96.51	87.67	80.73	84.17	72.02	83.25	78.47	100.86
pt28	81.93	82.96	79.82	83.63	82.39	74.34	77.84	68.54	68.56	76.15	83.63
pt29	74.37	86.47	82.12	80.25	77.92	71.84	74.50	65.86	68.63	74.02	86.47
pt30	66.13	84.58	84.12	76.87	76.75	68.66	68.13	61.88	69.14	72.24	84.58
pt31	70.35	90.15	92.42	107.96	80.75	69.11	69.42	60.17	72.20	70.47	107.96
pt32	122.79	140.22	170.06	205.69	184.58	174.71	135.73	85.48	158.73	145.71	205.69
pt33	89.27	110.22	131.13	155.40	109.10	110.65	75.17	65.97	97.79	83.87	155.40
pt34	99.38	141.12	147.41	181.01	138.02	145.61	112.35	74.76	127.44	115.69	181.01
pt35	114.15	130.27	163.36	234.10	169.68	169.33	126.66	77.01	158.38	145.63	234.10
Max	184.88	199.89	180.38	234.10	184.58	174.71	135.73	100.08	158.73	145.71	234.10

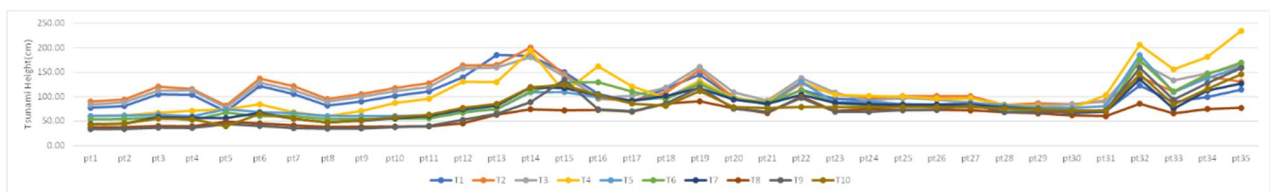
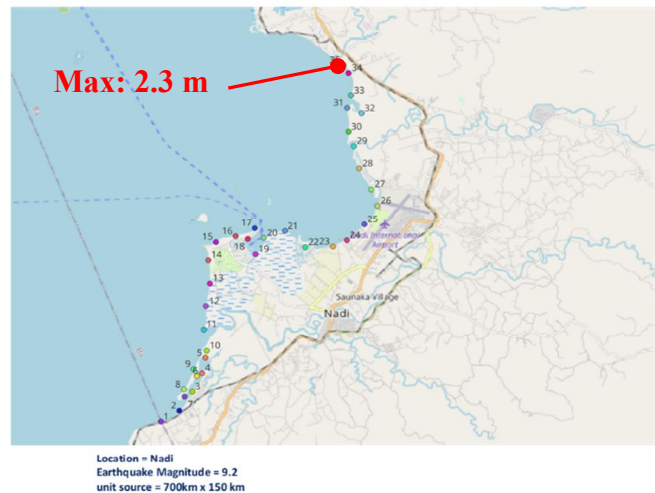


Figure 5-14 Maximum Tsunami Height- Nadi (M9.2)

(4) M9.5 from Vanuatu Trench

cal pt	HT1	HT2	HT3	HT4	HT5	HT6	HT7	HT8	HT9	HT10	Max
pt1	188.15	176.67	178.00	121.07	89.85	110.24	112.94	82.22	65.84	88.30	188.15
pt2	195.12	188.48	189.19	135.33	100.66	117.50	129.61	84.14	70.45	96.60	195.12
pt3	204.64	202.69	202.07	144.60	121.97	140.21	149.96	98.14	84.88	118.32	204.64
pt4	188.79	193.17	198.13	155.98	120.51	142.72	142.53	96.66	86.65	117.52	198.13
pt5	183.27	187.33	182.90	124.97	91.28	109.47	114.65	102.25	73.74	80.81	183.27
pt6	235.37	230.02	231.11	189.75	132.61	166.12	165.75	121.76	110.40	132.62	231.11
pt7	239.23	228.43	224.43	152.85	120.57	146.97	152.75	97.84	83.07	119.36	239.23
pt8	198.23	186.90	187.65	128.73	99.77	119.93	126.03	81.90	72.44	96.01	198.23
pt9	217.56	206.23	208.42	158.01	113.03	135.84	137.08	85.97	78.32	105.61	217.56
pt10	248.92	237.43	242.78	197.84	125.87	154.09	151.39	108.84	86.84	115.77	248.92
pt11	256.41	251.33	259.22	215.18	141.49	178.39	168.23	113.16	97.67	125.96	259.22
pt12	327.42	316.78	326.81	298.49	180.86	269.77	252.19	176.25	140.27	159.20	327.42
pt13	324.95	310.61	300.38	290.45	197.62	217.01	232.67	163.14	130.99	162.51	324.95
pt14	348.14	319.07	320.70	390.02	279.58	347.26	355.61	223.20	191.26	220.42	390.02
pt15	212.00	220.65	202.16	189.21	236.53	229.39	195.44	184.88	169.99	219.25	236.53
pt16	210.32	166.75	147.98	241.09	169.11	318.75	291.39	187.59	139.29	180.87	318.75
pt17	169.33	146.08	134.38	183.60	152.07	268.59	174.59	143.86	120.01	152.72	268.59
pt18	175.65	180.63	140.26	161.37	156.31	177.57	108.36	133.13	131.33	142.41	180.63
pt19	204.47	257.97	206.74	223.32	196.43	220.46	219.82	176.03	209.76	216.69	257.97
pt20	176.60	150.30	133.64	152.04	150.46	173.23	171.97	115.56	126.01	138.16	176.60
pt21	150.74	155.89	149.27	144.03	134.45	161.66	152.45	107.06	117.41	132.72	161.66
pt22	189.31	218.25	179.47	228.38	169.17	260.91	170.02	176.07	135.56	136.71	228.38
pt23	168.25	197.81	161.64	111.95	150.03	172.50	161.67	138.20	123.21	135.80	197.81
pt24	162.76	177.24	149.61	200.63	137.89	160.21	151.10	121.08	128.55	135.81	200.63
pt25	165.76	189.49	155.39	210.09	143.87	161.25	152.08	136.30	136.75	136.08	210.09
pt26	166.47	184.80	152.09	188.97	139.43	157.59	150.66	124.72	129.87	136.06	188.97
pt27	162.08	182.75	156.36	196.38	146.71	158.55	156.29	127.97	117.57	135.08	196.38
pt28	152.57	160.36	148.88	145.23	124.14	147.31	147.22	118.26	118.28	131.45	160.36
pt29	149.81	154.00	157.60	159.62	119.23	139.76	144.12	112.51	116.63	127.84	154.00
pt30	147.66	165.49	157.38	176.03	116.27	131.98	134.99	134.62	151.59	171.06	176.03
pt31	152.80	157.77	163.39	219.30	162.19	172.12	184.01	187.41	213.94	231.87	231.87
pt32	222.20	250.78	264.07	309.94	256.99	265.84	309.91	233.36	277.74	283.84	309.94
pt33	164.12	188.24	196.56	262.05	215.89	220.74	239.08	249.41	258.16	277.45	277.45
pt34	223.15	246.49	275.94	309.44	215.55	218.68	244.16	183.07	236.87	238.97	309.44
pt35	217.35	238.42	250.54	261.43	272.59	267.61	302.88	267.99	297.90	284.45	302.88
Max	348.14	319.07	326.81	390.02	279.58	347.26	355.61	223.20	191.26	220.42	390.02

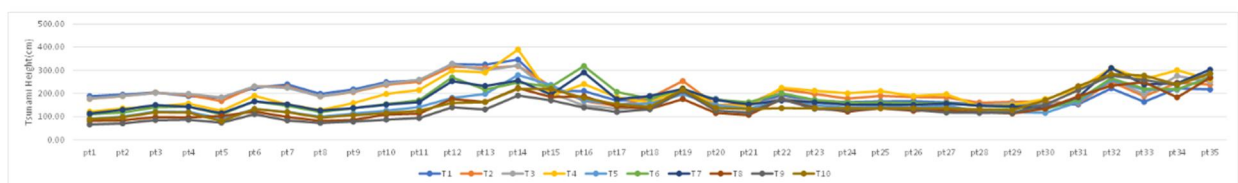
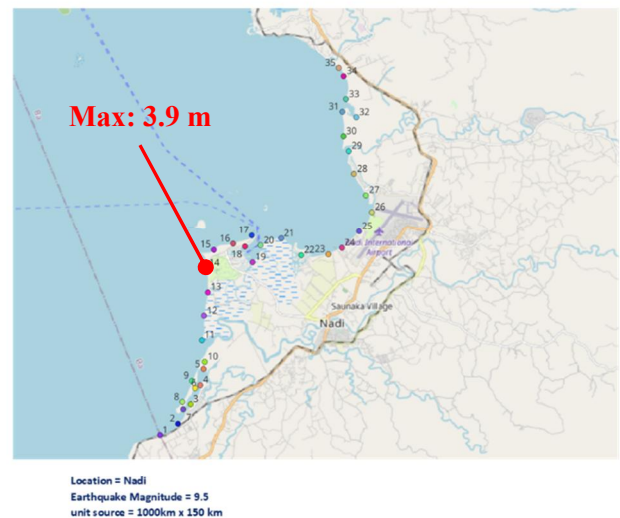


Figure 5-15 Maximum Tsunami Height- Nadi (M9.5)

From the results of the 1st case study (M9.0), the maximum expected tsunami height observed at the Nadi coastline measures 1.7meters, occurring at point 19. Similarly, maximum wave observed 2.3meters occurring at point 34 for 2nd case study, 2.3meters occurring at point 14 for 3rd case study, and 3.9meters occurring at point 14 for 4th case study are measured respectively.

(5) M9.0 from Tonga Trench

cal_pt	T1(9.0)	T2(9.0)
1	48.80	49.65716
2	49.35	50.11977
3	51.31	53.36154
4	54.47	60.56728
5	55.51	58.36372
6	53.95	58.18192
7	50.00	51.66474
8	49.29	49.80297
9	49.68	49.92313
10	50.20	50.16353
11	50.87	50.65356
12	55.15	55.4846
13	62.77	62.83373
14	67.86	70.94106
15	54.72	57.73856
16	50.95	61.83344
17	50.43	58.64722
18	55.07	61.20499
19	56.76	73.36916
20	53.01	58.83698
21	50.07	55.18139
22		
23	51.13	56.49
24	51.02	56.36444
25	51.07	56.22607
26	51.24	56.42203
27	50.71	56.00983
28	48.58	53.08684
29	45.98	49.72607
30	43.54	47.0031
31	42.80	43.92887
32	61.44	55.07823
33	48.08	42.39642
34	55.47	48.43351
35	55.68	51.11143
max	67.86	73.37

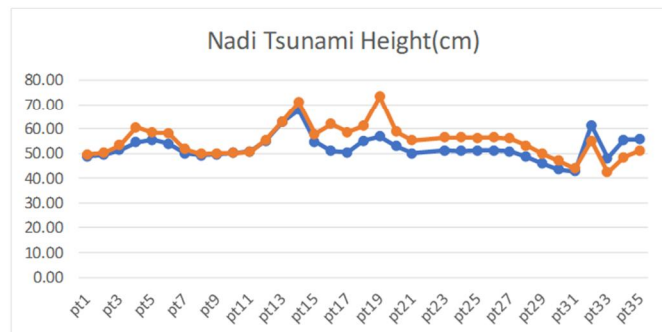
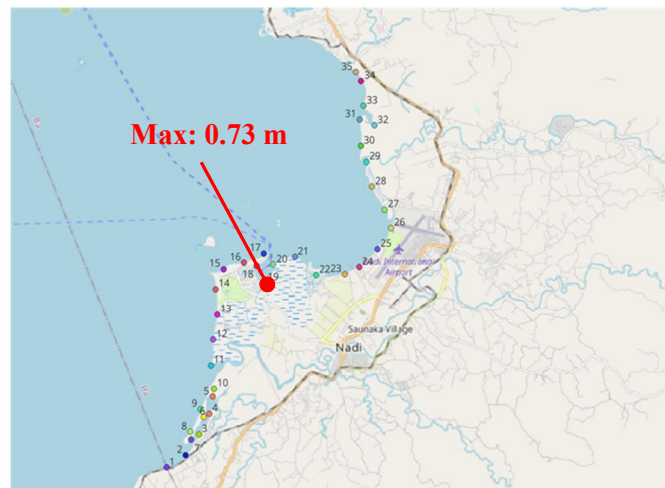


Figure 5-16 Maximum Tsunami Height- Nadi (M9.0)

From the results of the 5th case study with two different unit sources from the Tonga Trench, the maximum expected tsunami height observed at the Nadi coastline measures 0.73meters, occurring at point 19.

5.2 Inundation Analysis

5.2.1 Target Tsunami Level for Hazard Map

By accumulating the estimated maximum tsunami height obtained by ComMIT Simulation from the above case studies, this study selected the M9.5 tsunami in Vanuatu as a worst-case scenario. The Maximum tsunami height is 3.9 m at coastline.

Table 5-2 Scenario Tsunami Source Setting

Case No.	Trench	Magnitude	No. of Cases	Maximum Tsunami Height	Remark
1	Vanuatu	9.0	T1-T10	1.7 m	
2	Vanuatu	9.1	T1-T10	2.3 m	
3	Vanuatu	9.2	T1-T10	2.3 m	
4	Vanuatu	9.5	T1-T11	3.9 m	Selected
5	Tonga	9.0	T1-T2	0.7 m	

Source: JICA Expert Team

Using the maximum tsunami height and highest astronomical tide in Lautoka (MSL + 1.142m), total estimated tsunami elevation of Nadi can be evaluated as follows.

Magnitude	Maximum Tsunami Height	Highest Astronomical Tide (HAT) in Lautoka	Total Tsunami Elevation
9.5	3.9m	MSL+1.142m	MSL+5.0m
9.2	2.3m	MSL+1.142m	MSL+3.4m
9.1	2.3m	MSL+1.142m	MSL+3.4m
9.0	1.7m	MSL+1.142m	MSL+2.8m

As the worst-case scenario, MSL+5.0m is applied to the Target Level of the Tsunami Hazard Map in Nadi.

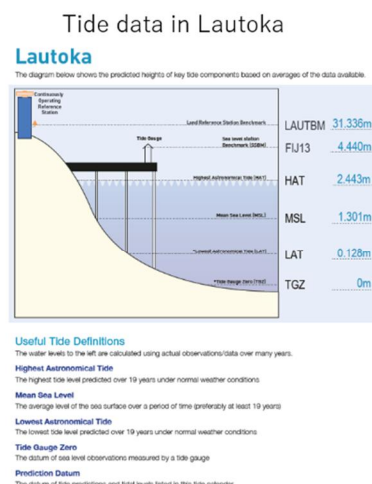
Source: JICA Expert Team

Figure 5-17 Target Tsunami Level for Hazard Map (Nadi)

Based on the above evaluation, MSL+5.0 m is applied to the target level of the Tsunami Hazard Map in Nadi as the worst-case scenario.

5.2.2 Tsunami Hazard Map of Nadi

The resulting inundated area or depth can be integrated with LiDAR and SRTM-derived digital elevation model (DEMs) to generate hazard maps with the indication of the inundation depth. The following is the Tsunami Hazard Map created by LiDAR and SRTM data for North and South zone of Nadi.



(1) Tsunami Hazard Map (Nadi) by LiDAR data

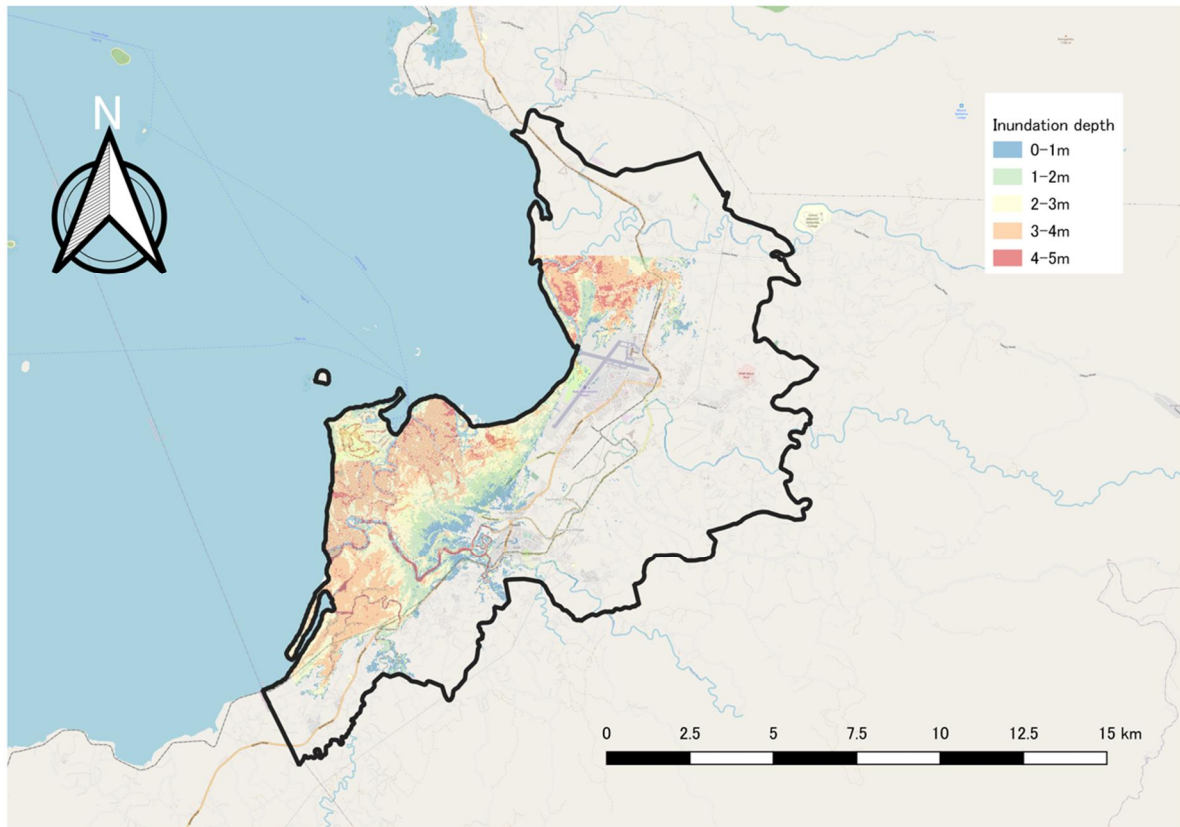


Figure 5-18 Tsunami Hazard Map (Nadi)- LiDAR Data

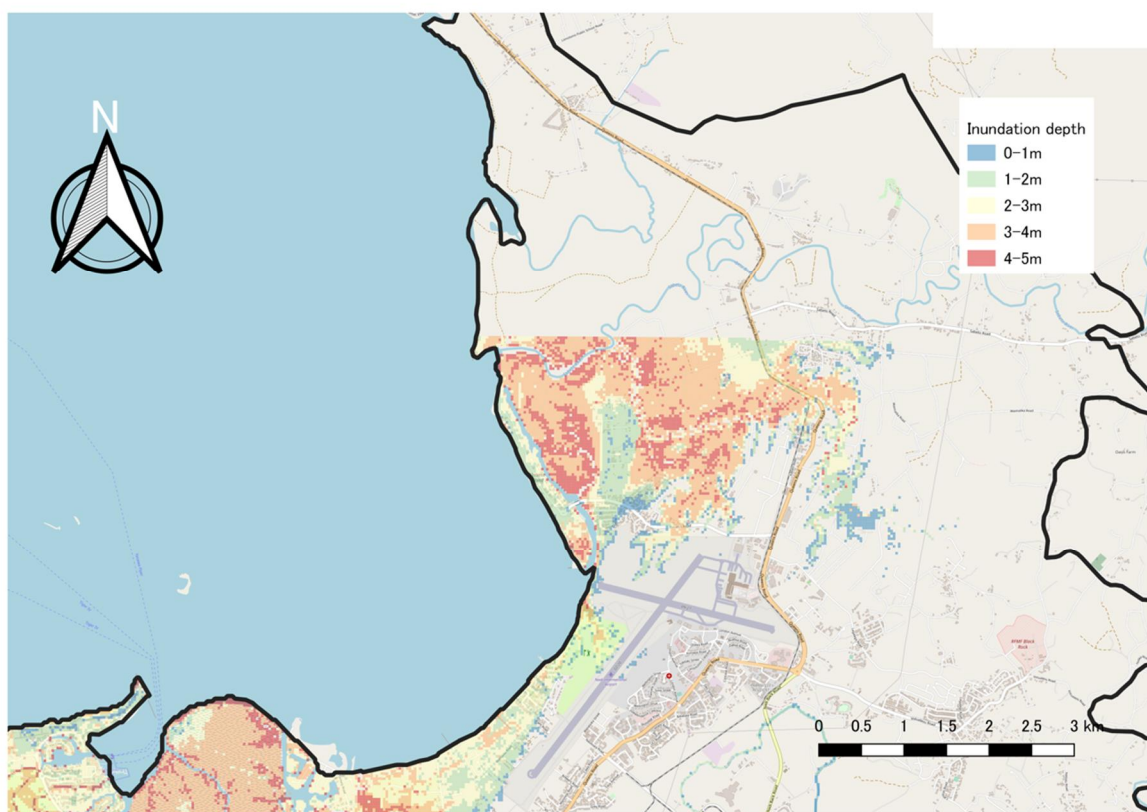


Figure 5-19 Tsunami Hazard Map (Nadi)- LiDAR Data (North)

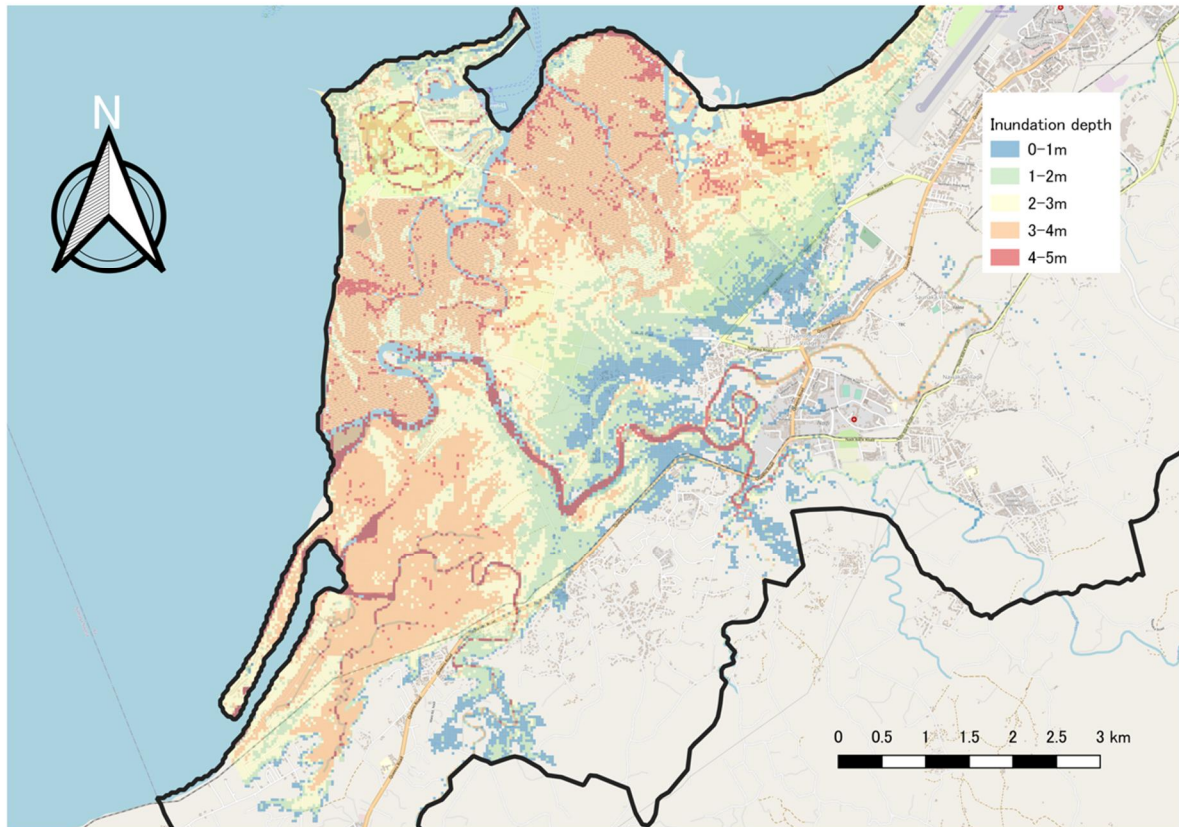


Figure 5-20 Tsunami Hazard Map (Nadi) – LiDAR data (South)

(2) Tsunami Hazard Map (Nadi) by SRTM data

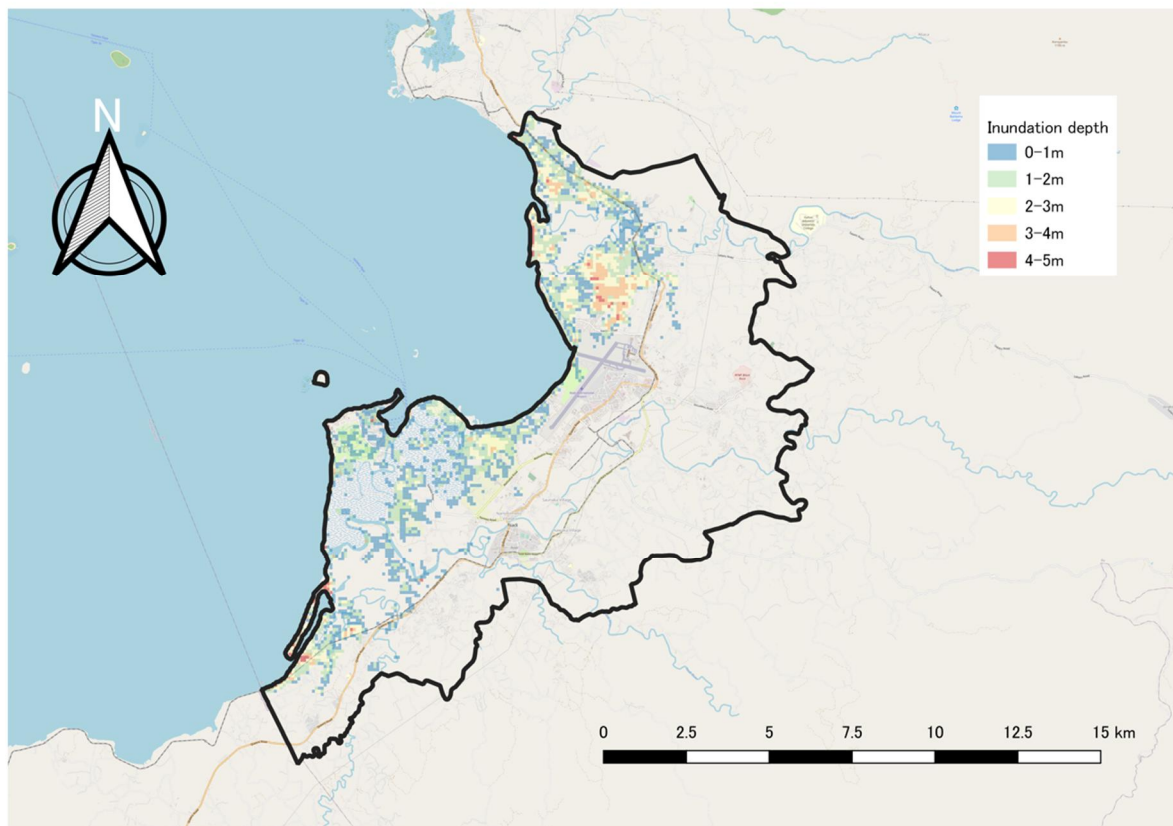


Figure 5-21 Tsunami Hazard Map (Nadi) – SRTM data

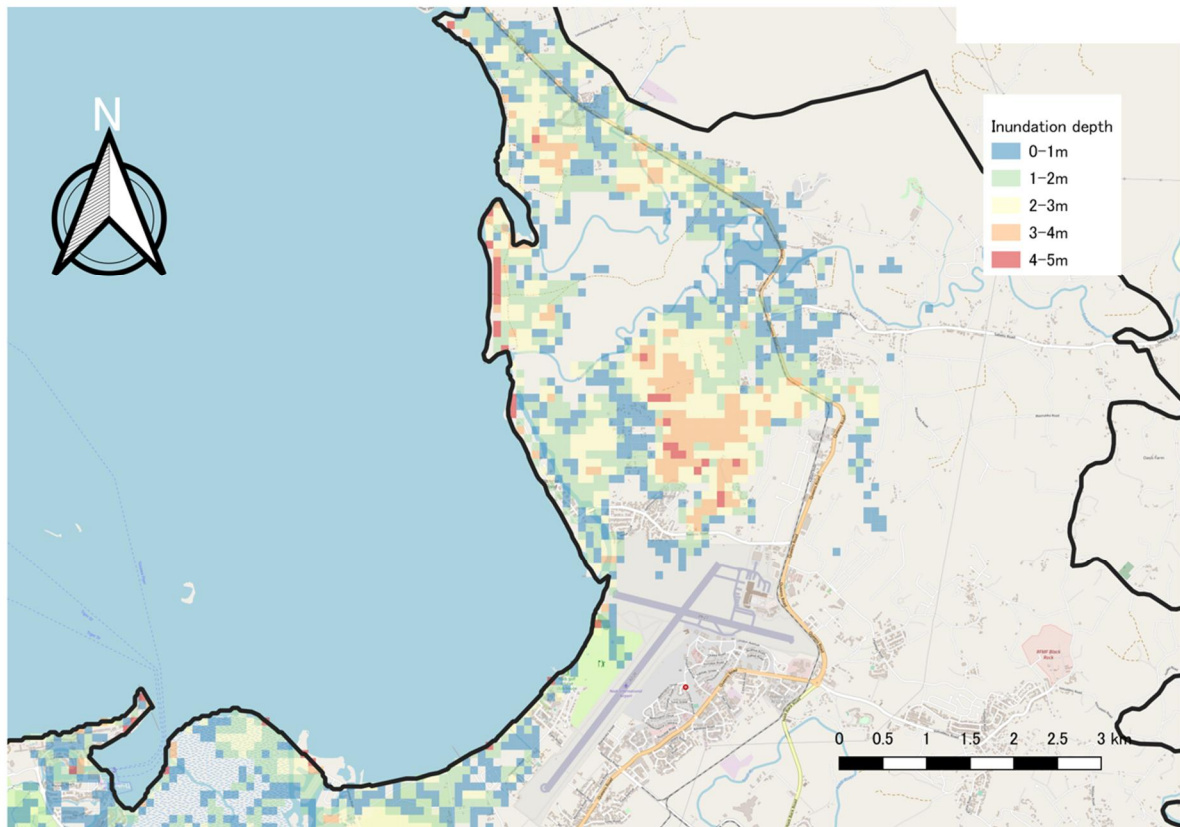


Figure 5-22 Tsunami Hazard Map (Nadi) – SRTM (North)

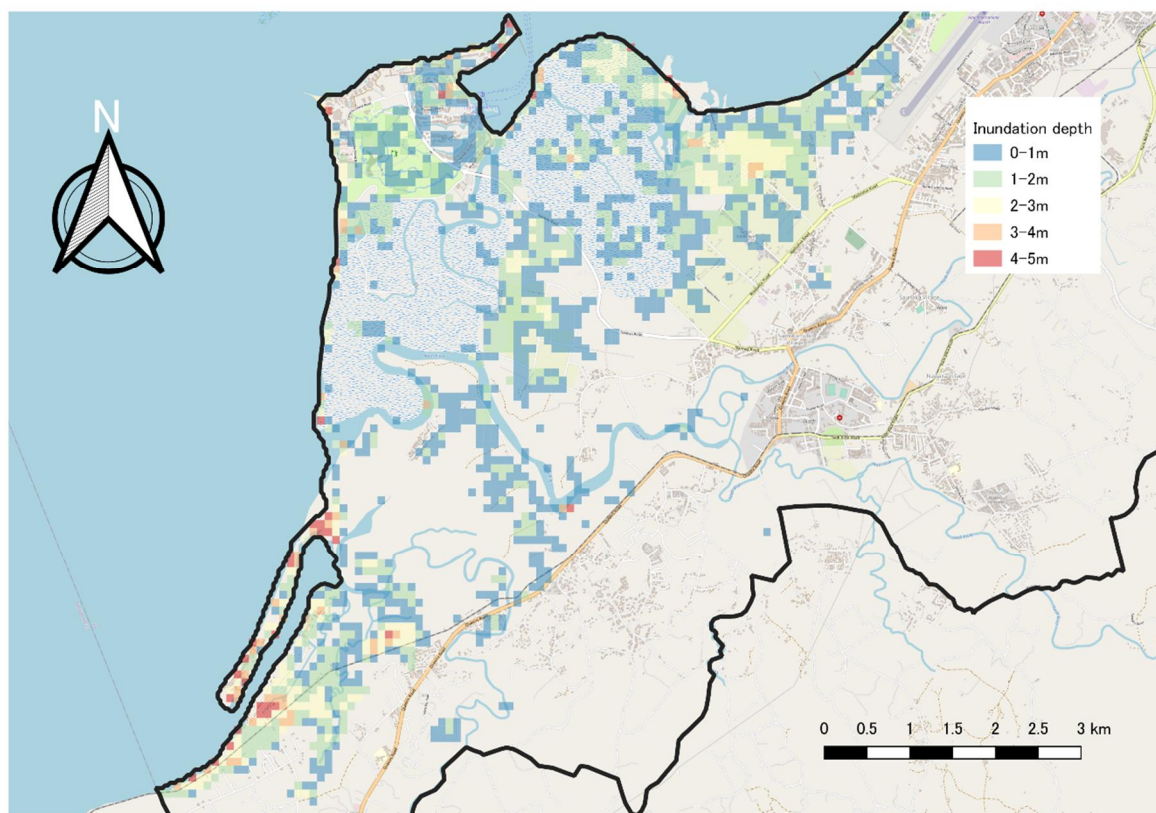


Figure 5-23 Tsunami Hazard Map (Nadi) – SRTM (South)

Chapter 6. Case Study in Suva

6.1 Tsunami Analysis

6.1.1 Setting Target Area

This case study focuses on assessing hazards in coastal regions of Suva which is located on the southern side of the main Viti Levu Island in Fiji.



Figure 6-1 Target Area of This Study (Suva, Fiji)

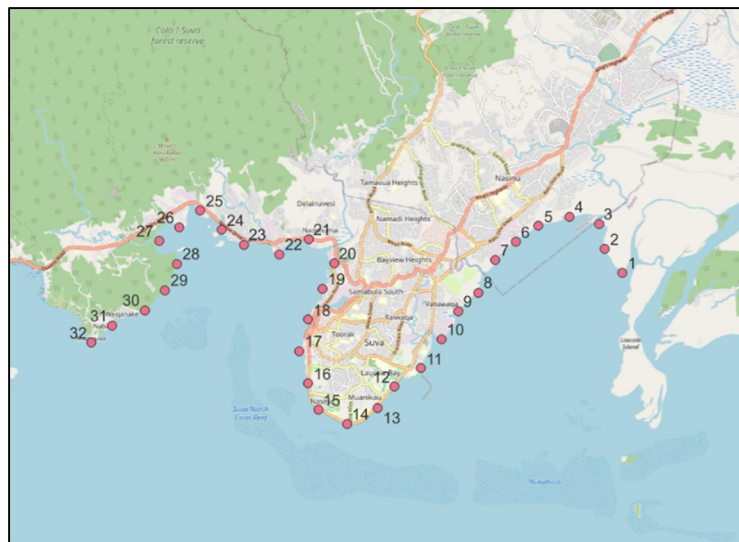
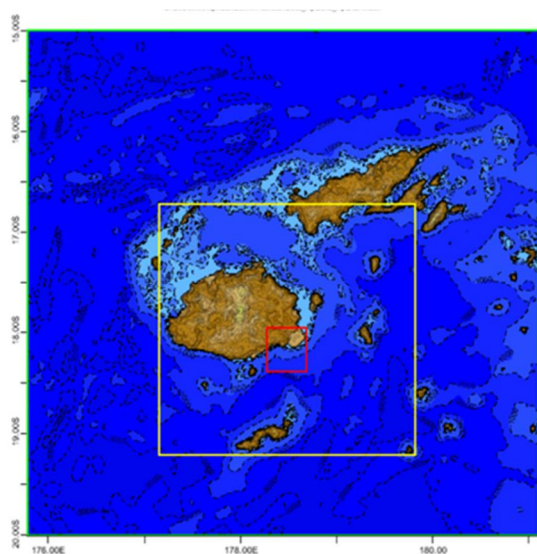


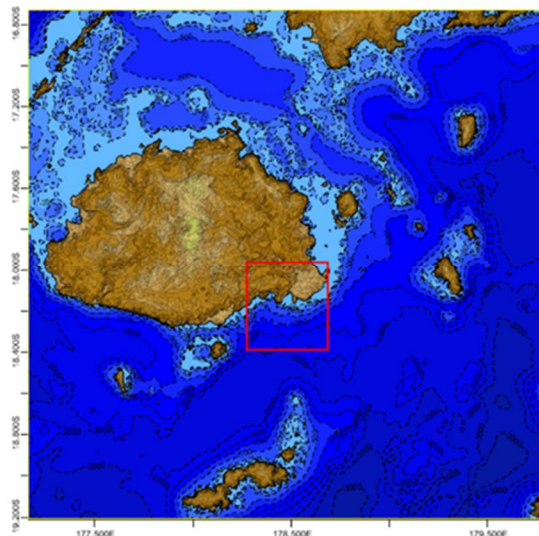
Figure 6-2 Extraction Points of Tsunami Heights along the Coastline of Target Area

6.1.2 Setting Bathymetry for Calculation

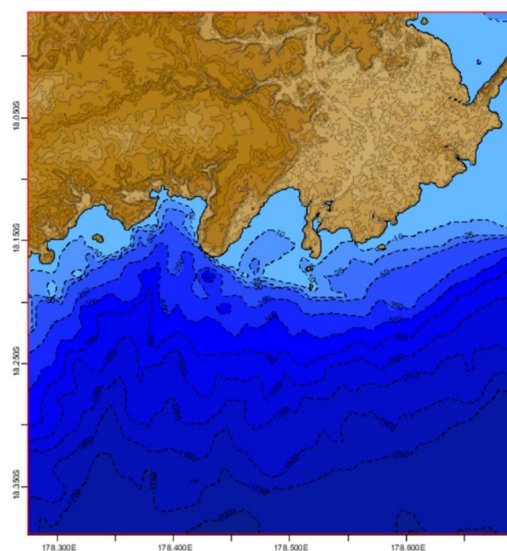
The bathymetry data for the calculation are follows.



Low resolution A-grid



Medium resolution B-grid



High resolution C-grid

Figure 6-3 Bathymetric data for Tsunami Analysis

6.1.3 Setting Assumed Earthquake and Tsunami sources

This case study covers both the Tonga Trench and the Vanuatu Trench. The scenarios of each Trench are Magnitude 8.5, 9.0, 9.1, 9.2, and 9.5, as shown in Table 6-1.

Table 6-1 Scenario Tsunami Sources Setting

Case No.	Trench	Magnitude	Rupture Zone (Length)	Rupture Zone (Width)	No. of Cases
1	Tonga	8.5	400km	150km	T1-T7
2	Tonga	9.0	500km	150km	T1-T9
3	Tonga	9.1	700km	150km	T1-T9
4	Tonga	9.2	800km	150km	T1-T9
5	Tonga	9.5	1000km	150km	T1-T10
6	Vanuatu	8.5	400km	150km	T1-T5
7	Vanuatu	9.0	500km	150km	T1-T6
8	Vanuatu	9.1	700km	150km	T1-T6
9	Vanuatu	9.2	800km	150km	T1-T6
10	Vanuatu	9.5	1000km	150km	T1-T7

Source: JICA Expert Team

(1) M8.5 from Tonga Trench

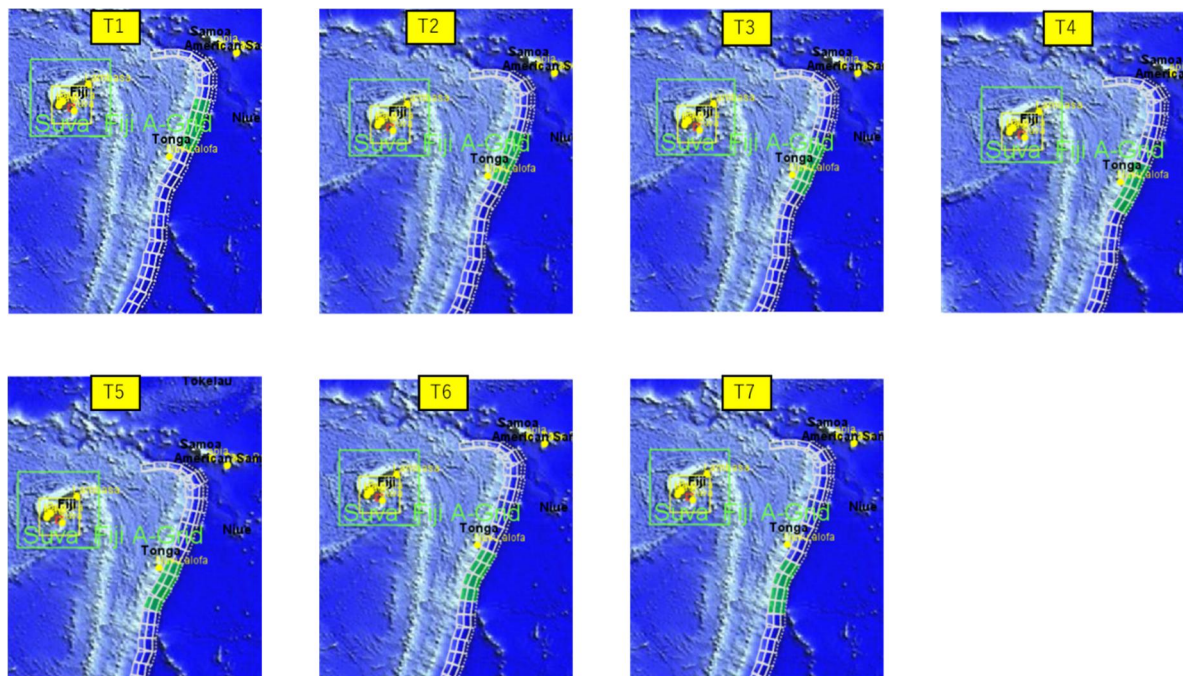


Figure 6-4 Unit source combinations: M8.5 from Tonga Trench

(2)M9.0 from Tonga Trench

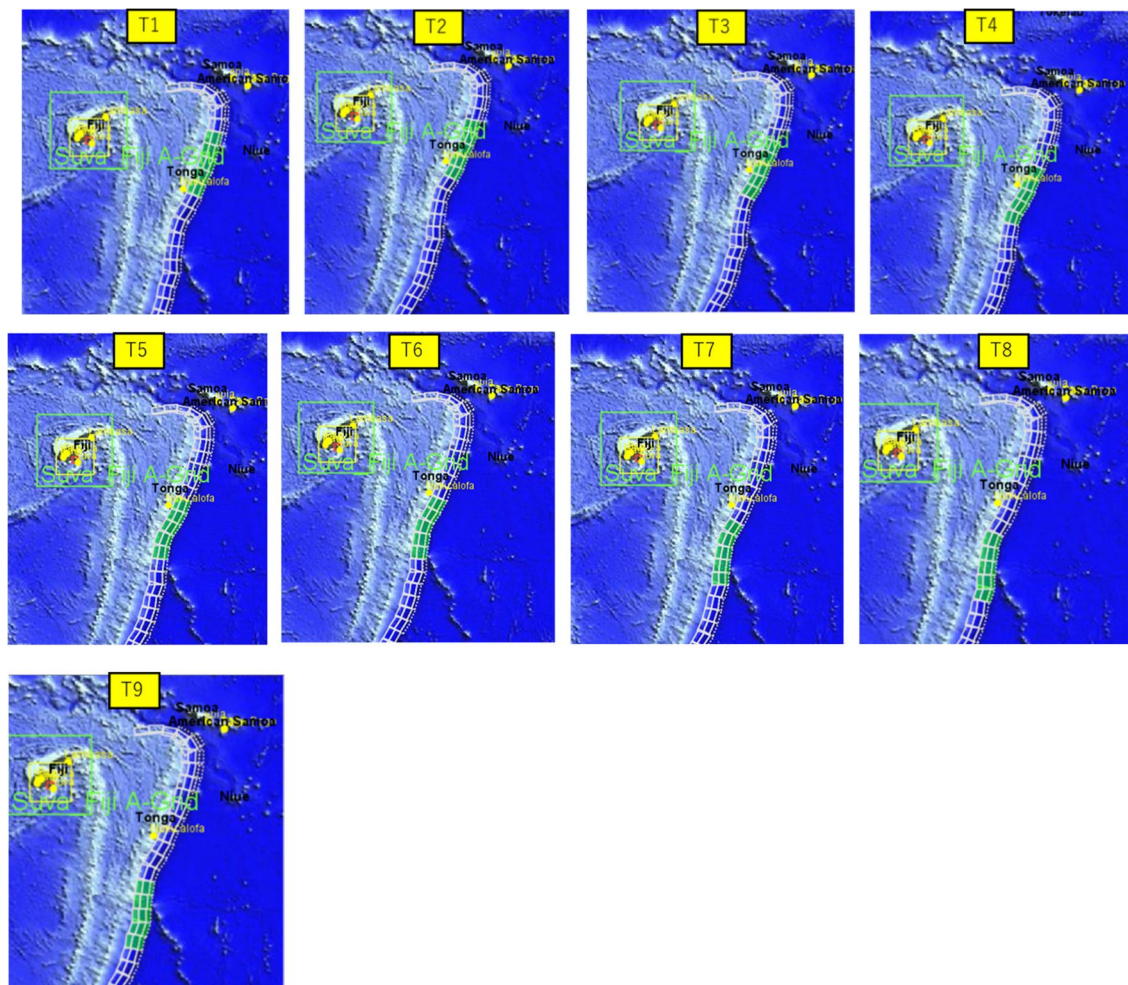


Figure 6-5 Unit source combinations: M9.0 from Tonga Trench

(3)M9.1 from Tonga Trench

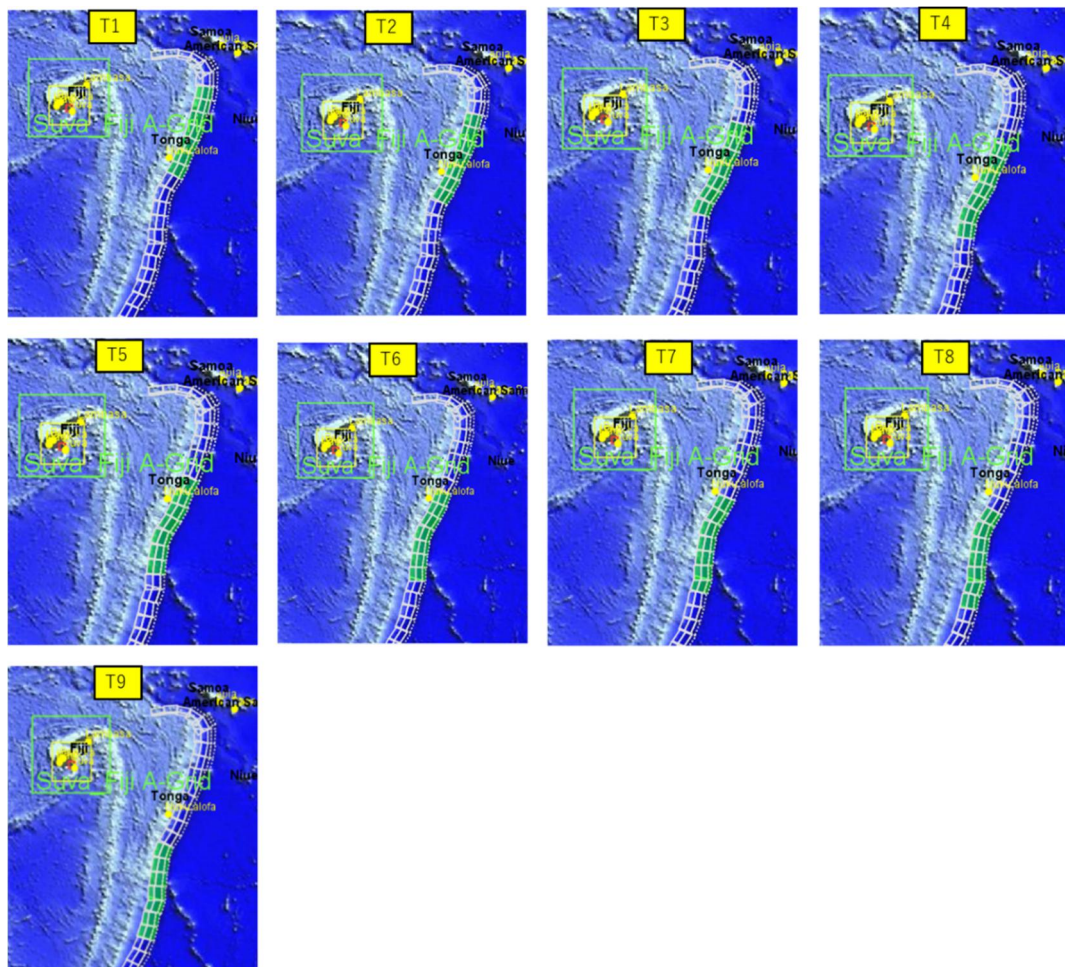


Figure 6-6 Unit source combinations: M9.1 from Tonga Trench

(4)M9.2from Tonga Trench

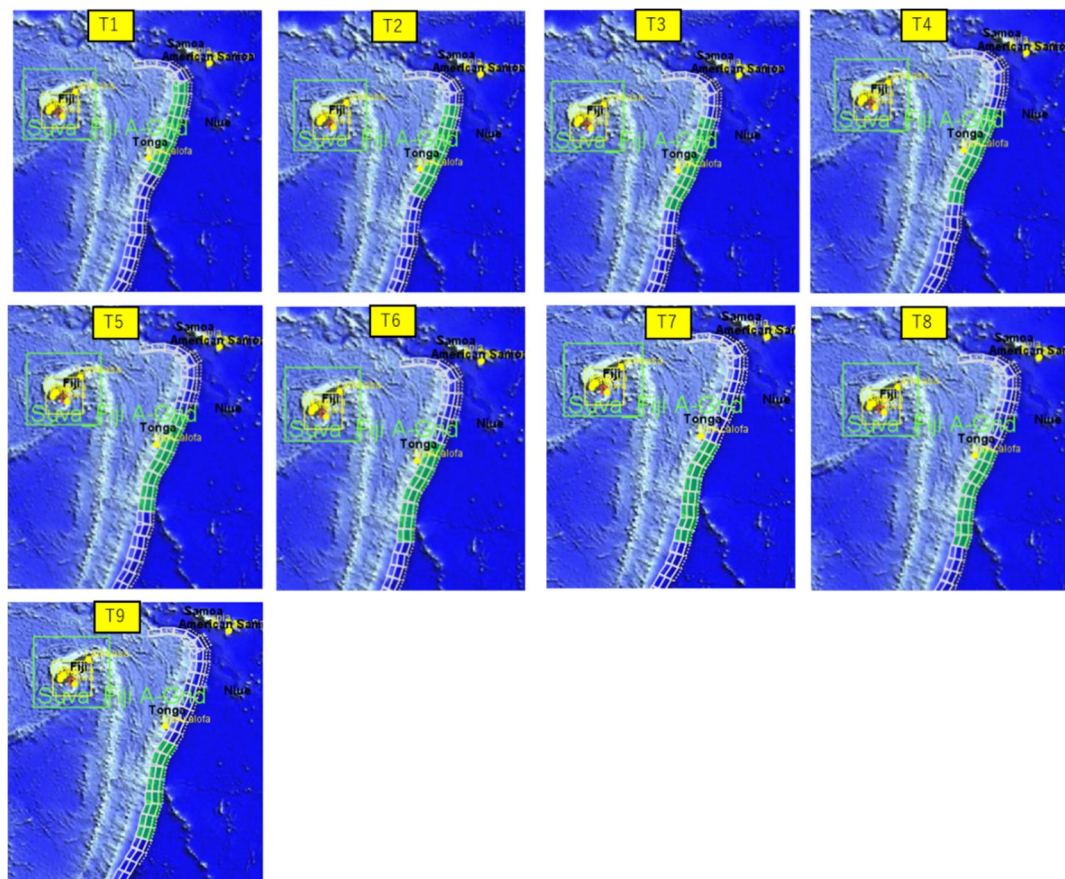


Figure 6-7 Unit source combinations: M9.2 from Tonga Trench

(5)M9.5 from Tonga Trench

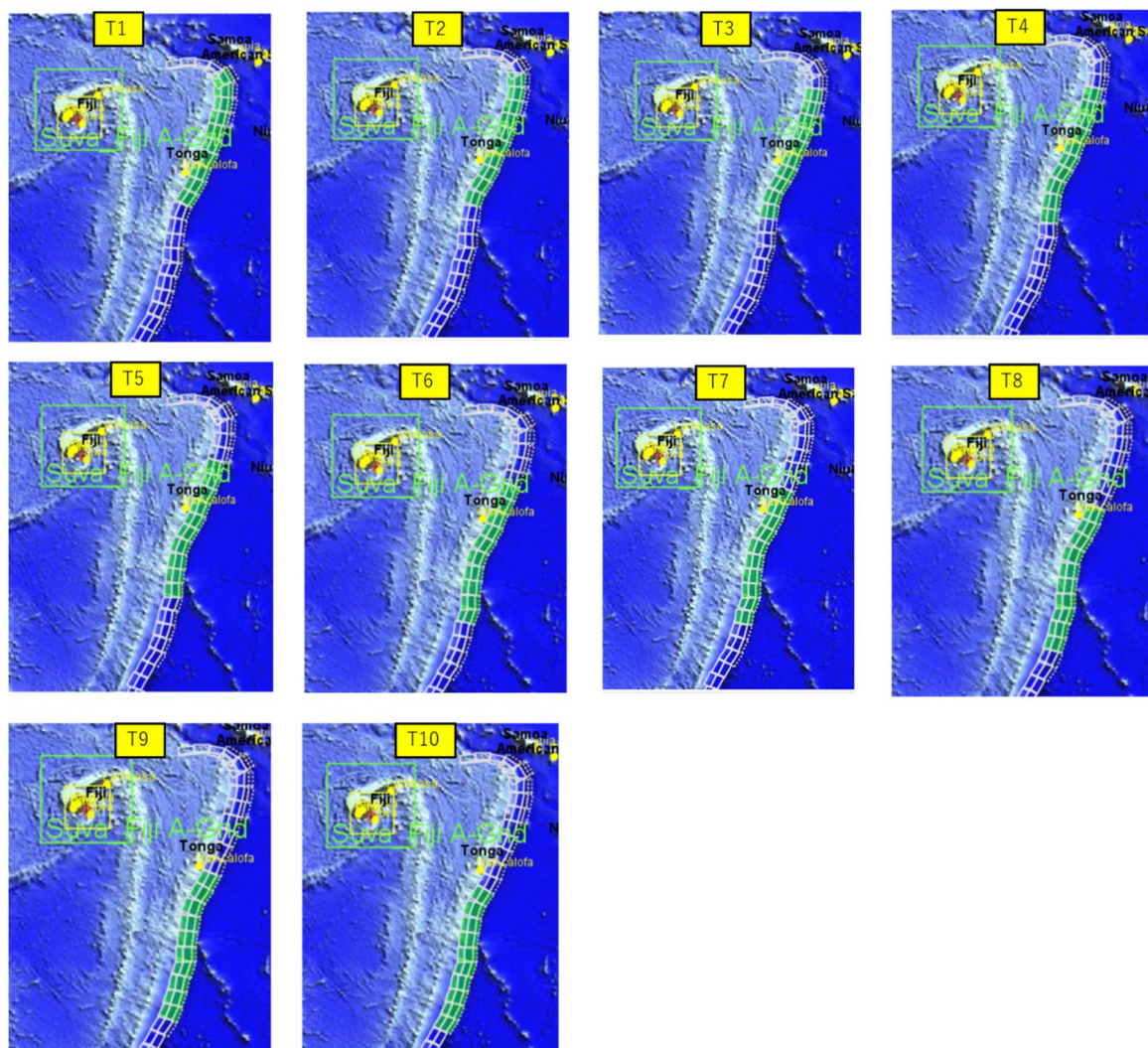


Figure 6-8 Unit source combinations: M9.5 from Tonga Trench

(6)M8.5 from Vanuatu Trench

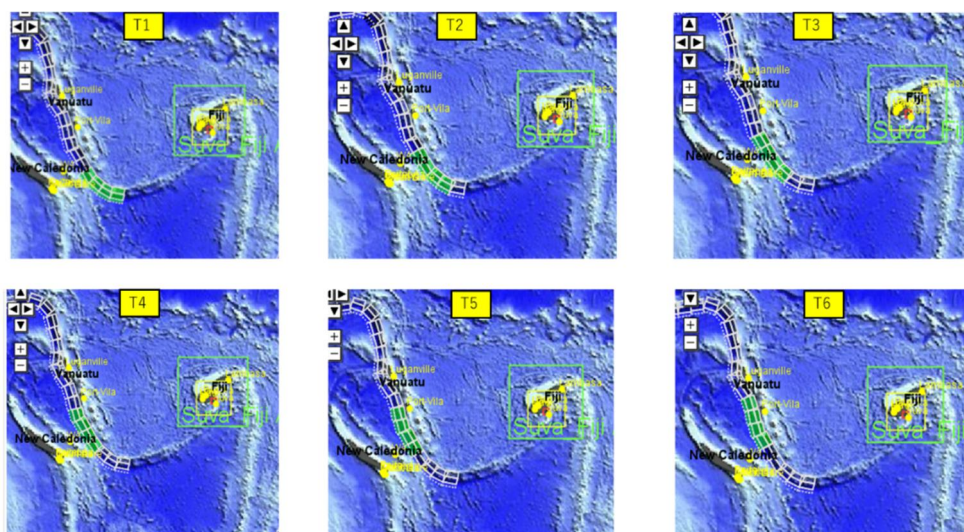


Figure 6-9 Unit source combinations: M8.5 from Vanuatu Trench

(7) M9.0 from Vanuatu Trench

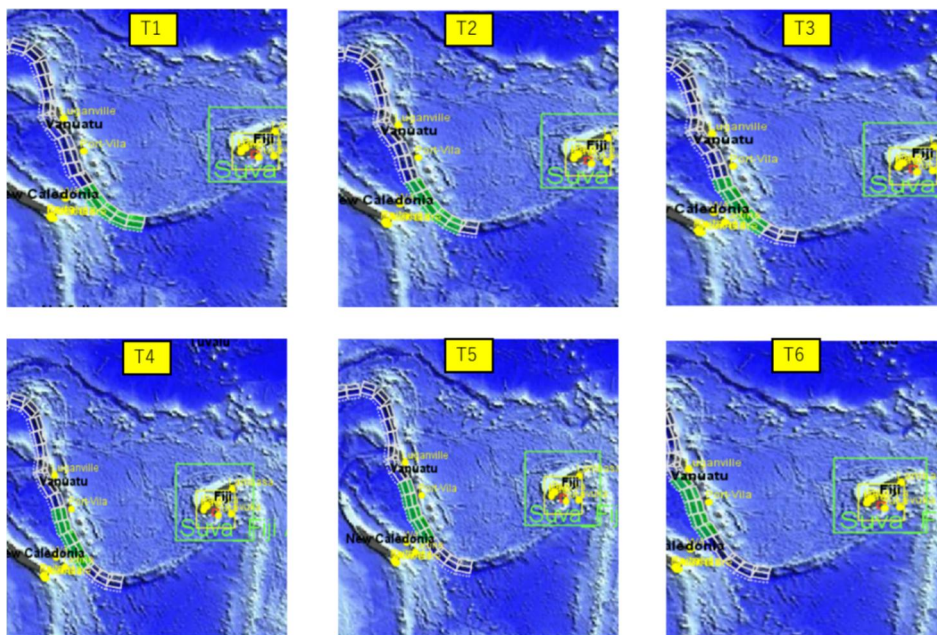


Figure 6-10 Unit source combinations: M9.0 from Vanuatu Trench

(8) M9.1 from Vanuatu Trench

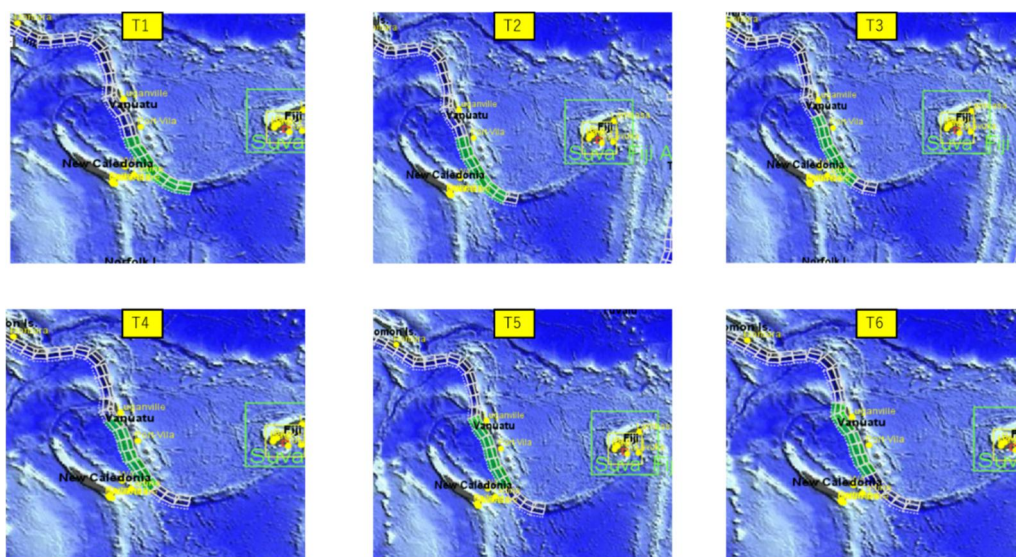


Figure 6-11 Unit source combinations: M9.1 from Vanuatu Trench

(9) M9.2 from Vanuatu Trench

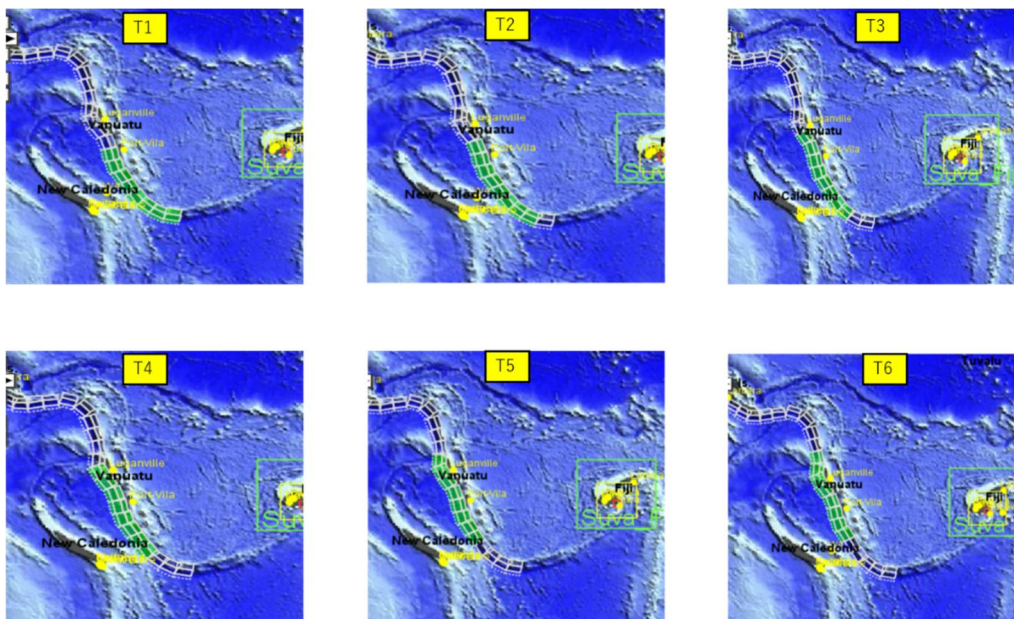


Figure 6-12 Unit source combinations: M9.2 from Vanuatu Trench

(10) M9.5 from Vanuatu Trench

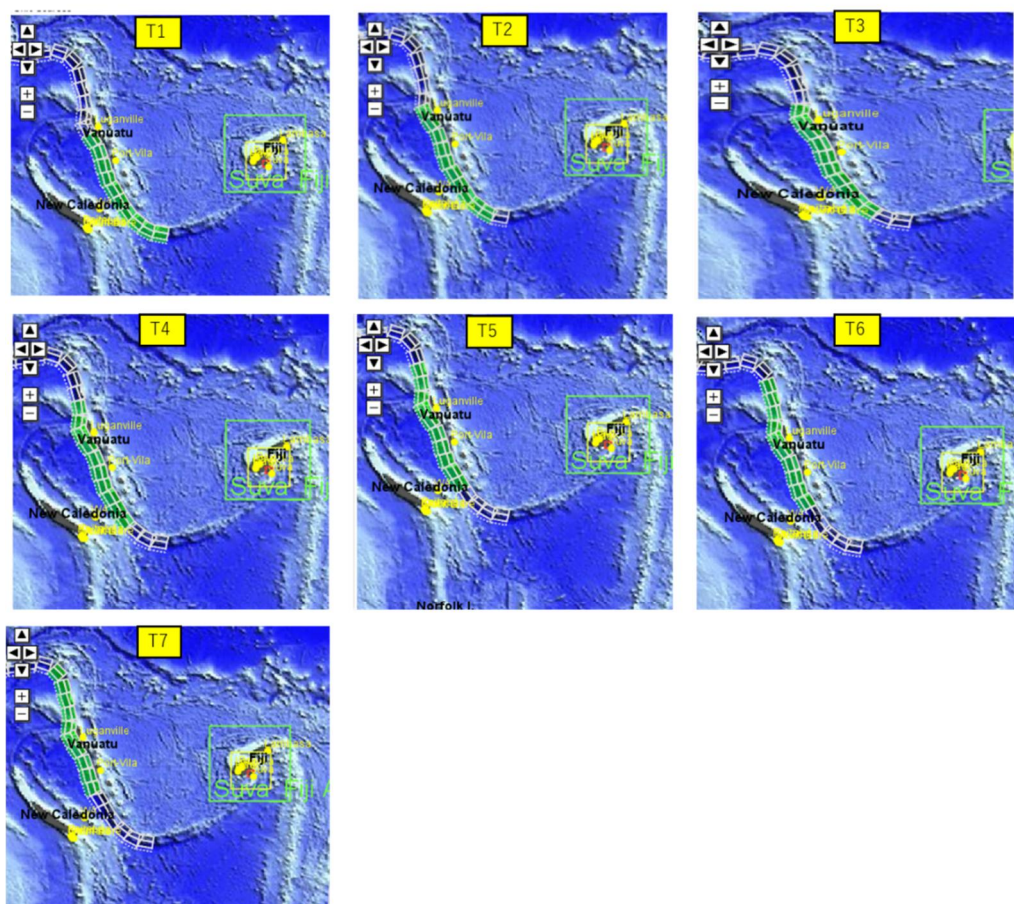


Figure 6-13 Unit source combinations: M9.5 from Vanuatu Trench

6.1.4 Results of Tsunami Simulation

Expected maximum inundated results from the ComMIT model simulation of the above case scenarios are as follows.

(1) M8.5 from Tonga Trench

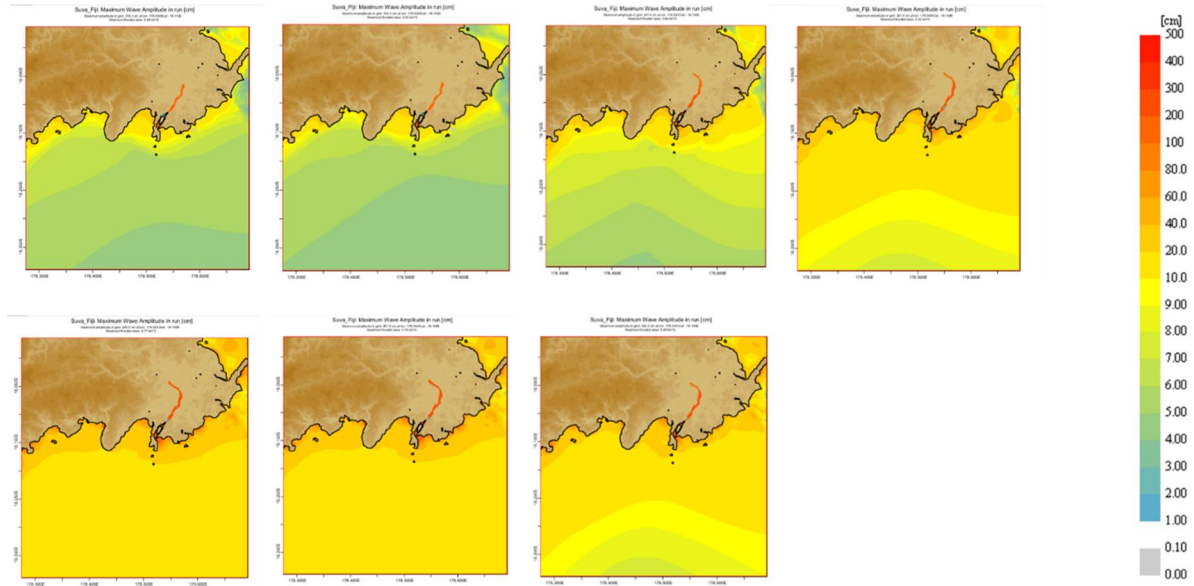


Figure 6-14 Results of Tsunami Simulation -Tsunami Height (M8.5) in cases T1-7

(2) M9.0 from Tonga Trench

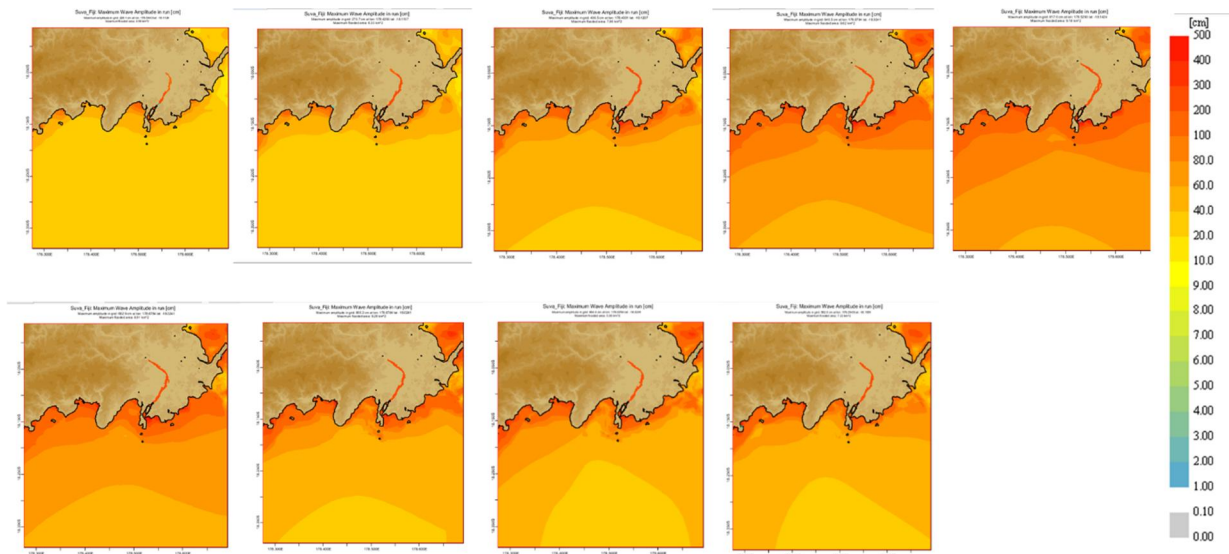


Figure 6-15 Results of Tsunami Simulation -Tsunami Height (M9.0) in cases T1-9

(3) M9.1 from Tonga Trench

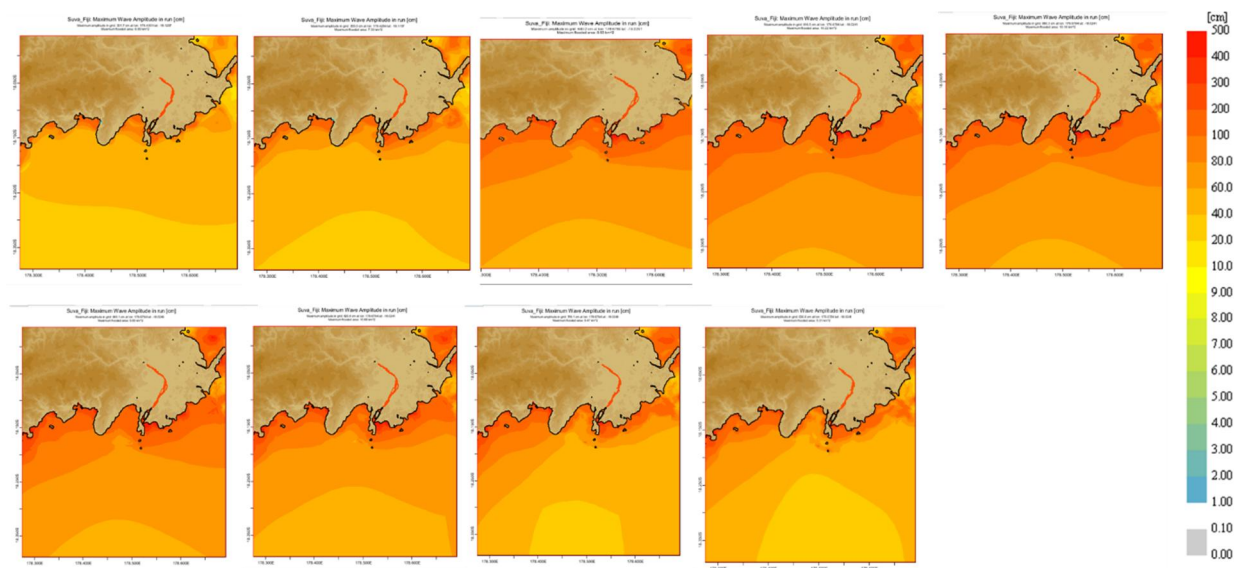


Figure 6-16 Results of Tsunami Simulation -Tsunami Height (M9.1) in cases T1-9

(4) M9.2 from Tonga Trench

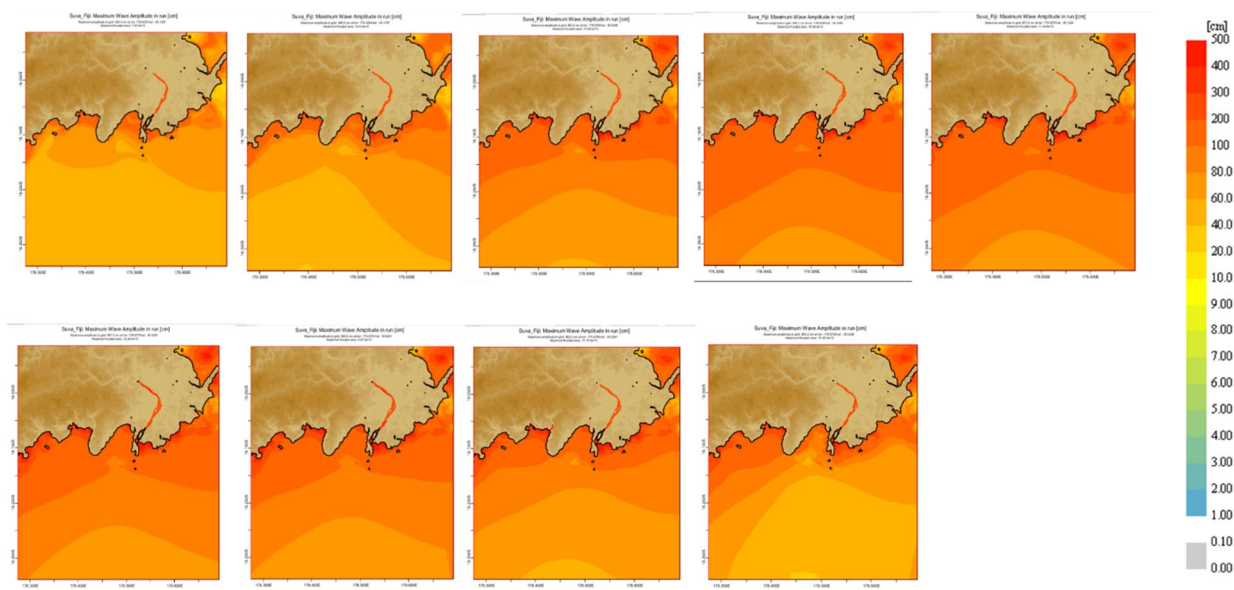


Figure 6-17 Results of Tsunami Simulation -Tsunami Height (M9.2) in cases T1-9

(5) M9.5 from Tonga Trench

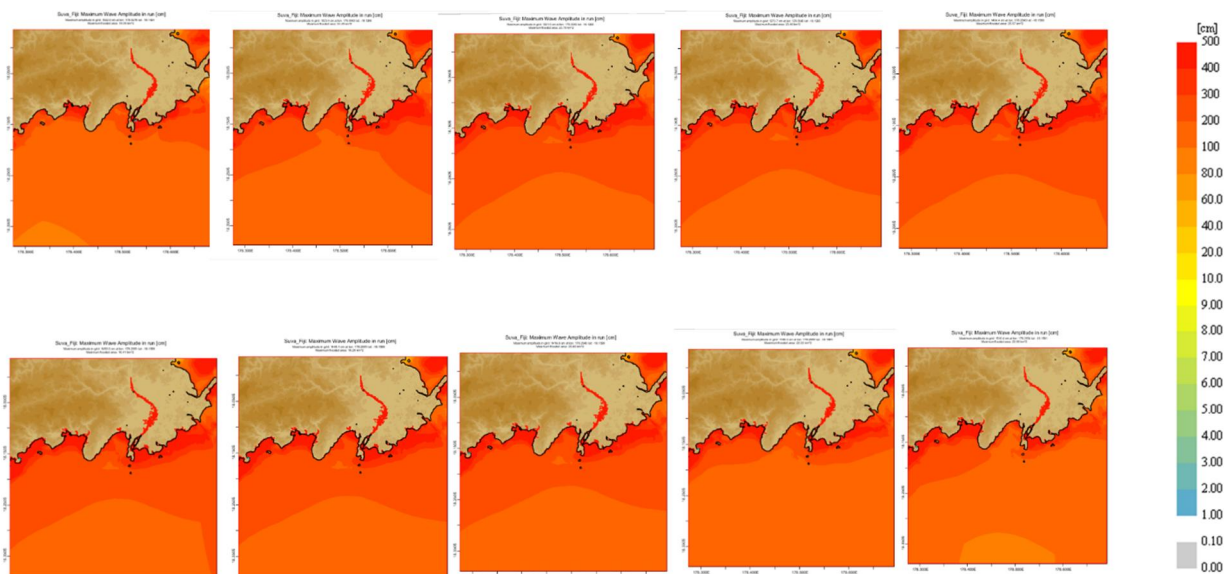


Figure 6-18 Results of Tsunami Simulation -Tsunami Height (M9.5) in cases T1-10

(6) M8.5 from Vanuatu Trench

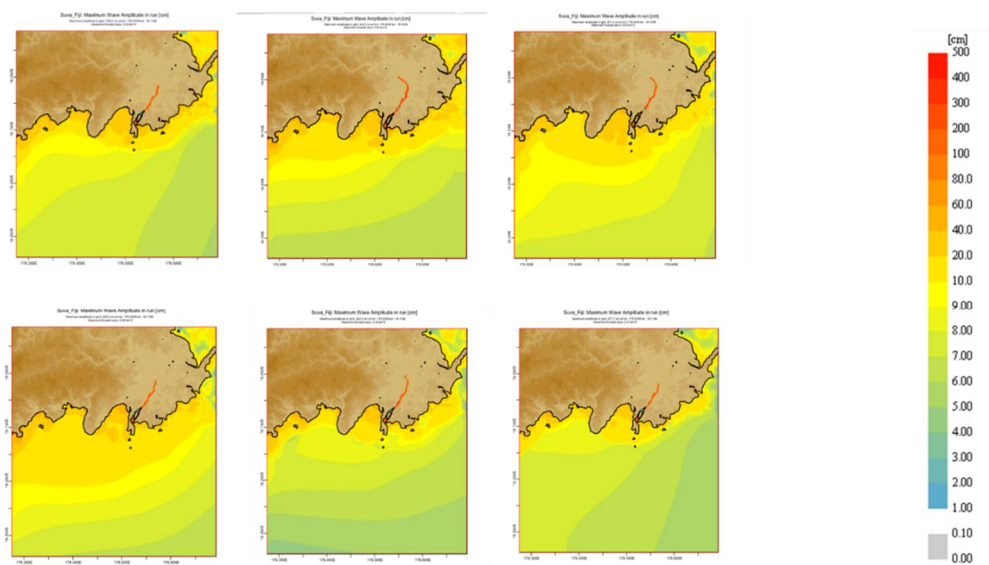


Figure 6-19 Results of Tsunami Simulation -Tsunami Height (M8.5) in cases T1-6

(7) M9.0 from Vanuatu Trench

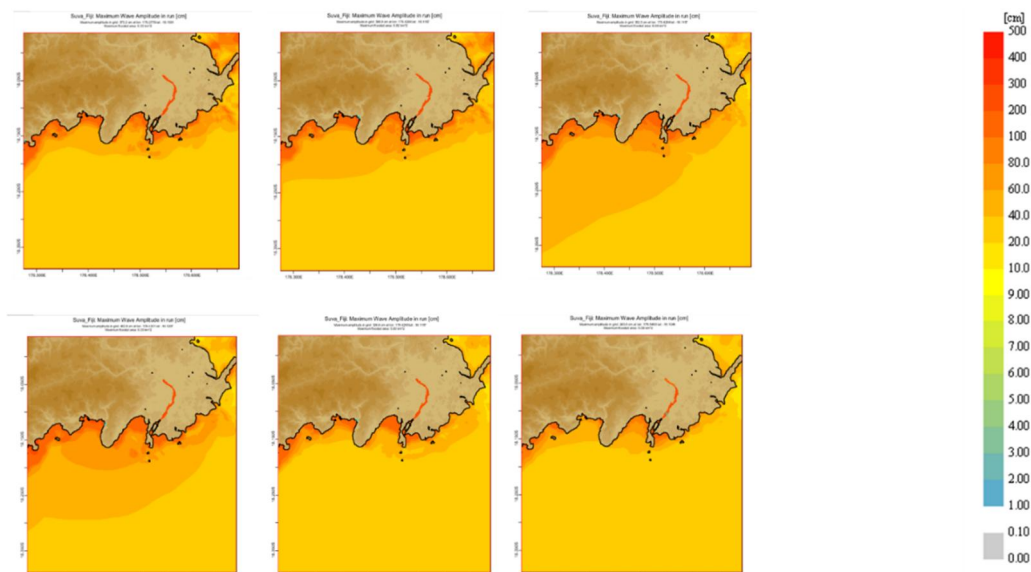


Figure 6-20 Results of Tsunami Simulation -Tsunami Height (M9.0) in cases T1-6

(8) M9.1 from Vanuatu Trench

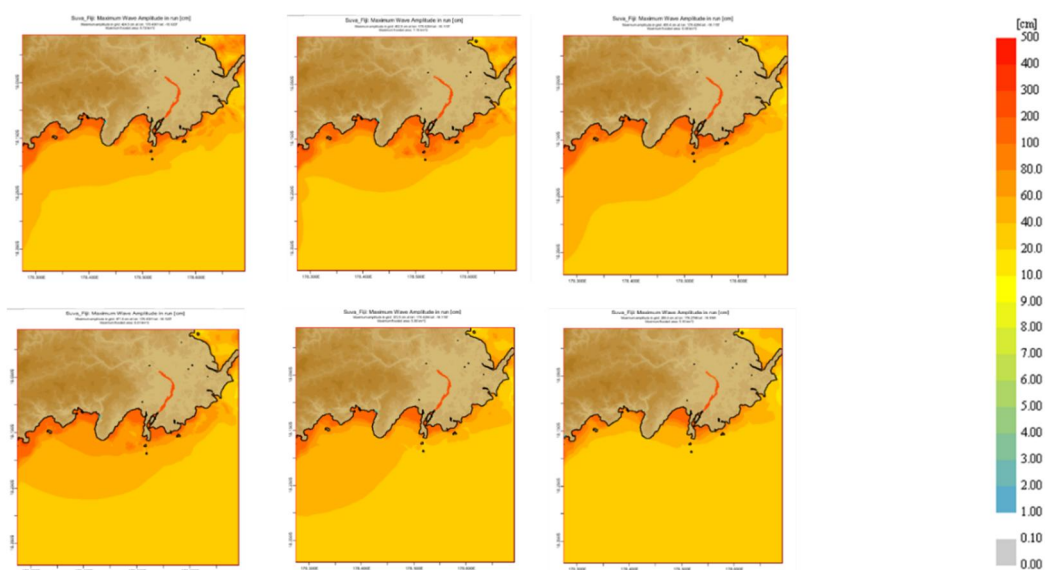


Figure 6-21 Results of Tsunami Simulation -Tsunami Height (M9.1) in cases T1-6

(9) M9.2 from Vanuatu Trench

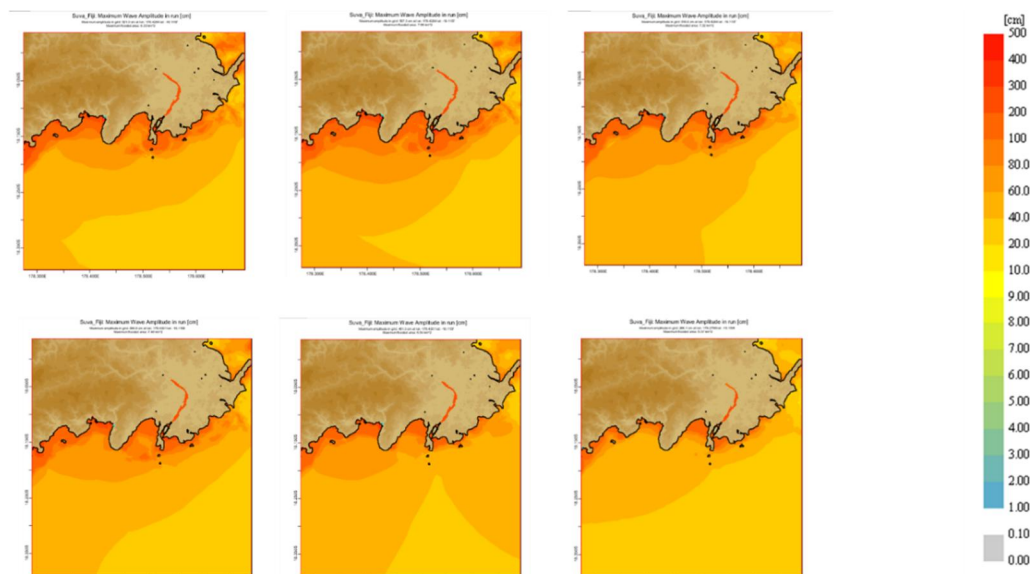


Figure 6-22 Results of Tsunami Simulation -Tsunami Height (M9.2) in cases T1-6

(10) M9.5 from Vanuatu Trench

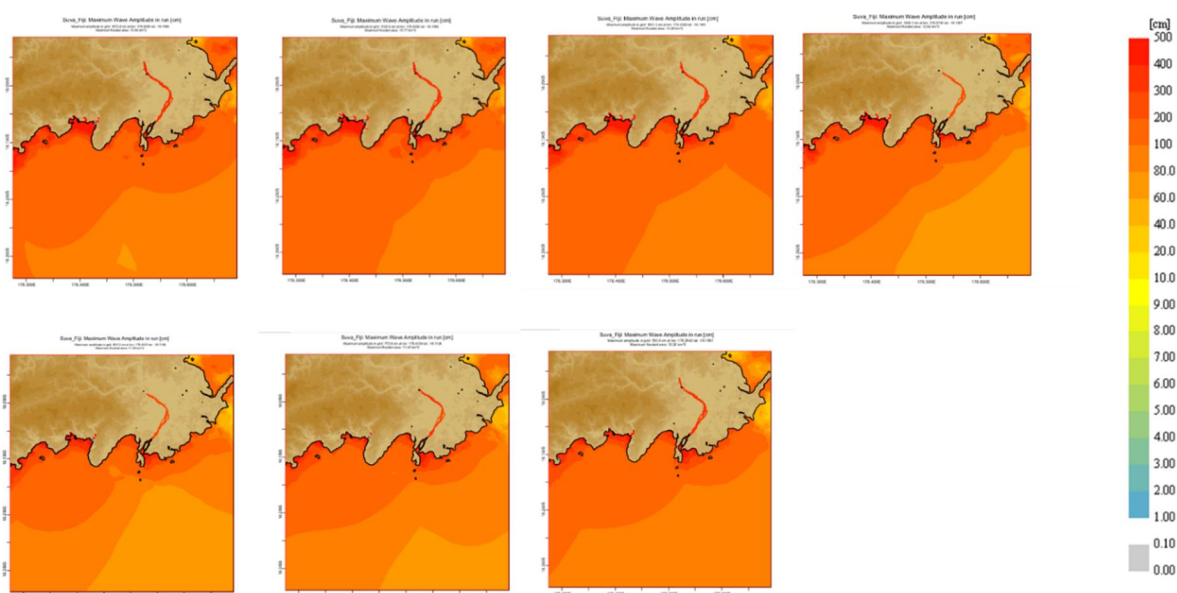


Figure 6-23 Results of Tsunami Simulation -Tsunami Height (M9.5) in cases T1-7

6.1.5 Evaluation of Expected Maximum Tsunami Height

The same method as in 5.1.5 was used to evaluate the expected maximum tsunami height in Suva on the QGIS software.

(1) M8.5 from Tonga Trench

Point	T1	T2	T3	T4	T5	T6	T7	Max
1	31	20	26	38	51	49	56	56
2	29	29	42	54	63	75	64	75
3	33	34	53	66	73	84	75	84
4	30	32	46	62	75	88	74	88
5	26	26	30	43	65	66	60	66
6	22	20	29	41	44	44	34	44
7	23	22	29	40	37	44	32	44
8	16	21	29	34	36	43	42	43
9	13	16	25	27	35	35	37	37
10	14	12	18	28	43	38	34	43
11	12	9	13	23	30	27	30	30
12	10	8	14	22	32	31	33	33
13	8	7	12	16	24	23	23	24
14	7	6	9	13	19	19	14	19
15	7	6	9	14	20	20	14	20
16	7	7	9	14	21	21	15	21
17	8	7	10	16	24	24	17	24
18	12	11	30	32	33	43	40	43
19	22	14	32	46	57	52	47	57
20	42	30	74	100	133	126	93	133
21	31	24	51	62	122	120	78	122
22	12	11	22	29	48	47	35	48
23	11	10	23	29	49	48	30	49
24	31	27	45	56	72	71	58	72
25	24	20	45	62	92	90	60	92
26	24	23	31	42	57	56	55	57
27	25	24	36	47	59	60	50	60
28	10	10	19	24	35	35	26	35
29	9	9	15	21	31	31	22	31
30	9	8	13	19	28	28	25	28
31	8	7	12	18	26	26	24	26
32	8	8	12	15	22	22	20	22

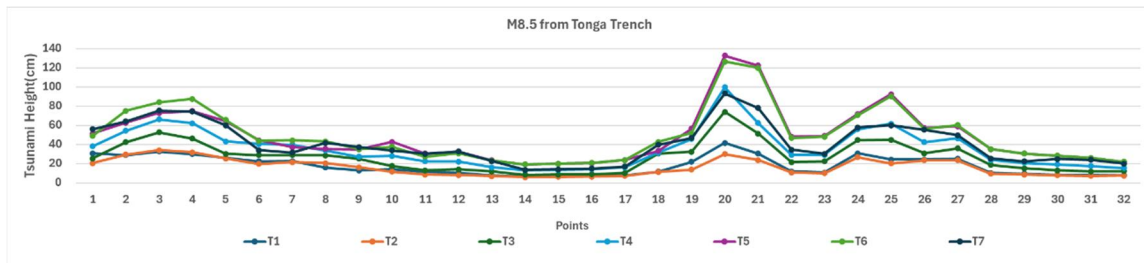
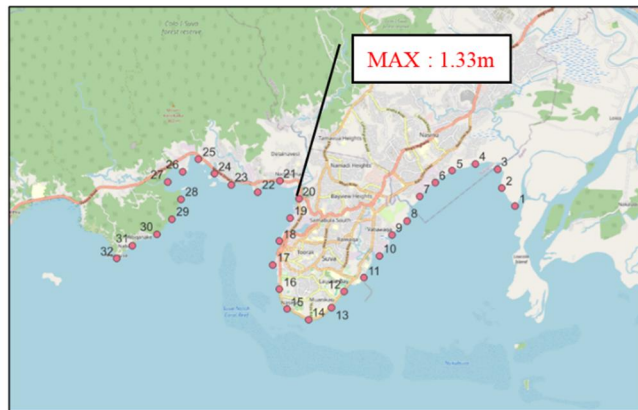


Figure 6-24 Maximum Tsunami Height- Suva (M8.5)

(2) M9.0 from Tonga Trench

Point	T1	T2	T3	T4	T5	T6	T7	T8	T9	MAX
1	92	93	118	151	160	142	124	137	149	160
2	112	129	173	224	243	216	232	207	167	243
3	118	140	195	260	282	253	232	199	188	282
4	117	136	183	242	258	232	199	176	201	258
5	106	117	152	196	209	184	155	126	155	209
6	87	90	112	145	157	137	107	151	138	157
7	74	78	103	136	147	131	124	141	141	147
8	63	85	98	129	139	124	146	138	112	146
9	57	93	114	146	150	159	146	108	113	159
10	51	61	92	131	141	155	191	178	113	191
11	43	53	80	112	119	118	140	134	97	140
12	41	59	83	125	127	131	136	161	126	161
13	36	47	69	97	104	101	118	129	67	129
14	33	39	60	88	96	84	65	68	65	96
15	33	40	62	91	99	87	70	71	68	99
16	35	42	65	97	104	93	81	79	82	104
17	38	48	74	108	118	104	99	102	101	118
18	48	88	148	198	199	192	199	202	232	232
19	73	123	205	291	293	287	253	273	270	293
20	139	223	380	530	529	523	490	496	396	530
21	107	182	303	339	331	341	334	359	356	359
22	56	104	167	268	274	266	241	255	195	274
23	56	110	179	316	310	319	253	257	218	319
24	83	217	182	314	305	305	284	292	287	314
25	99	177	332	435	438	432	388	410	345	438
26	79	116	196	285	292	282	250	262	247	292
27	82	116	192	244	254	241	249	260	249	260
28	49	93	161	235	247	232	200	210	205	247
29	45	69	139	138	150	133	160	192	201	201
30	41	56	109	128	139	123	158	154	154	158
31	39	51	80	119	129	114	181	152	121	181
32	35	51	60	86	92	92	112	129	110	129

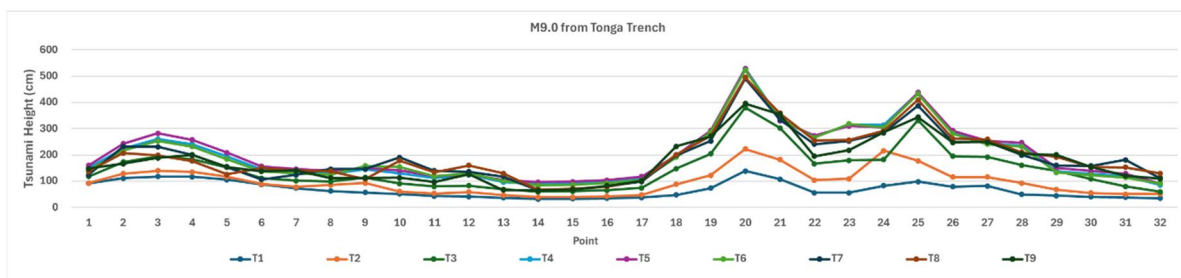


Figure 6-25 Maximum Tsunami Height- Suva (M9.0)

(3)M9.1 from Tonga Trench

Point	T1	T2	T3	T4	T5	T6	T7	T8	T9	MAX
1	86	114	155	173	164	155	154	161	143	173
2	128	175	235	257	250	274	251	201	141	274
3	138	197	270	298	286	296	256	198	186	298
4	133	185	248	268	260	253	229	197	183	268
5	114	153	200	219	211	203	182	142	116	219
6	85	109	146	160	156	151	157	166	129	166
7	94	101	139	151	147	143	184	153	124	184
8	112	105	133	145	141	152	164	141	136	164
9	102	117	146	157	175	205	182	130	116	205
10	70	90	134	147	152	221	208	171	142	221
11	64	78	114	122	119	171	149	152	141	171
12	77	80	128	131	128	154	144	184	159	184
13	64	67	99	107	104	141	151	100	104	151
14	50	58	90	100	96	93	83	79	69	100
15	51	61	93	103	99	96	85	85	75	103
16	51	64	99	108	105	102	100	92	88	108
17	53	73	111	123	119	144	141	105	102	144
18	116	124	188	202	200	229	246	230	220	246
19	161	169	270	285	283	306	300	306	249	306
20	292	326	512	534	528	541	534	458	464	541
21	219	240	318	326	325	372	393	395	357	395
22	124	156	258	270	266	279	270	213	227	279
23	128	156	302	305	307	319	322	237	221	322
24	209	173	258	289	267	326	291	321	279	326
25	204	242	420	431	425	443	444	420	357	444
26	136	156	260	282	274	302	300	286	228	302
27	132	166	239	267	256	271	279	287	237	287
28	119	138	220	237	229	246	241	225	183	246
29	81	101	144	157	151	156	186	208	191	208
30	65	86	132	145	140	157	156	161	143	161
31	66	79	123	135	143	186	155	161	151	186
32	69	60	92	94	104	152	110	120	120	152

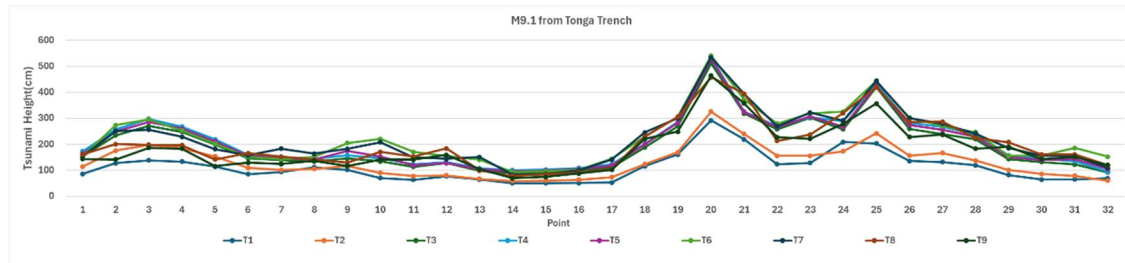
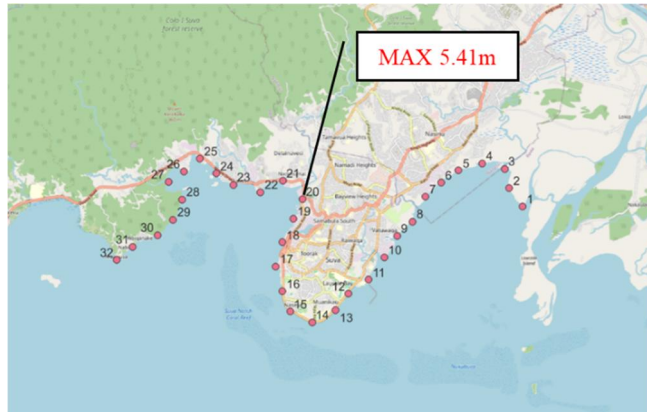


Figure 6-26 Maximum Tsunami Height- Suva (M9.1)

(4)M9.2 from Tonga Trench

Point	Case1	Case2	Case3	Case4	Case5	Case6	Case7	Case8	Case9	MAX
1	116	129	185	211	206	196	183	184	198	211
2	145	202	279	315	309	330	304	257	198	330
3	157	232	324	363	355	342	331	300	234	363
4	150	211	281	309	309	300	293	266	232	309
5	128	173	227	256	255	243	236	211	164	256
6	116	122	165	190	189	209	230	219	160	230
7	129	120	161	180	178	191	231	215	141	231
8	147	157	155	178	177	174	191	177	130	191
9	133	164	171	193	190	259	251	169	150	259
10	94	106	158	178	177	240	242	203	199	242
11	83	91	149	149	148	189	189	153	174	189
12	99	107	169	160	159	176	178	201	216	216
13	82	82	115	130	129	144	174	122	151	174
14	67	69	108	124	123	118	114	102	96	124
15	66	71	111	127	126	120	116	104	103	127
16	68	75	117	136	134	128	140	134	113	140
17	72	87	132	153	151	190	213	192	121	213
18	143	189	212	224	236	270	284	266	259	284
19	190	237	332	334	354	370	372	369	338	372
20	372	428	572	563	580	598	592	592	526	598
21	281	367	414	414	456	449	485	484	406	485
22	163	209	312	307	326	331	331	334	271	334
23	153	227	361	368	389	395	403	399	268	403
24	245	256	384	381	409	407	421	420	366	421
25	281	393	474	472	497	495	500	507	458	507
26	181	268	322	320	353	384	391	373	309	391
27	170	236	294	333	329	347	377	363	326	377
28	157	211	282	290	311	327	337	337	254	337
29	117	183	173	194	192	212	246	262	227	262
30	84	139	159	180	178	196	209	196	175	209
31	86	94	148	167	165	233	223	201	206	233
32	87	89	120	120	124	179	151	145	149	179

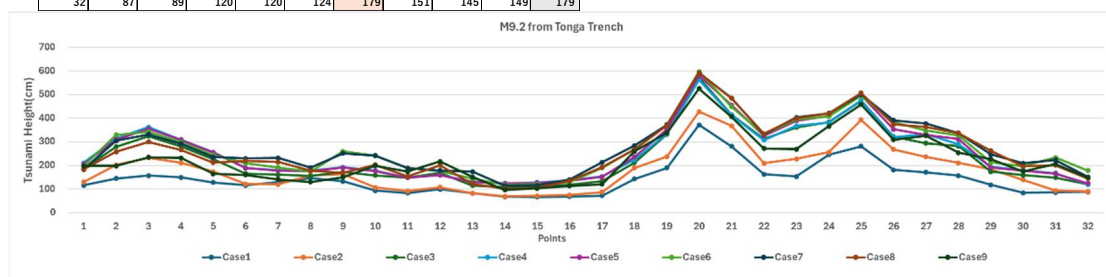
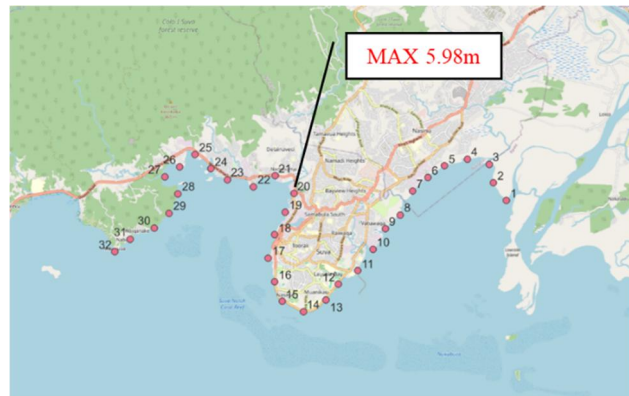


Figure 6-27 Maximum Tsunami Height- Suva (M9.2)

(5) M9.5 from Tonga Trench

Point	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	MAX
1	272	378	438	441	445	431	419	402	328	281	445
2	378	545	629	628	633	617	599	583	491	416	633
3	423	674	711	715	729	715	713	695	589	455	729
4	351	501	580	583	583	575	551	535	449	365	583
5	307	429	484	492	496	489	486	475	391	318	496
6	340	315	363	363	377	398	381	332	294	269	398
7	268	304	356	358	360	358	346	335	258	219	360
8	340	308	357	357	370	368	337	325	278	228	370
9	309	343	374	375	392	431	417	401	375	373	431
10	223	322	326	325	338	352	363	421	410	413	421
11	253	332	345	336	337	350	346	375	366	363	375
12	234	324	306	306	346	380	365	337	327	393	393
13	202	216	245	277	338	274	311	337	315	309	338
14	148	231	264	264	267	262	258	252	205	242	267
15	152	238	274	273	276	271	267	260	212	253	276
16	167	253	290	290	333	321	310	298	350	307	350
17	265	383	338	362	420	454	443	446	366	371	454
18	419	566	498	474	602	656	644	659	539	584	659
19	554	698	650	599	677	758	751	763	665	776	776
20	816	907	843	776	910	979	1014	920	833	983	1014
21	678	827	826	791	829	894	912	852	816	1006	1006
22	488	707	679	652	616	637	656	669	612	635	707
23	523	754	708	684	695	716	697	703	675	611	754
24	556	692	641	586	601	677	692	650	565	712	712
25	714	884	787	751	783	813	869	829	805	846	884
26	554	605	603	604	613	622	713	619	580	704	713
27	586	690	640	639	651	719	746	700	619	768	768
28	514	621	575	555	577	615	674	597	592	637	674
29	415	449	429	404	477	562	589	513	501	596	596
30	293	336	380	379	420	450	509	471	436	573	573
31	204	504	463	591	695	643	619	599	575	694	695
32	223	305	344	336	344	332	366	374	358	381	381

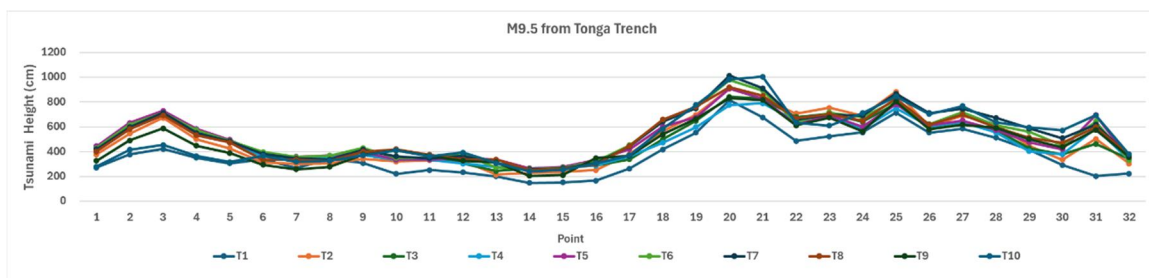
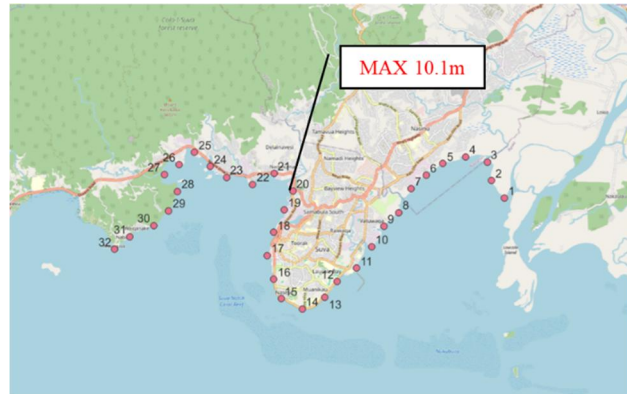


Figure 6-28 Maximum Tsunami Height- Suva (M9.5)

(6) M8.5 from Vanuatu Trench

Point	T1	T2	T3	T4	T5	T6	MAX
1	39	53	43	48	48	29	53
2	35	40	49	52	49	38	52
3	41	53	57	53	57	47	57
4	43	56	50	53	52	39	56
5	38	39	38	54	34	28	54
6	38	44	33	46	41	29	46
7	40	56	36	46	47	28	56
8	26	33	38	37	33	19	38
9	30	41	38	38	22	21	41
10	30	38	31	30	19	20	38
11	27	39	27	37	21	18	39
12	44	54	25	51	24	19	54
13	37	39	24	29	20	13	39
14	10	11	12	14	9	9	14
15	10	12	12	14	9	9	14
16	11	12	13	15	9	9	15
17	12	14	14	15	12	9	15
18	34	43	30	41	28	26	43
19	34	41	42	46	33	25	46
20	75	103	64	83	69	46	103
21	61	88	56	86	54	36	88
22	32	40	23	31	24	26	40
23	34	44	19	33	24	24	44
24	64	71	41	60	45	44	71
25	69	87	45	80	47	43	87
26	43	52	42	45	37	35	52
27	45	45	44	38	40	29	45
28	29	36	18	32	20	19	36
29	21	23	19	18	16	14	23
30	17	20	18	18	12	20	20
31	18	16	13	19	15	12	19
32	17	19	13	28	19	15	28

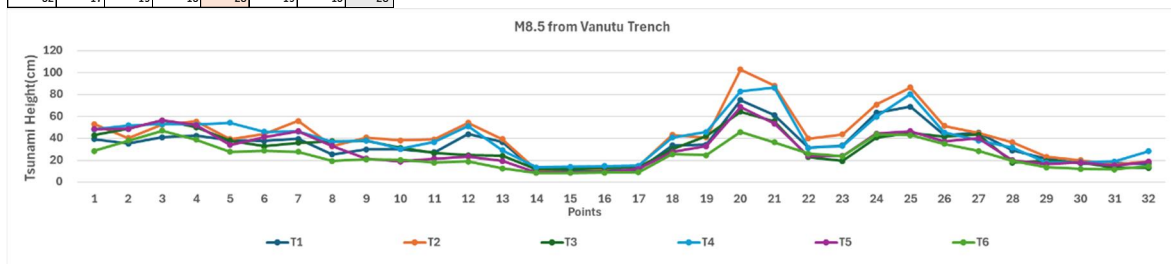
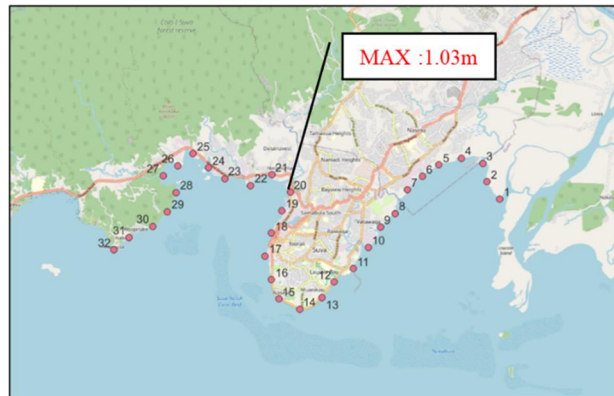


Figure 6-29 Maximum Tsunami Height- Suva (M8.5)

(7) M9.0 from Vanuatu Trench

Point	T1	T2	T3	T4	T5	T6	MAX
1	139	148	164	160	146	95	164
2	120	137	194	148	142	115	194
3	144	175	202	169	155	130	202
4	133	151	175	164	142	105	175
5	106	131	150	164	123	96	164
6	134	135	134	143	156	105	156
7	143	119	115	140	166	109	166
8	75	88	99	88	79	93	99
9	91	90	94	134	65	92	134
10	101	115	94	157	77	83	157
11	107	122	79	156	85	60	156
12	139	148	96	168	106	66	168
13	108	88	77	116	92	50	116
14	43	49	61	71	38	39	71
15	43	50	60	73	38	40	73
16	59	53	63	82	42	41	82
17	56	60	76	89	49	42	89
18	118	137	132	138	99	70	138
19	128	166	165	199	130	85	199
20	277	363	321	414	263	148	414
21	198	254	262	294	205	148	294
22	127	169	155	218	119	72	218
23	138	178	146	239	123	75	239
24	249	192	225	234	253	99	253
25	235	296	225	361	197	122	361
26	147	168	144	196	129	87	196
27	118	168	149	173	126	79	173
28	112	138	111	167	105	60	167
29	88	102	80	138	79	50	138
30	89	89	89	134	94	50	134
31	90	77	91	112	91	53	112
32	78	72	88	94	52	48	94

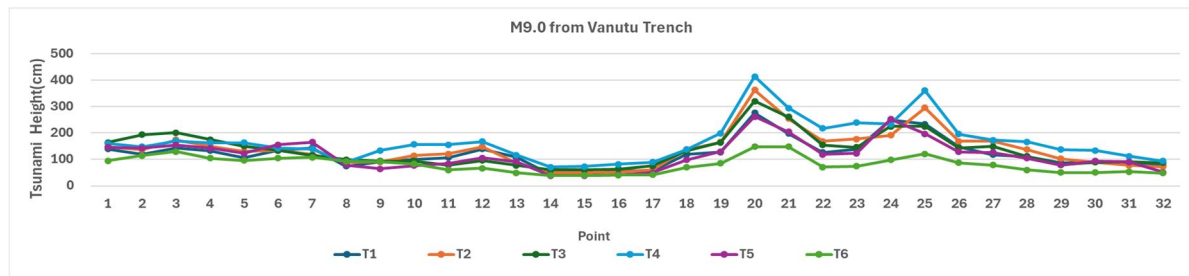


Figure 6-30 Maximum Tsunami Height- Suva (M9.0)

(8) M9.1 from Vanuatu Trench

Point	T1	T2	T3	T4	T5	T6	MAX
1	163	142	168	158	136	143	168
2	128	170	184	156	140	128	184
3	156	189	205	145	159	136	205
4	122	199	180	142	142	129	199
5	131	155	159	151	131	127	159
6	127	127	147	138	147	138	147
7	134	139	133	134	159	150	159
8	67	100	92	86	89	104	104
9	87	116	99	119	87	86	119
10	106	167	109	160	85	68	167
11	103	169	120	156	94	66	169
12	163	192	112	162	116	69	192
13	101	117	81	119	86	48	119
14	56	59	61	68	54	39	68
15	55	60	58	68	56	39	68
16	63	76	70	76	62	41	76
17	74	71	68	80	66	46	80
18	142	155	137	132	129	83	155
19	171	203	172	203	171	104	203
20	372	418	358	424	315	181	424
21	286	305	286	297	236	162	305
22	170	205	178	223	148	85	223
23	179	218	182	254	153	87	254
24	220	246	225	230	228	112	246
25	316	372	291	361	247	147	372
26	188	221	167	174	160	98	221
27	154	194	172	157	179	110	194
28	147	181	140	169	134	74	181
29	108	125	95	125	108	57	125
30	95	102	111	126	97	52	126
31	91	117	111	117	94	60	117
32	69	88	97	96	47	51	97

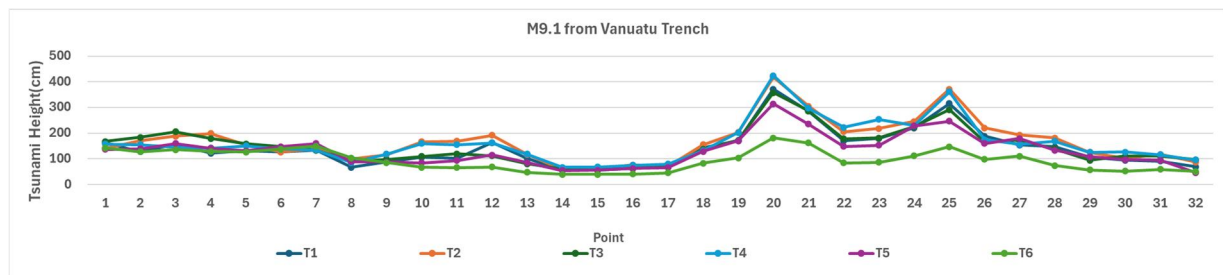
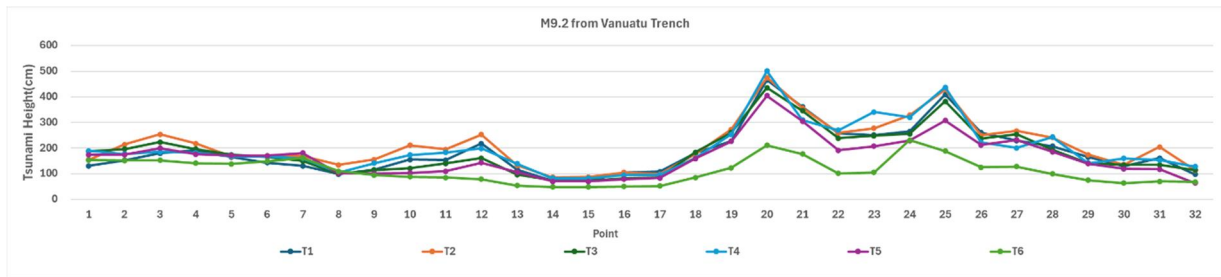


Figure 6-31 Maximum Tsunami Height- Suva (M9.1)

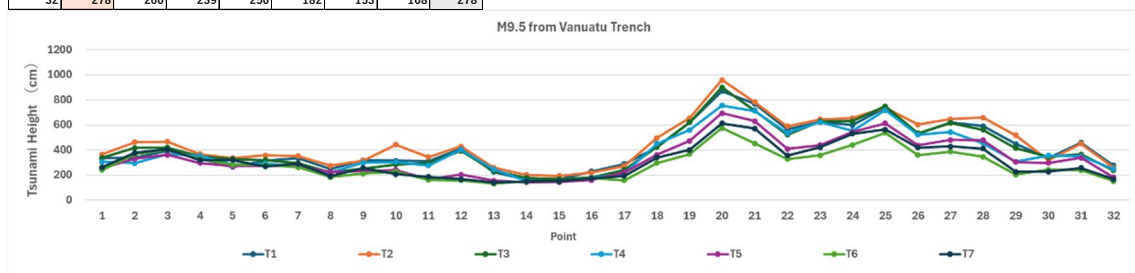
(9) M9.2 from Vanuatu Trench

Point	T1	T2	T3	T4	T5	T6	MAX
1	131	154	188	189	174	154	189
2	153	214	196	177	174	151	214
3	180	254	223	186	200	152	254
4	191	217	196	182	176	141	217
5	164	166	174	168	171	138	174
6	143	170	165	166	171	149	171
7	130	168	149	160	181	162	181
8	98	135	100	105	101	109	135
9	115	155	115	141	101	95	155
10	155	212	121	173	103	88	212
11	154	195	140	183	110	85	195
12	218	253	161	199	143	78	253
13	117	133	96	139	106	53	139
14	72	86	75	82	70	48	86
15	73	87	72	82	70	48	87
16	104	105	82	94	78	50	105
17	108	98	86	95	83	52	108
18	180	176	184	161	159	85	184
19	227	273	260	254	227	123	273
20	466	475	436	501	405	211	501
21	361	356	346	310	305	177	361
22	258	260	238	270	191	101	270
23	251	278	248	341	207	105	341
24	265	329	256	320	229	231	329
25	409	430	383	438	308	189	438
26	260	250	237	223	212	125	260
27	229	267	254	200	232	128	267
28	208	241	193	243	186	99	243
29	165	175	141	141	139	75	175
30	129	136	134	160	120	63	160
31	161	204	135	154	118	70	204
32	98	114	115	128	63	68	128



(10) M9.5 from Vanuatu Trench

Point	T1	T2	T3	T4	T5	T6	T7	MAX
1	335	367	339	307	255	243	264	367
2	341	463	419	296	331	369	378	463
3	394	468	419	368	363	405	407	468
4	336	368	351	356	298	328	321	368
5	266	337	330	286	272	285	322	337
6	315	359	321	294	275	280	269	359
7	336	352	296	275	271	264	291	352
8	249	277	222	223	224	185	192	277
9	319	317	254	300	232	212	258	319
10	315	444	285	306	242	227	209	444
11	311	345	295	277	164	163	187	345
12	412	430	394	405	204	160	168	430
13	227	260	237	248	157	133	141	260
14	166	202	178	155	142	149	152	202
15	166	195	170	152	145	154	153	195
16	229	219	181	179	162	177	176	229
17	289	274	242	215	223	160	195	289
18	425	498	426	451	363	298	341	498
19	622	657	622	560	473	369	403	657
20	871	960	902	757	696	577	614	960
21	772	785	718	714	632	454	573	785
22	565	590	524	538	411	329	356	590
23	624	646	630	624	441	360	423	646
24	600	656	632	555	544	443	532	656
25	741	742	750	719	614	539	564	750
26	530	604	535	522	437	360	420	604
27	621	649	618	546	482	389	430	649
28	593	660	563	456	479	347	412	660
29	451	520	417	308	306	205	228	520
30	336	322	348	357	297	244	228	357
31	461	452	366	352	340	241	258	461
32	278	260	239	250	182	153	168	278



6.2 Inundation Analysis

6.2.1 Target Tsunami Level for Hazard Map

Based on the estimated maximum tsunami heights obtained from the ComMIT Simulation in the above case studies, this study presents the worst-case scenarios for each magnitude range from M9.0 to M9.5, as shown in Table 6-2.

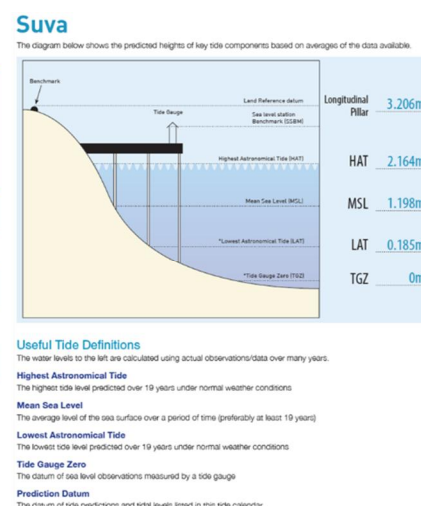
Table 6-2 Scenario Tsunami Source Setting

Case No.	Trench	Magnitude	No. of Cases	Maximum Tsunami Height
1	Tonga	9.0	T-4	5.30 m
2	Tonga	9.1	T-6	5.41 m
3	Tonga	9.2	T-6	5.98 m
4	Tonga	9.5	T-7	10.14 m

Source: JICA Expert Team

Using the maximum tsunami height and highest astronomical tide in Suva (MSL + 0.966m), total estimated tsunami elevation of Suva can be evaluated as follows.

Magnitude	Maximum Tsunami Height	Height Astronomical Tide (HAT) in Suva	Total Tsunami Elevation
9.5	10.14m	MSL+0.966m	MSL+11.2m
9.2	5.98m	MSL+0.966m	MSL+7.0m
9.1	5.41m	MSL+0.966m	MSL+6.4m
9.0	5.30m	MSL+0.966m	MSL+6.3m
8.5	1.33m	MSL+0.966m	MSL+2.3m



Source: JICA Expert Team

Figure 6-32 Target Tsunami Level for Hazard Map (Suva)

Based on the above evaluation, we create individual Tsunami Hazard Maps of Suva using the values of MSL+ 11.2m, MSL+7.0m, MSL+6.4m, and MSL+6.3m.

6.2.2 Tsunami Hazard Map of Suva

The resulting inundated area and depth were integrated with satellite DEM (using elevation data based on AW3D) to generate a hazard map indicating the inundation depth for Suva. The following are Tsunami Hazard Maps for each magnitude.

Tsunami Hazard Map (Suva) by AW3D data

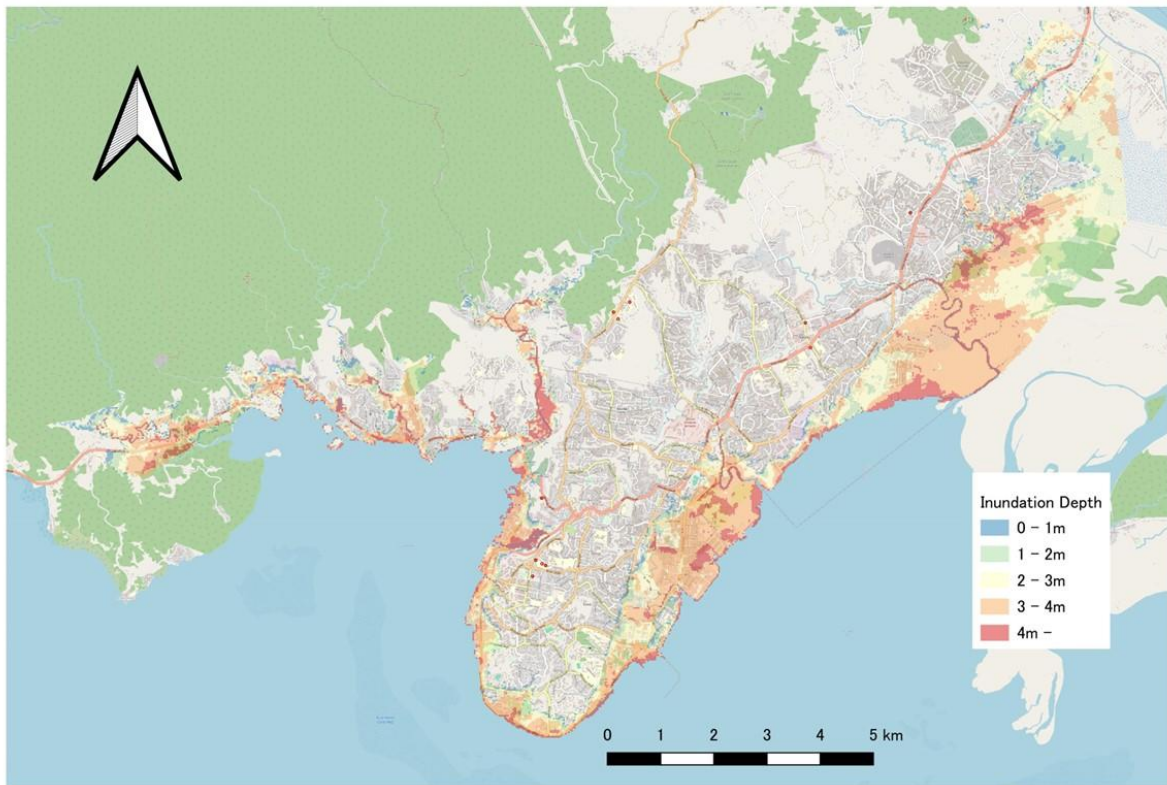


Figure 6-33 Tsunami Hazard Map of M9.0 (Suva)- AW3D Data

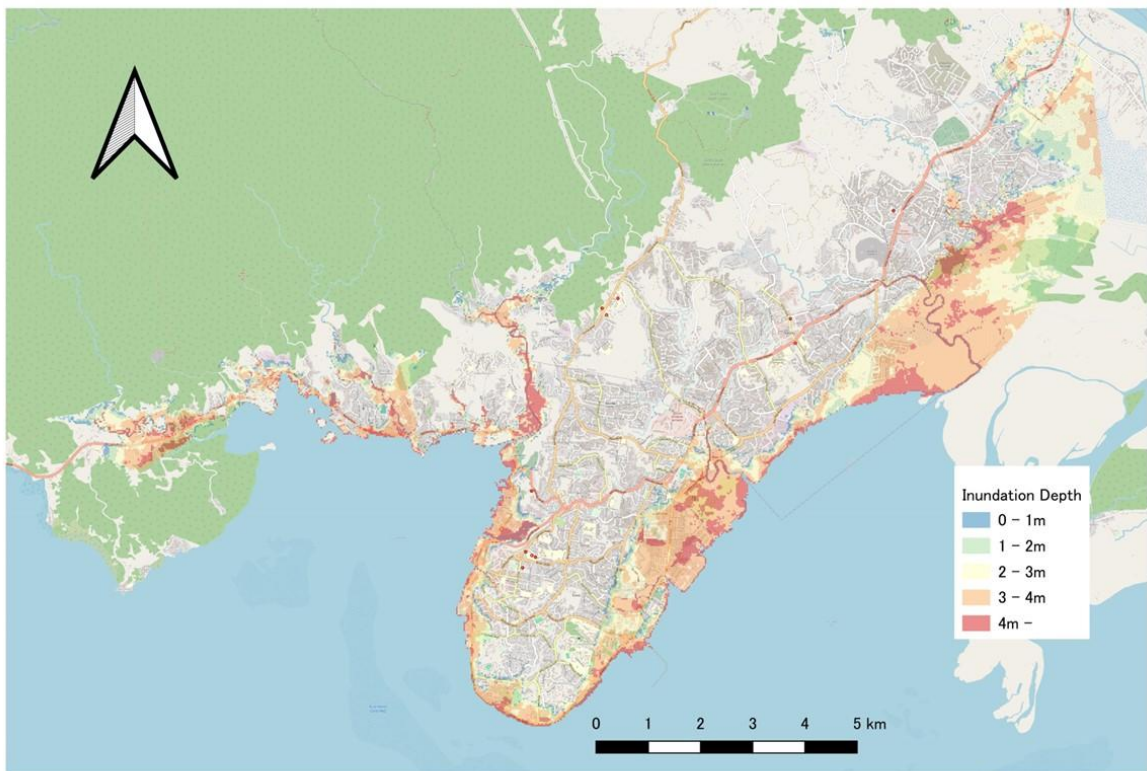


Figure 6-34 Tsunami Hazard Map of M9.1 (Suva)- AW3D Data

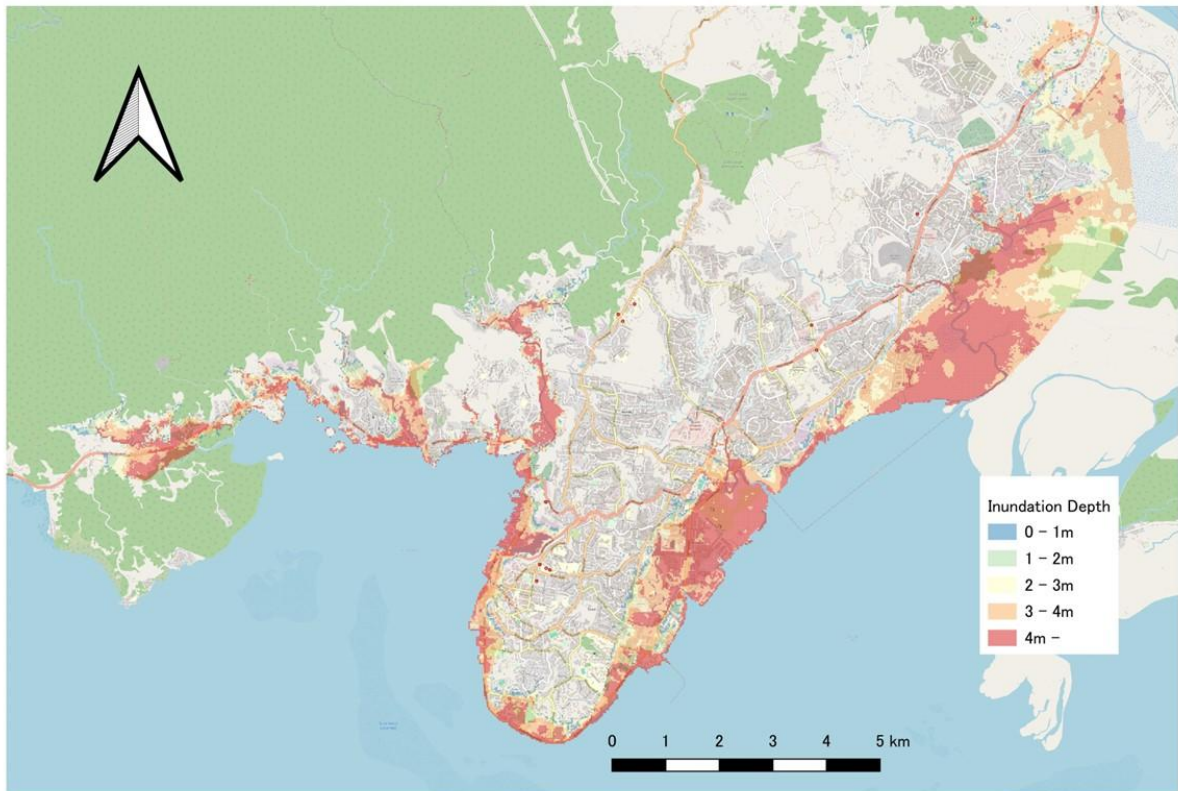


Figure 6-35 Tsunami Hazard Map of M9.2 (Suva) – AW3D data

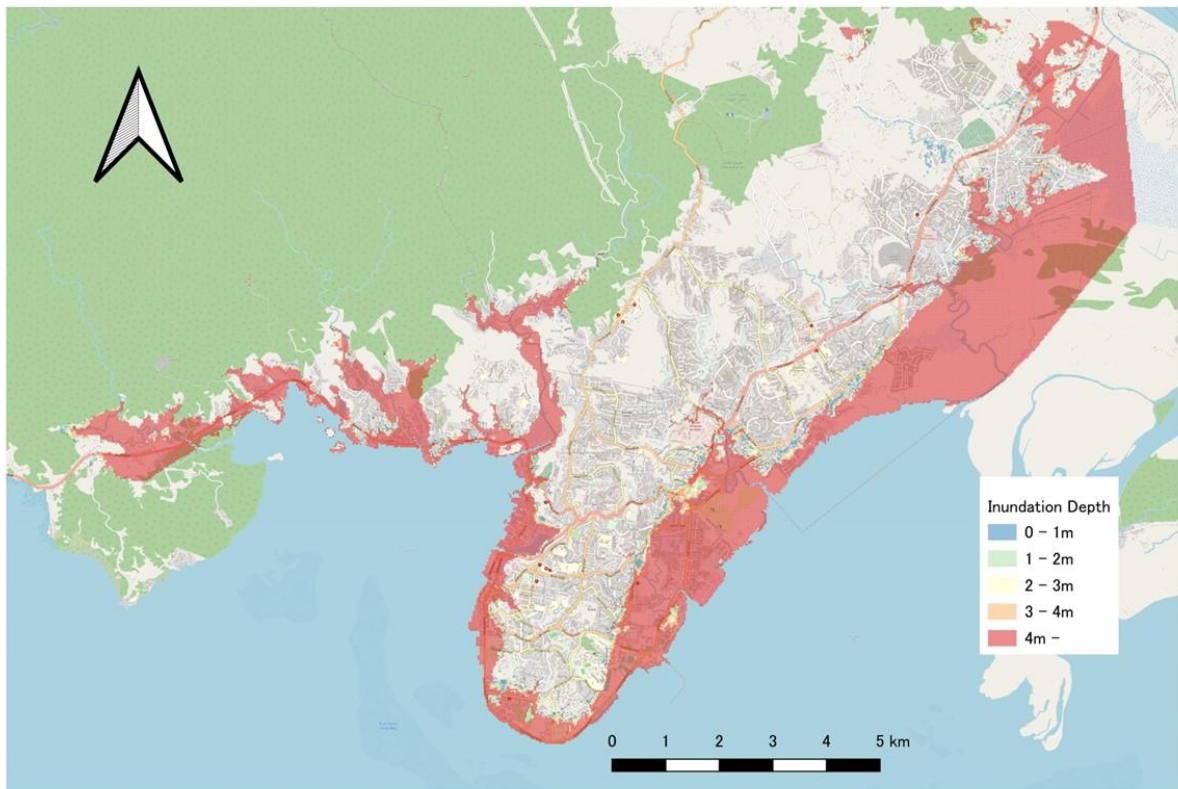


Figure 6-36 Tsunami Hazard Map of M9.5 (Suva) – AW3D data

Chapter 7. Way Forward

7.1 Tsunami Analysis

This guideline provides a method for conducting tsunami analysis, which involves modeling the behavior and impact of tsunami of assumed earthquakes in Fiji. This involves using simplified computational models and historical data to simulate the behavior of tsunamis. By simulating different scenarios, the relevant organizations can better understand the potential magnitude and extent of tsunamis, enabling them to develop more effective evacuation plans and response strategies.

7.2 Inundation Analysis

This guideline outlines procedures for conducting inundation analysis, which involves assessing the areas at risk of inundation due to tsunami. This analysis considers factors such as coastal topography, land elevation, and the potential impact of tsunami. By conducting inundation analysis, the relevant organizations can identify vulnerable coastal areas and prioritize their efforts in terms of evacuation planning, infrastructure development, and the allocation of resources for disaster response. The methodology of inundation analysis used in this guideline is relatively simple for the organizations. In the future, more accurate simulations are needed for better understanding tsunami hazard and risk.

7.3 Risk Analysis

This guideline does not include risk analysis because the risk analysis is the same as that of the simplified assessment. This analysis will take into account factors such as the vulnerability of coastal communities, the exposure of critical infrastructure, and the potential economic and social impacts of tsunami-related disasters in the future. The results of risk analysis should be shared with the relevant organisations such as MRD, NDRMO and others for better disaster risk management.



Republic of Fiji

PROJECT for Mainstreaming of Disaster
Risk Reduction Project

Guideline on
Storm Surge Hazard / Risk
Enhanced Assessment
~Enhanced Assessment~

December 2025

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

ORIENTAL CONSULTANTS GLOBAL
YACHIYO ENGINEERING CO., LTD
PACIFIC CONSULTANTS CO., LTD



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Chapter 1. Introduction

1.1 Background

The Republic of Fiji, located in the South Pacific Ocean, is a beautiful island nation known for its pristine beaches, vibrant coral reefs, and lush tropical landscapes. However, Fiji is also highly vulnerable to natural disasters, particularly tropical cyclones and their associated impacts, including storm surges. These extreme weather events pose significant risks to the population, infrastructure, and overall socio-economic development of the country.

Tropical cyclones, are powerful and destructive weather phenomena characterized by intense low-pressure systems and strong rotating winds. These cyclones are often accompanied by heavy rainfall, strong winds, and storm surges, which are a significant concern for coastal communities.

Storm surges, one of the most hazardous and damaging impacts of tropical cyclones, occur when strong winds and low atmospheric pressure push seawater onto the coastline, resulting in a temporary rise in sea levels. The combination of high tides and storm surges can lead to coastal inundation.

Fiji has experienced several devastating tropical cyclones and storm surge events throughout its history, with varying degrees of impact. Cyclone Winston, which struck Fiji in February 2016, was one of the most severe cyclones on record in the South Pacific with minimum central pressure of 898hPa, causing extensive damage and loss of life. The storm surge associated with Cyclone Winston resulted in widespread flooding affecting numerous communities and exacerbating the overall impact of the cyclone.

These recurring cyclone and storm surge events have highlighted the urgent need for comprehensive guidelines and strategies to mitigate the risks associated with tropical cyclones and storm surges in Fiji. By developing effective disaster risk reduction measures and implementing appropriate adaptation strategies, Fiji aims to enhance its resilience and minimize the adverse impacts of future cyclones and storm surges on its population and infrastructure.

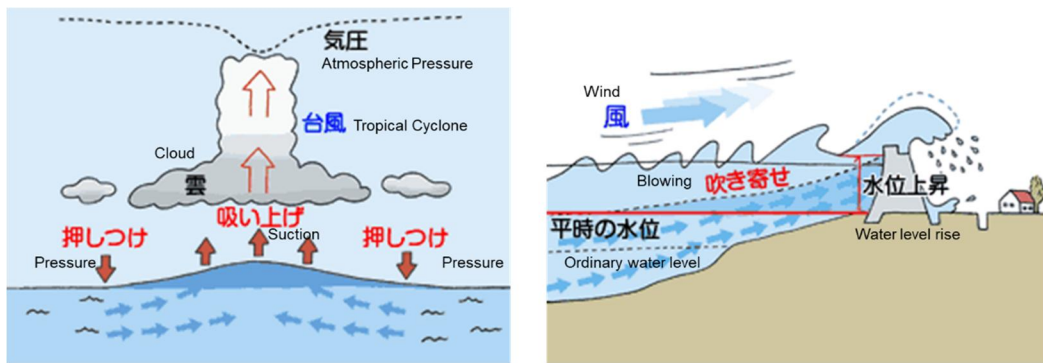
1.2 Major Types of Coastal Disaster

Coastal disasters are damage that happens at coastal area, mainly water related disaster. For example, tropical cyclone induces storm surge if it passes through coastal area and strong wind causes high wave, resulting in overtopping at coast. High wave also causes coastal erosion and sedimentation at coastal and river mouth. Not only meteorological phenomena, geological one (e.g., earthquake, land slide and eruption) can cause tsunamis, which induce coastal inundation at coastal area.

This part will explain the coastal disasters in Fiji, referencing the technical reports and papers.

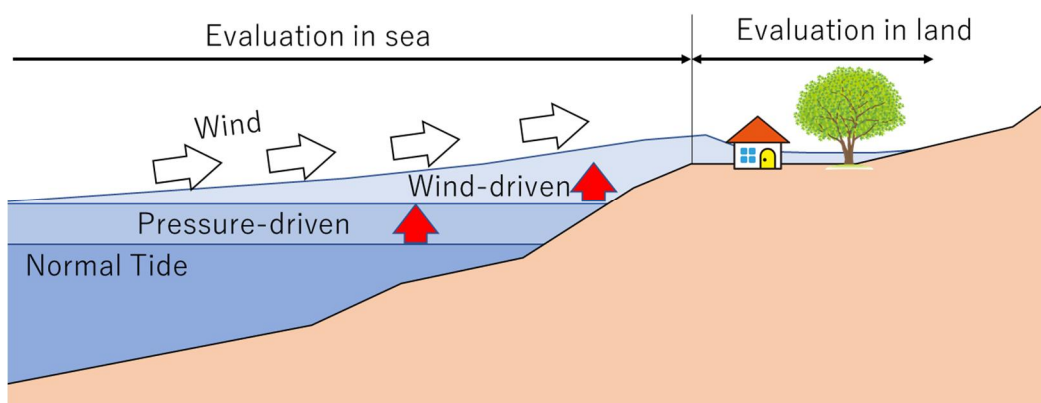
1.2.1 Storm Surge

Storm surge is a phenomenon in which the sea surface is raised up by weather disturbances such as typhoons, and its main factors are suction by atmospheric pressure lowering and blowing by wind, and in some cases, it includes wave setup by ocean waves as shown in Figure 1-1. The storm surges generated by weather disturbances reach the shoreline with sea level rising, as shown in Figure 1-2, and inundation to land areas occurs when the water level exceeds the ground height or the facility height. Therefore, it is very important to appropriately estimate the amount of sea level deviation caused by storm surges in the coastal area. In addition, as physical phenomena, storm surges are mainly caused by weather external forces (atmospheric pressure and wind) on the sea, and the behavior of storm surges is determined. On the other hand, the extent of inundation and the behavior of inundation flows in land areas are determined by land use conditions such as ground height, houses, commercial facilities, and agricultural lands. Therefore, the following parts will outline each method from simplified method to detailed method by categorizing the hazard evaluation methods according to the target area: the sea side and the land side.



Source: Portal site of Storm surge and Tsunami in Hiroshima http://www.takashio.pref.hiroshima.lg.jp/portal/help/sakusei_1.html

Figure 1-1 Mechanism of storm surge



Source: JICA Survey Team

Figure 1-2 Image of storm surge along the coast

Chapter 2. Overall Method

2.1 Outline of Method

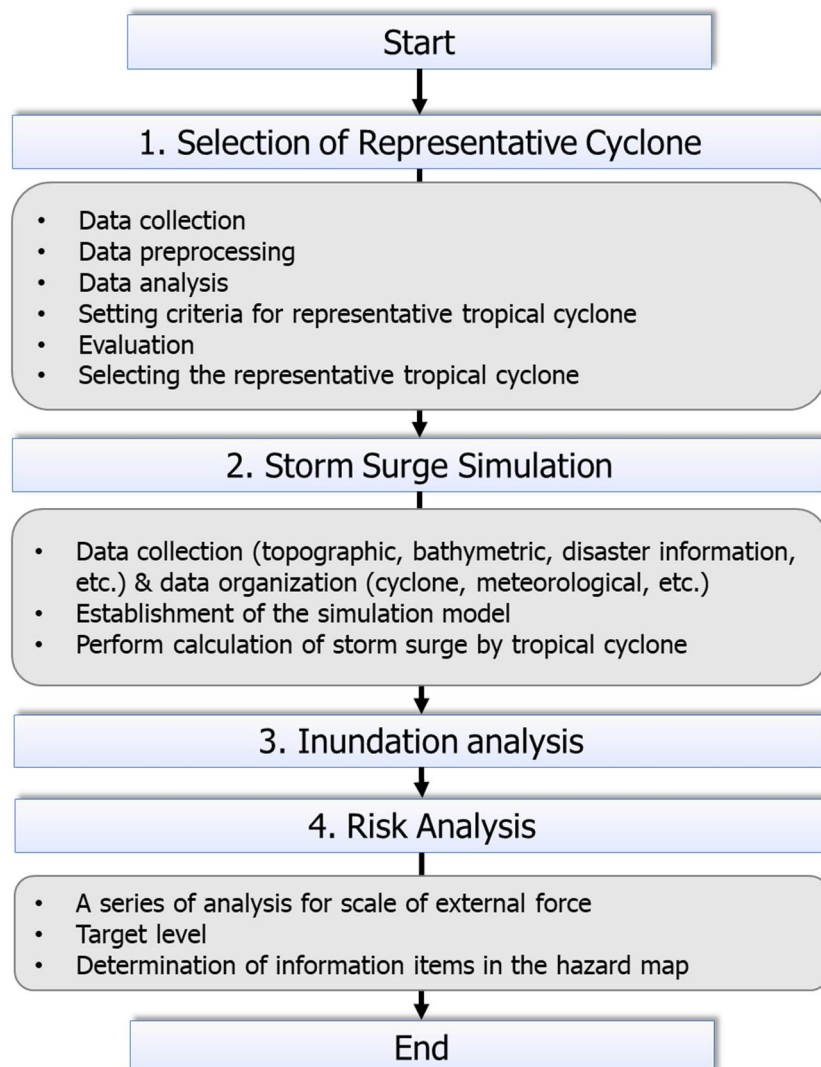
2.1.1 Purpose

The primary objective of this guideline is to provide a systematic approach for tropical cyclone and storm surge risk analysis in Fiji. By following the steps outlined in this guideline, stakeholders will be able to develop effective mitigation strategies, enhance preparedness measures, and contribute to the overall tropical cyclone and storm surge related disaster risk reduction efforts in Fiji.

2.1.2 Analysis Flow

The simplified hazard and risk analysis for coastal disasters proposed in this project is following.

1. Selection of representative cyclone
2. Storm surge simulation
3. Inundation analysis
4. Risk analysis (not be covered by the guideline)



Source: JICA Expert Team

Figure 2-1 Analysis Flow

2.2 Analysis Procedures

2.2.1 Selection of representative cyclone

The first step in the analysis flow is to select a representative cyclone that accurately reflects the typical behavior and characteristics of cyclones in Fiji. This involves studying historical cyclone data, including tracks, intensities, and associated impacts. By considering factors such as frequency, intensity, and geographical coverage, a representative cyclone can be identified for further analysis.

2.2.2 Storm surge simulation

Once the representative cyclone has been selected, the next step is to simulate the storm surge associated with the cyclone. Storm surge simulation helps estimate the extent of coastal flooding and the potential impact on vulnerable areas.

2.2.3 Inundation analysis

Following the storm surge simulation, the inundation analysis aims to assess the extent and depth of flooding in coastal areas. This analysis helps identify vulnerable areas, critical infrastructure, and communities at risk.

2.2.4 Risk analysis

The final step in the analysis flow is to conduct a comprehensive risk analysis, considering the potential consequences of the cyclone and storm surge. However, the guideline does not cover this step.

Chapter 3. Selection of Representative Cyclone

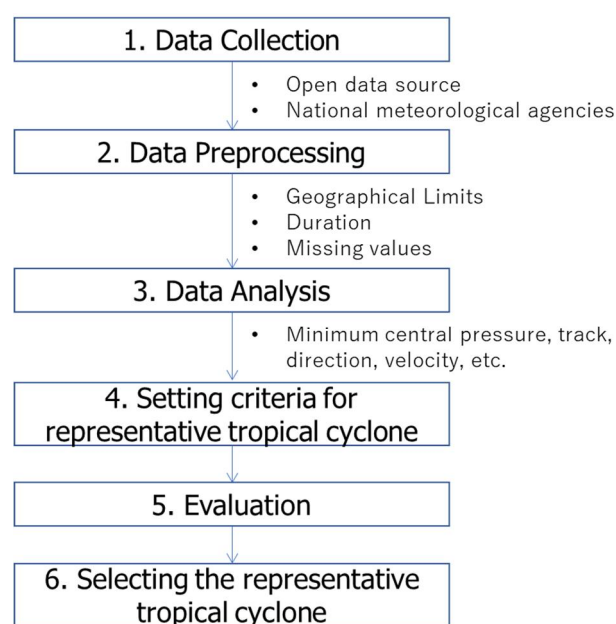
3.1 Purpose

Selecting a representative cyclone is crucial for accurate analysis and risk assessment of cyclone-induced storm surge and inundation. The chosen cyclone should reflect the typical behavior of cyclones in the study area. It ensures relevance to local conditions and serves as the basis for storm surge simulation and inundation analysis. This enables reliable simulations and comparisons with other cyclones, aiding in comprehensive risk assessment and the development of mitigation strategies.

3.2 Selection Flow

The analysis flow for selecting a representative tropical cyclone typically involves a systematic approach to identify a cyclone that best represents the typical behaviour and characteristics of cyclones in a specific region or cyclone-prone area. Here is a general outline of the analysis flow for selecting a representative tropical cyclone:

1. Data collection
2. Data pre-processing
3. Data analysis
4. Setting criteria for representative tropical cyclone
5. Evaluation
6. Selecting the representative tropical cyclone



Source: JICA Expert Team

Figure 3-1 Selection Flow

3.2.1 Data Collection

The first step in the data collection process is to identify reliable sources of tropical cyclone data. National meteorological agencies are often excellent sources of data, as they have comprehensive records of cyclone activity within the country.

If data from national meteorological agencies is not readily available or insufficient, open-source data can be utilized. The open-source database used in this sample is the National Oceanic and Atmospheric Administration (NOAA) International Best Track Archive for Climate Stewardship (IBTrACS). NOAA IBTrACS provides global cyclone tracks and associated information, including intensity, location, and wind speed.

NOAA is a scientific agency within the United States Department of Commerce. Its primary mission is to understand and predict changes in the Earth's environment, including the atmosphere, oceans, and climate. NOAA plays a critical role in monitoring and studying weather patterns, climate phenomena, and natural hazards, providing valuable data and information to researchers, policymakers, and the public.

IBTrACS is a project led by NOAA that aims to provide a comprehensive and quality-controlled global dataset of tropical cyclone tracks and related information. It serves as a centralized repository for historical tropical cyclone data from various meteorological agencies worldwide. IBTrACS collects, standardizes, and maintains consistent track and intensity data for tropical cyclones, allowing for comparative studies, trend analysis, and the creation of global climatologies.

The steps to obtain tropical cyclone data from the NOAA IBTrACS is as follows.

(1) Access the NOAA IBTrACS

The database may be accessed from the link: <https://www.ncei.noaa.gov/data/international-best-track-archive-for-climate-stewardship-ibtracs/v04r00/access/csv/>

(2) Define the Study Region

The basins include the following:

- NA - North Atlantic
- EP - Eastern North Pacific
- WP - Western North Pacific
- NI - North Indian
- SI - South Indian
- SP - Southern Pacific
- SA - South Atlantic

Fiji is located in the Southern Pacific ocean.

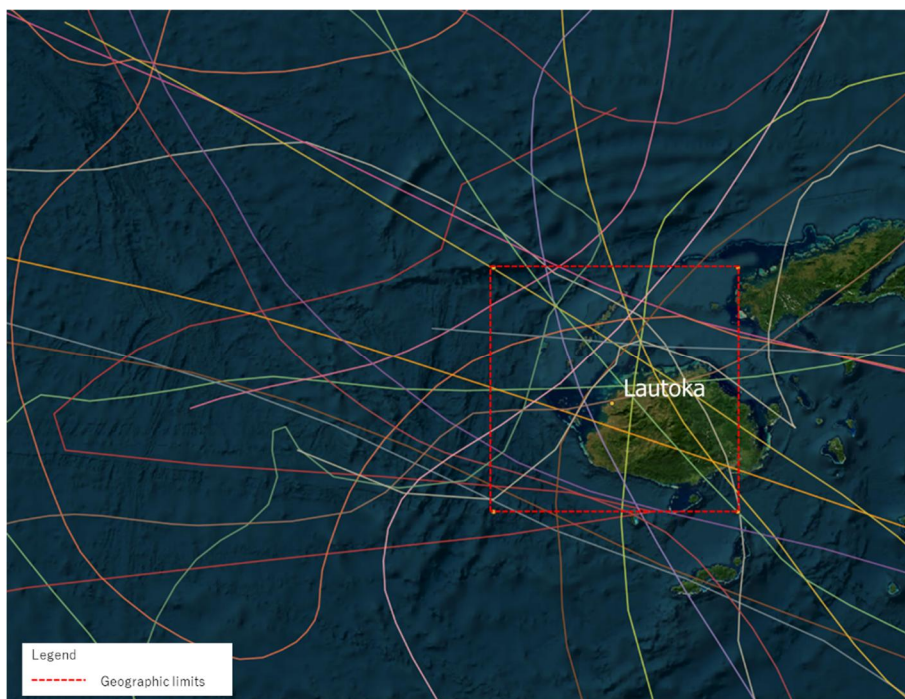
3.2.2 Data pre-processing

Pre-processing tropical cyclone data involves several steps to ensure data quality and suitability for analysis. The common steps for data pre-processing are as follows.

(1) Set geographical limits

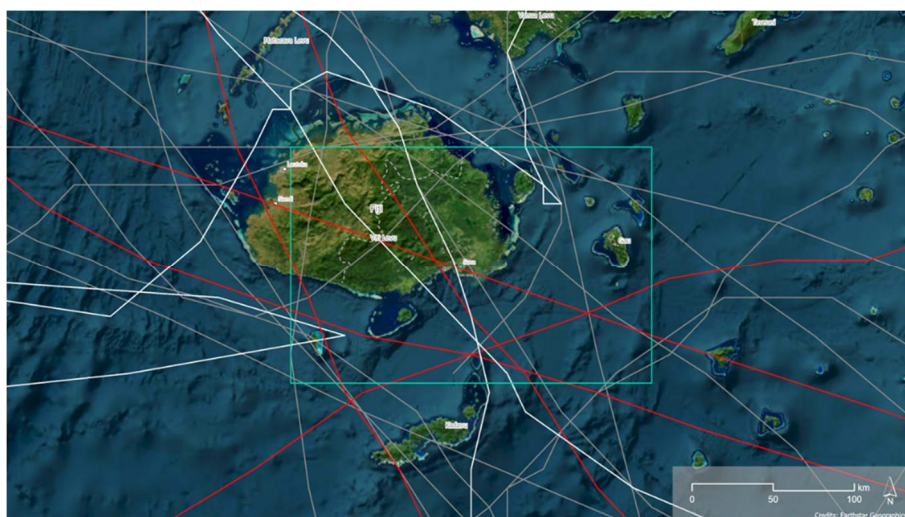
Define the geographical limits or study area for the analysis. Exclude cyclones that fall outside of these limits to focus on the region of interest. This helps ensure that the data aligns with the specific area under study.

As sample cases for the study, tropical cyclones passing near Lautoka (Case 1) and Suva (Case 2) were analyzed. For each location, a 2-degree pitch from their respective latitude and longitude was taken as the geographical limits for considering tropical cyclone data. The figures below illustrate the geographical limits around Lautoka and Suva. In these figures, the tropical cyclone tracks, represented by the lines, are those that pass within the defined geographical limits.



Source: JICA Expert Team

Figure 3-2 Geographic limits for tropical cyclones in Lautoka (Case 1)



Source: JICA Expert Team

Figure 3-3 Geographic limits for tropical cyclones in Suva (Case 2)

(2) Set duration

Determine the desired time period for analysis, considering factors such as the research objective, availability of data, and the cyclone-prone season in the study area. Exclude cyclones that fall outside of this duration to maintain consistency and relevance in the dataset.

Tropical cyclone data for Lautoka and Suva were obtained from IBTrACS, covering the periods 1959–2022 for Lautoka and 1959–2023 for Suva. These durations were considered for the respective sample cases. The tables below show the tropical cyclone data within the geographical limits set above.

Table 3-1 Tropical cyclone data from year 1959 to 2022 in Lautoka, Fiji (Case 1)

No	year	min.Pressure	Average direction	Direction	Remarks
		hPa	degrees		
1	1964	-999.99	204.59	Southward	Missing Data
2	1964	-999.99	142.25	Southward	Missing Data
3	1970	-999.99	157.6	Southward	Missing Data
4	1972	990	233.84	Westward	
5	1972	960	149.34	Southward	
6	1973	990	107.37	Eastward	
7	1974	-999.99	269.51	Westward	Missing Data
8	1974	-999.99	113.65	Eastward	Missing Data
9	1980	-999.99	135.02	Southward	Missing Data
10	1980	997	186.15	Southward	
11	1981	965	157.97	Southward	
12	1983	997	87.96	Eastward	
13	1983	930	110.03	Eastward	
14	1985	960	109.42	Eastward	
15	1985	-999.99	104.38	Eastward	Missing Data
16	1985	-999.99	150.73	Southward	Missing Data
17	1986	-999.99	150.73	Southward	Missing Data
18	1990	997	238.99	Westward	
19	1990	960	107.35	Eastward	
20	1992	-999.99	153.84	Southward	Missing Data
21	1992	-999.99	124.59	Eastward	Missing Data
22	1993	-999.99	145.99	Southward	Missing Data
23	1997	935	228.13	Westward	
24	1997	993	207.46	Southward	
25	2004	997	123.99	Eastward	
26	2008	989	259.98	Westward	
27	2009	975	139.29	Southward	
28	2012	995	93.5	Eastward	
29	2012	944	200.78	Southward	
30	2014	1000	73.7	Eastward	
31	2016	898	268.13	Westward	
32	2018	964	116.53	Eastward	
33	2020	958	116.28	Eastward	
34	2021	975	142.71	Southward	

Source: Created by JICA Expert Team based on NOAA IBTrACS

Table 3-2 Tropical cyclone data from year 1959 to 2023 in Suva, Fiji (Case 2)

No	year	min.Pressure	Average direction	Direction	Remarks
1	1959	-999.99	147.51	Southwards	Missing Data
2	1970	-999.99	166.6	Southwards	Missing Data
3	1972	990.00	260.09	Westward	
4	1973	970.00	144.4	Southwards	
5	1974	-999.99	223.56	Southwards	Missing Data
6	1974	-999.99	232.76	Southwards	Missing Data
7	1975	-999.99	16.4	Northwards	Missing Data
8	1979	965.00	250.73	Westward	
9	1980	-999.99	180	Southwards	Missing Data
10	1981	965.00	159.12	Southwards	
11	1983	-999.99	124.98	Eastwards	Missing Data

12	1985	960.00	108.54	Eastwards	
13	1985	-999.99	103.54	Eastwards	Missing Data
14	1991	965.00	103.61	Eastwards	
15	1993	-999.99	136.38	Southwards	Missing Data
16	1993	-999.99	129.88	Eastwards	Missing Data
17	1993	-999.99	142.67	Southwards	Missing Data
18	2000	-999.99	242.31	Southwards	Missing Data
19	2004	-999.99	126.43	Eastwards	Missing Data
20	2008	-999.99	250.83	Westward	Missing Data
21	2010	985.00	139.04	Southwards	
22	2014	999.00	346.51	Eastwards	
23	2016	-999.99	270	Westward	Missing Data
24	2020	-999.99	115.49	Eastwards	Missing Data
25	2021	975.00	160.84	Southwards	

Source: Created by JICA Expert Team based on NOAA IBTrACS

(3) Remove invalid data points

Check for and handle any invalid or erroneous data points in the dataset. This may include missing values or outliers.

Case 1: As for Lautoka, the table includes data for a total of 34 tropical cyclones that have passed through the data limits and duration set for Lautoka. However, it should be noted that some of these cyclones do not have data on minimum pressure (-999.99) and were therefore removed from this study. Additionally, only tropical cyclones with a minimum pressure of less than 1000 hPa were considered for this analysis, resulting in a total of 21 tropical cyclones analyzed in the sample.

Case 2: For Suva, a total of 25 tropical cyclones passed through the defined data limits and duration. Among these, 16 cyclones had missing data (-999.99) and were excluded. Consequently, 9 tropical cyclones were analyzed in the sample.

3.2.3 Data Analysis

Once the data on tropical cyclones has been collected, the next step is to analyze the gathered data to derive meaningful insights. The analysis process involves examining the various parameters and characteristics of the cyclones to understand their behavior and impacts.

For example, plot histograms to visualize the distribution of minimum central pressure, velocity, direction or other parameter necessary for the study.

3.2.4 Setting criteria for representative tropical cyclone

After analyzing the collected data on tropical cyclones, the next step is to establish criteria for selecting a representative tropical cyclone. These criteria will help ensure that the chosen cyclone accurately reflects the typical behavior and characteristics of cyclones in the study area.

Thoroughly examine historical data on tropical cyclones in the study area or similar regions. Analyze past storm surge events, their impacts, and associated cyclone characteristics. Identify recurring patterns, critical variables, and parameters that significantly influence storm surge and inundation.

Identify key parameters that contribute to storm surge and inundation. Prioritize factors that have a strong correlation with past surge events or are known to have significant impacts on coastal areas.

Assess the availability and quality of data for the identified parameters. Ensure that sufficient and reliable data exist for the selected cyclone candidates.

3.2.5 Evaluation

Once the criteria for selecting a representative tropical cyclone have been established and potential candidates have been identified, it is important to evaluate the chosen cyclones to ensure they meet the desired objectives and accurately represent the behavior and characteristics of cyclones in the study area.

3.2.6 Selecting the representative tropical cyclone

After evaluating the potential candidates based on the established criteria, the final step is to select the representative tropical cyclone that best reflects the typical behavior and characteristics of cyclones in the study area.

Chapter 4. Storm Surge Simulation

4.1 Purpose

Storm surge simulations provide detailed technical information on potential inundation extents, depth, and impacts to assess vulnerability, develop risk reduction strategies, enhance preparedness and response, inform land use planning, and raise awareness.

4.2 Numerical models related to storm surge

The Fiji Meteorological Service (FMS) employs three key systems related to coastal disasters to enhance the assessment process. These systems are the Storm Surge Forecasting Model introduced by the Japan Meteorological Agency [SSFM-JMA], the Coastal Inundation Forecasting Demonstration Project by the World Meteorological Organization (WMO) and JMA [T+T], and the High Resolution Inundation Forecast in CIFDP by the Secretariat of the Pacific Community (SPC), WMO, Korea Meteorological Administration (KMA) [CIFDP]. Additionally, the Wave Forecasting System for the Southwest Pacific and Fiji region by Amit and JMA (WFS-SPF) is also utilized.

Table 4-1 Numerical Models related to storm surge

	1. SSFM- JMA	2. T+T	3. CIFDP	4. WFS-SPF
Supporter	JMA	WMO, JMA	SPC, WMO, KMA etc	JMA
Target Area	Whole Fiji and other Pacific	Whole Fiji	South of Viti Levu island	Whole Fiji and other Pacific
Grid size	1' or 30'' (900m~1.8km)	4km	Marine 300m Land 10m	1° , 0.25° , 0.05° (~5km)
Storm Surge	√(JMA model)	√(JMA model)	-	-
Wave		√(SWAN)	√(SWAN, Xbeach)	MRI-III
Tide		√	√	
Inundation		√(Bathtub)	√	
24/7			√	√

Source: JICA Expert Team

4.2.1 Storm Surge Forecasting Model introduced by the Japan Meteorological Agency [SSFM-JMA]

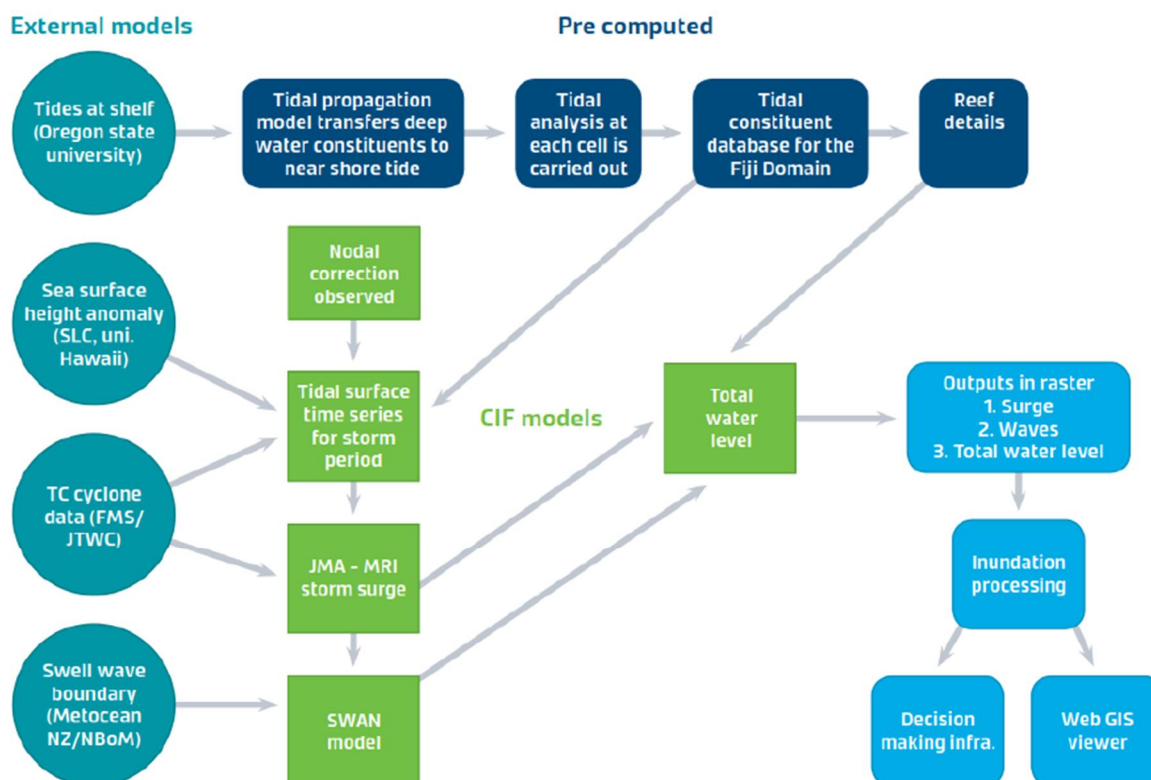
The Japan Meteorological Agency (JMA) operates a numerical storm surge model to provide warnings and predictions for storm surges. The model uses equations to simulate sea level variations caused by meteorological disturbances, such as strong winds and changes in atmospheric pressure. It takes into account the uncertainty in tropical cyclone track forecasts by running multiple scenarios with different meteorological inputs.

4.2.2 Coastal Inundation Forecasting Demonstration Project by the World Meteorological Organization (WMO) and Japan Meteorological Agency (JMA) [T+T]

The Coastal Inundation Forecasting Demonstration Project (T+T) is an initiative undertaken by the World Meteorological Organization (WMO) and the Japan Meteorological Agency (JMA) to develop and demonstrate advanced forecasting capabilities for coastal inundation events.

Calculation of inundation analysis consists of the following steps

1. Calculation of inundation analysis
 - Setting of the input data
 - Calculation of inundation depth and flow speed
 - Indication of the depth and the flow speed on a map



Source: Training Manual, Coastal Inundation Forecasting Demonstration Project (CIFDP-F), Fiji

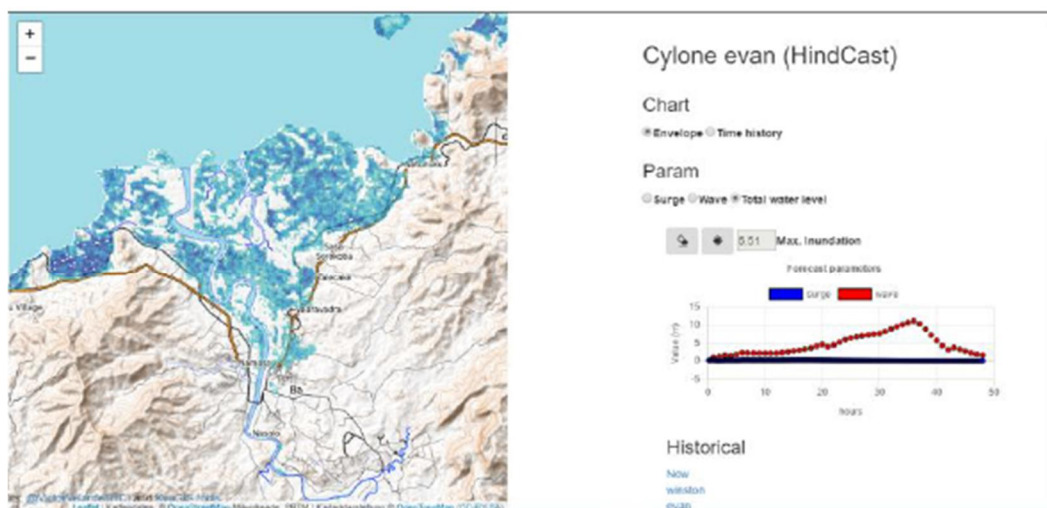
Figure 4-1 CIFDP Framework for Fiji

In the sample case, Cyclone Winston was selected as one of the representative cyclones to examine its characteristics and impacts. Cyclone Winston's data is shown in the figure below.

CYCLONE Winston(1609)		Start= 021818 End= 022118					
48 hours calculation		(←forecast hours)					
6 hourly data		(←information interval hours)					
date	Pc	lon	lat	r0	Coef	Pfar	
021818	927.00	-173.3	-17.5	30.0	0.70	1012.00	
021900	927.00	-174.7	-17.3	30.0	0.70	1012.00	
021906	914.00	-176.1	-17.5	30.0	0.70	1012.00	
021912	914.00	-177.4	-17.3	30.0	0.70	1012.00	

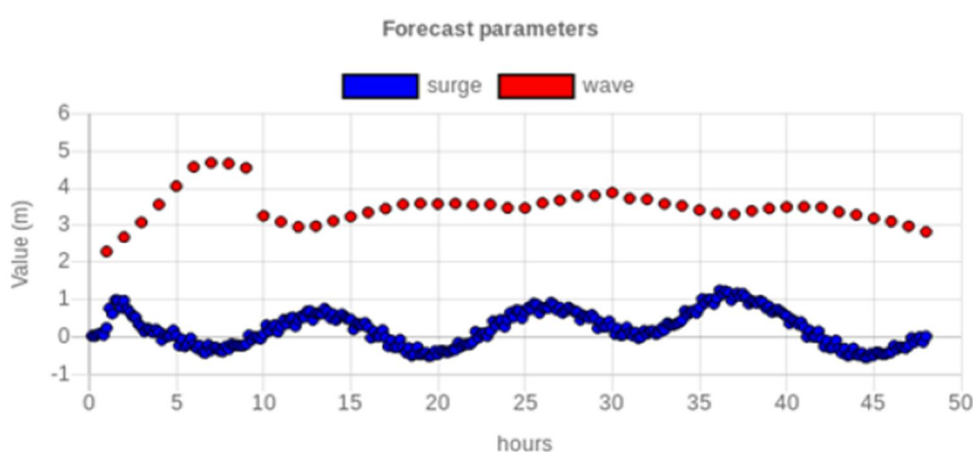
Source: Training Manual, Coastal Inundation Forecasting Demonstration Project (CIFDP-F), Fiji

Figure 4-2 Cyclone Winston fundamental data



Source: Training Manual, Coastal Inundation Forecasting Demonstration Project (CIFDP-F), Fiji

Figure 4-3 Inundation chart based on bathtub approach



Source: Training Manual, Coastal Inundation Forecasting Demonstration Project (CIFDP-F), Fiji

Figure 4-4 Storm surge and wave time series

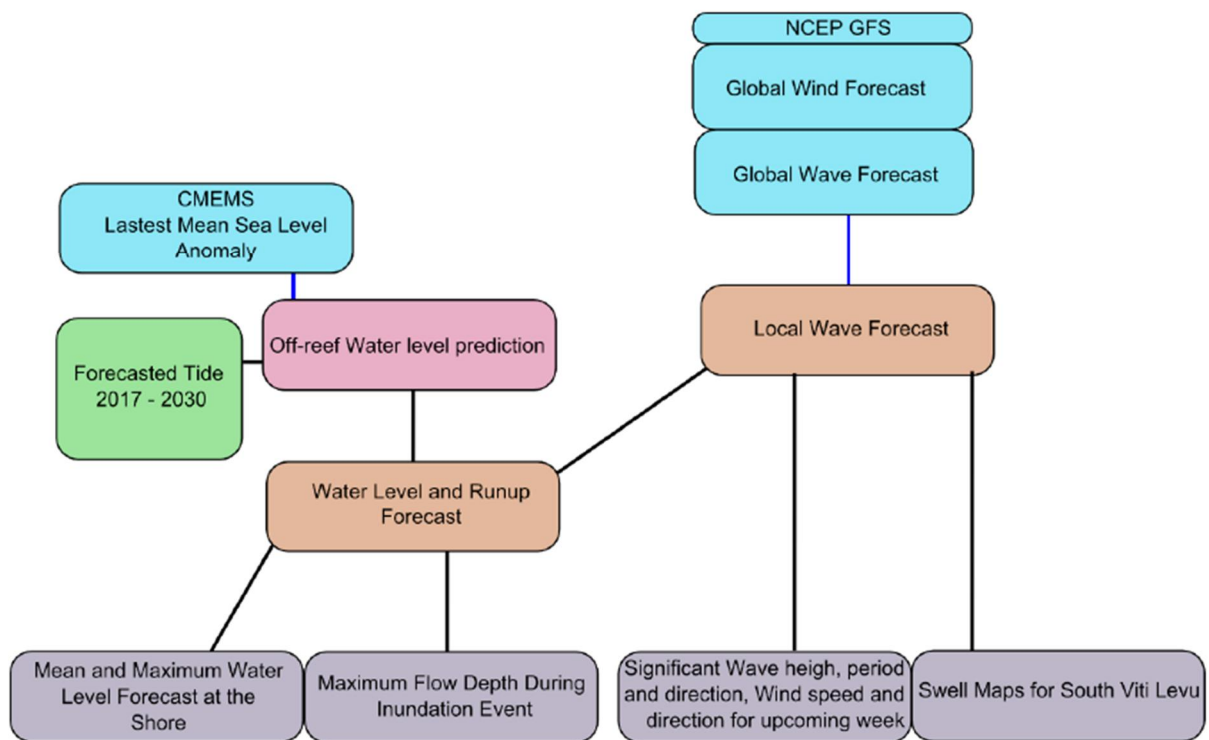
4.2.3 High Resolution Inundation Forecast in Coastal Inundation Forecasting Demonstration Project (CIFDP)

The High-Resolution Inundation Forecast is a component of the Coastal Inundation Forecasting Demonstration Project (CIFDP) conducted by various organizations such as the Pacific Community (SPC), World Meteorological Organization (WMO), and Korea Meteorological Administration (KMA). This initiative aims to provide detailed and accurate forecasts of coastal inundation events, particularly focusing on high-resolution inundation models and forecast maps depicting swell height and direction.

The High-Resolution Inundation Forecast offers a detailed and localized prediction of coastal inundation, taking into account various factors such as storm characteristics, topography, wave dynamics, and other relevant parameters. The forecast provides information on the extent, depth, and timing of inundation as shown in the figure below.

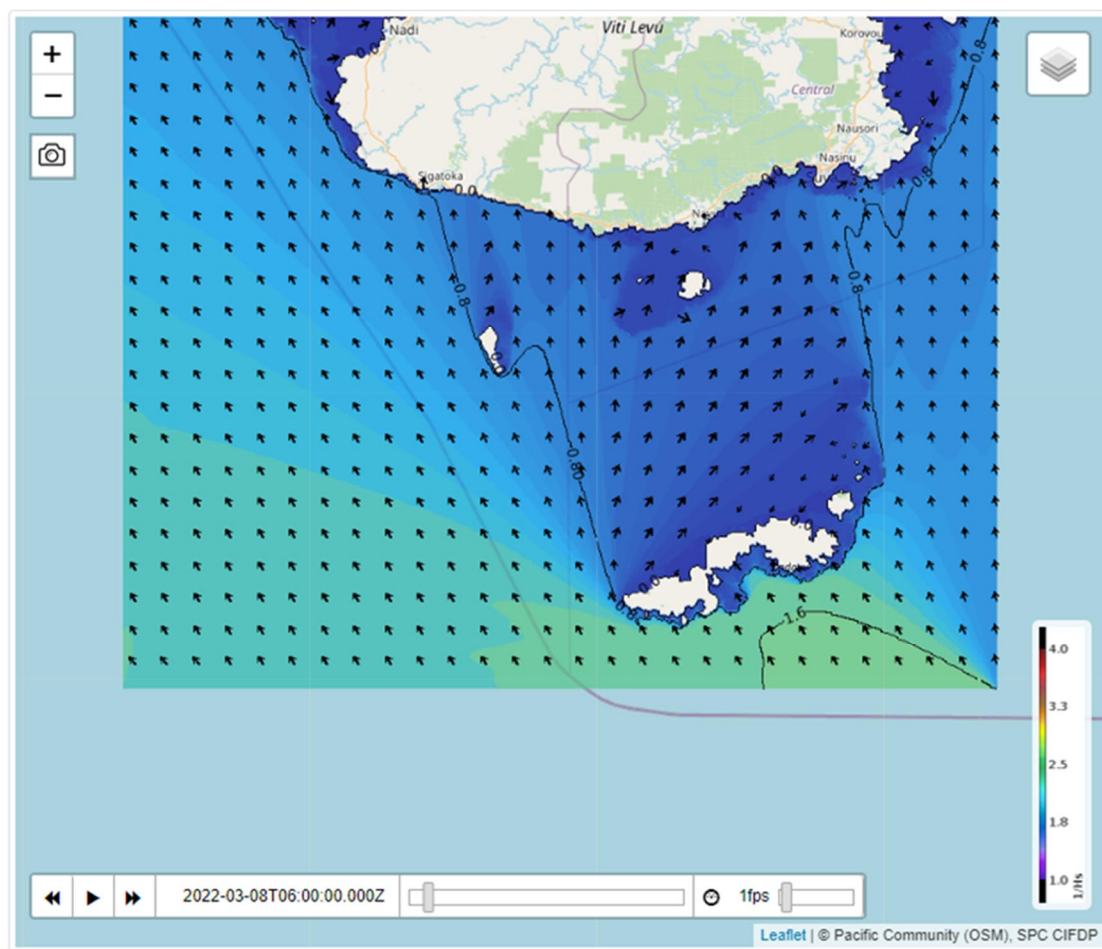
Calculation of inundation analysis consists of the following steps

1. Calculation of inundation analysis
 - Setting of the input data
 - Calculation of inundation depth and flow speed
 - Indication of the depth and the flow speed on a map



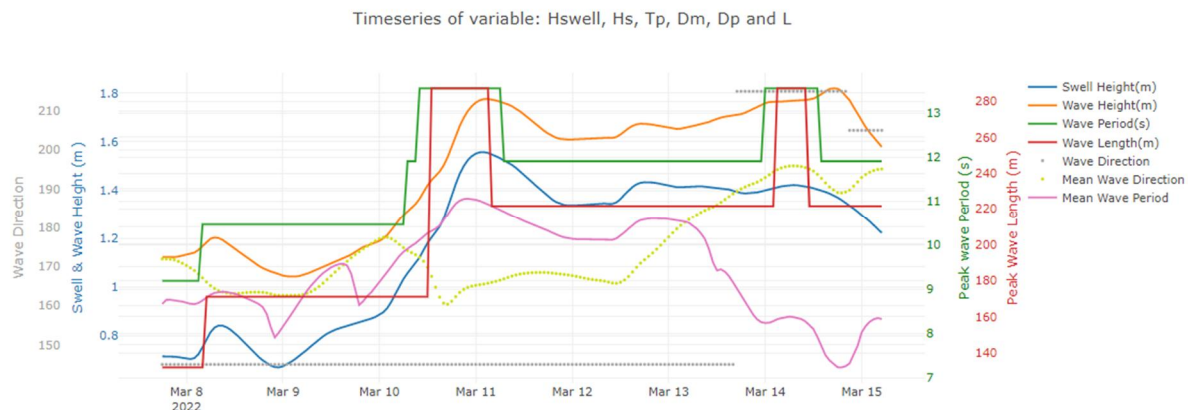
Source: CIFDP Fiji Forecasting Manual

Figure 4-5 Forecast system structure



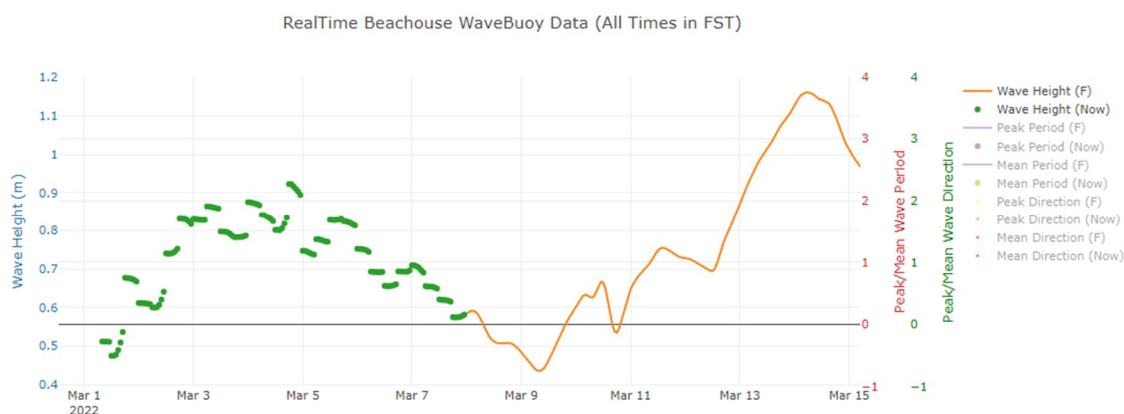
Source: CIFDP Fiji Forecasting Manual

Figure 4-6 Forecast map



Source: CIFDP Fiji Forecasting Manual

Figure 4-7 Timeseries of variable: Hswell, Hs, Tp, Dm, Dp and L



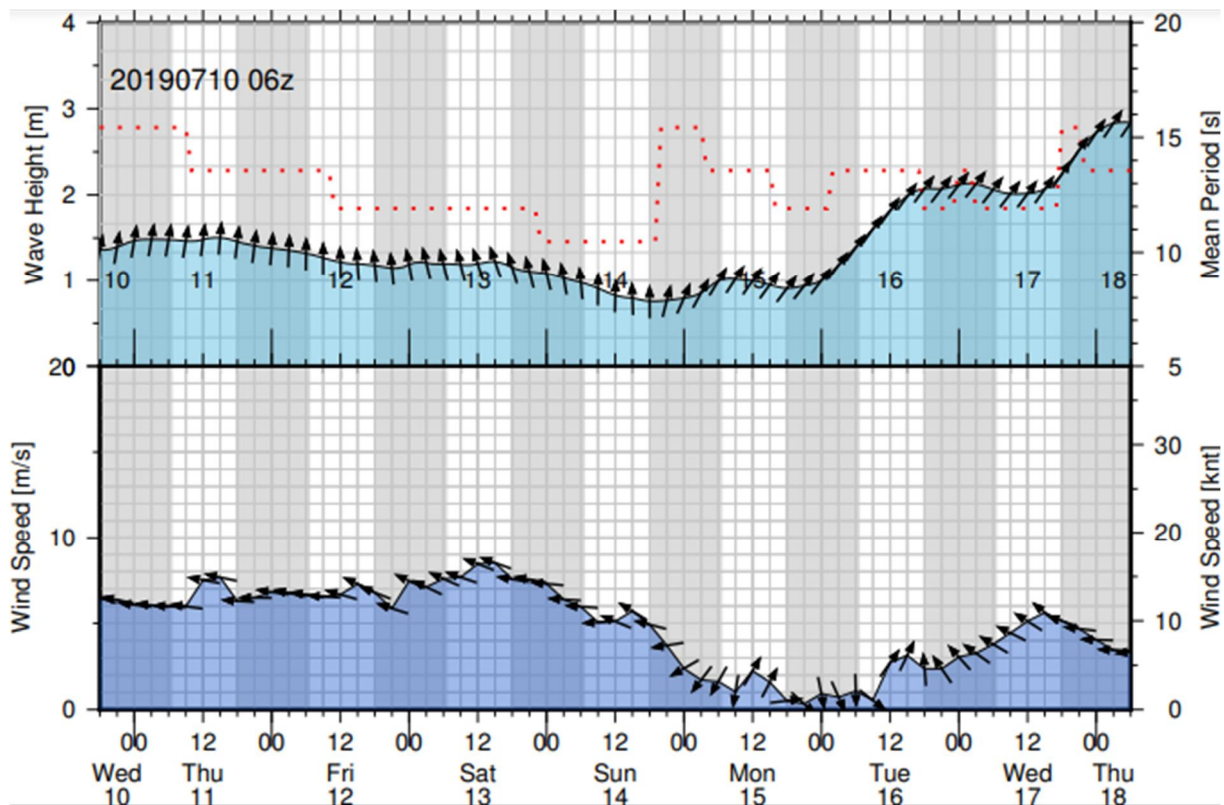
Source: CIFDP Fiji Forecasting Manual

Figure 4-8 RealTime Beachouse WaveBuoy Data (All Times in FST)

The detailed hourly forecast is now available for multiple locations, including the following

- Lighthouse Reef
- Cloudbreak
- Maui Bay
- Mango Bay

Users can access the updated PDF document by clicking on the link: https://wacop.gsd.spc.int/Fiji_Forecast.html for each location. By downloading the PDF, users can gain access to hourly weather predictions.



Source: CIFDP Fiji Forecasting Manual

Figure 4-9 Wave height and wave speed forecast

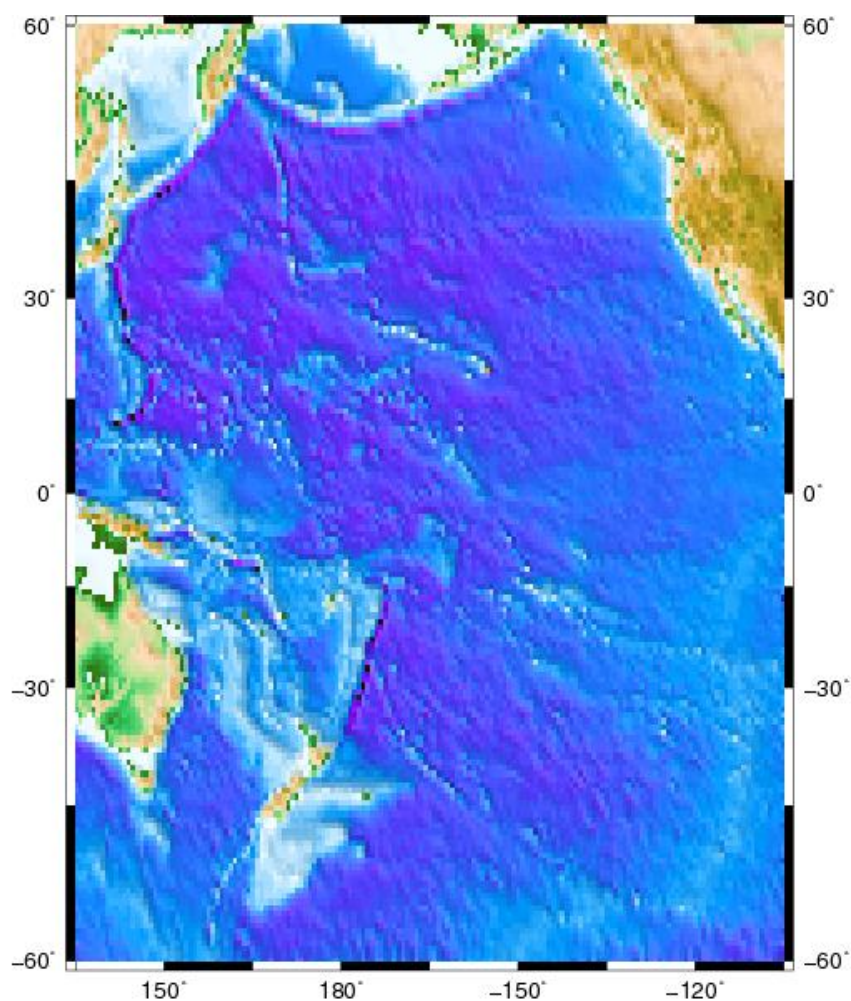
4.2.4 Wave Forecasting System for the Southwest Pacific and Fiji region by Amit and Japan Meteorological Agency (JMA) [WFS-SPF]

The Wave Forecasting System for the Southwest Pacific and Fiji region (WFS-SPF) is an advanced forecasting tool developed by the Pacific Community (SPC) in collaboration with the Japan Meteorological Agency (JMA). This system is designed to provide accurate and timely forecasts of wave conditions in the Southwest Pacific and Fiji region.

Calculation of inundation analysis consists of the following steps

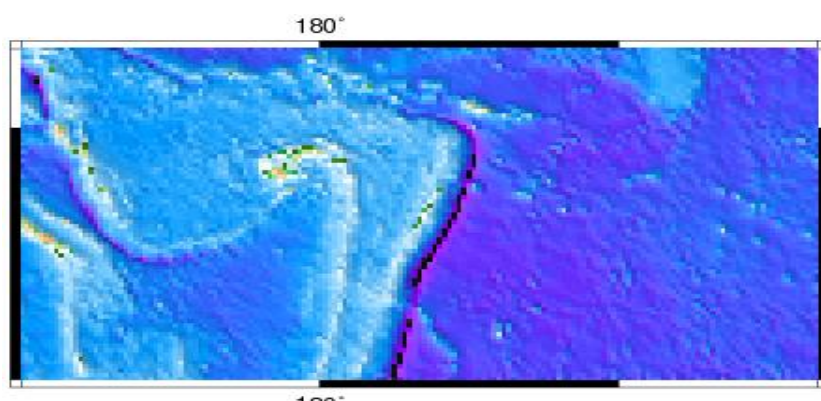
1. Calculation of inundation analysis

- Setting of the input data
- Calculation of inundation depth and flow speed
- Indication of the depth and the flow speed on a map
- Wave Model: MRI-III (JMA)
- Wind Data: GFS
- Pacific (1°)
 - South Pacific (0.25°)
 - Fiji (0.05°)



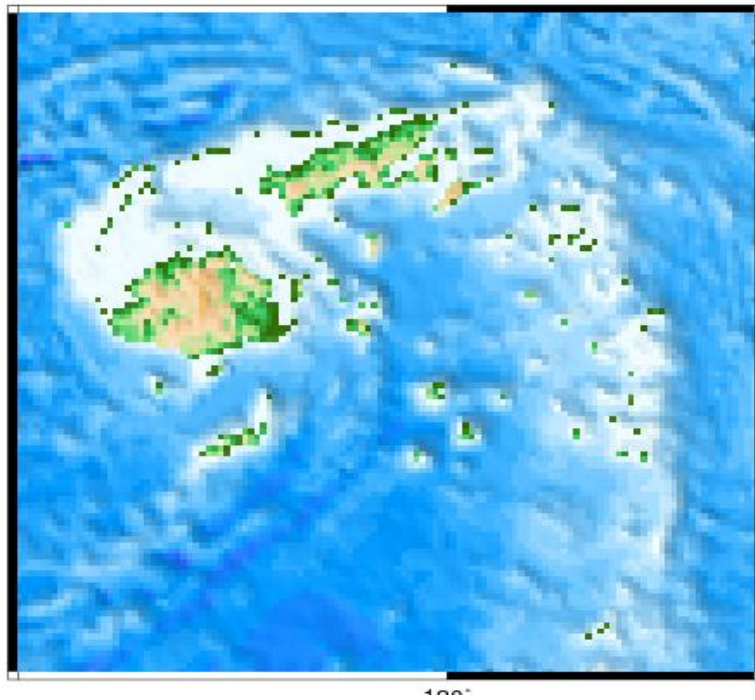
Source: Development of a Wave Forecasting System for the Southwest Pacific and Fiji region

Figure 4-10 Wave forecasting system in the Pacific region



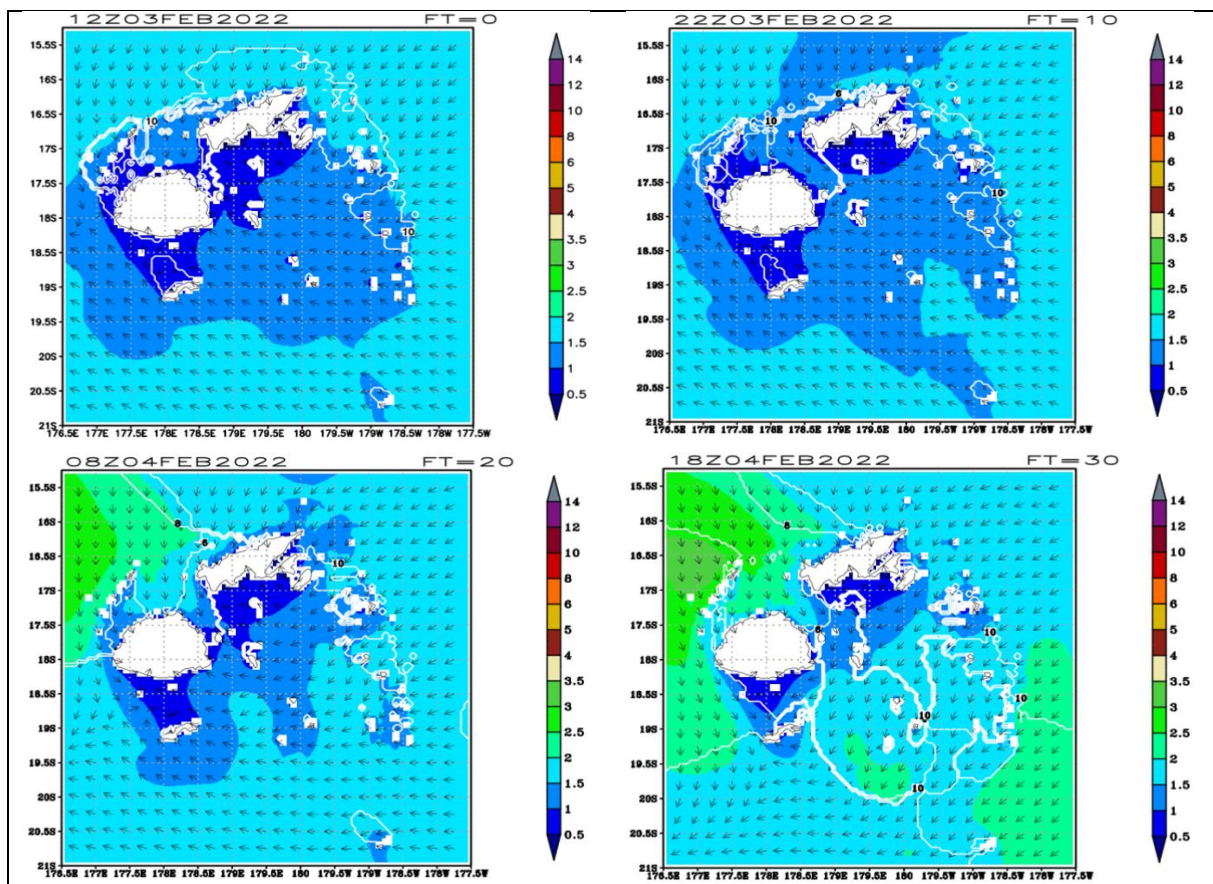
Source: Development of a Wave Forecasting System for the Southwest Pacific and Fiji region

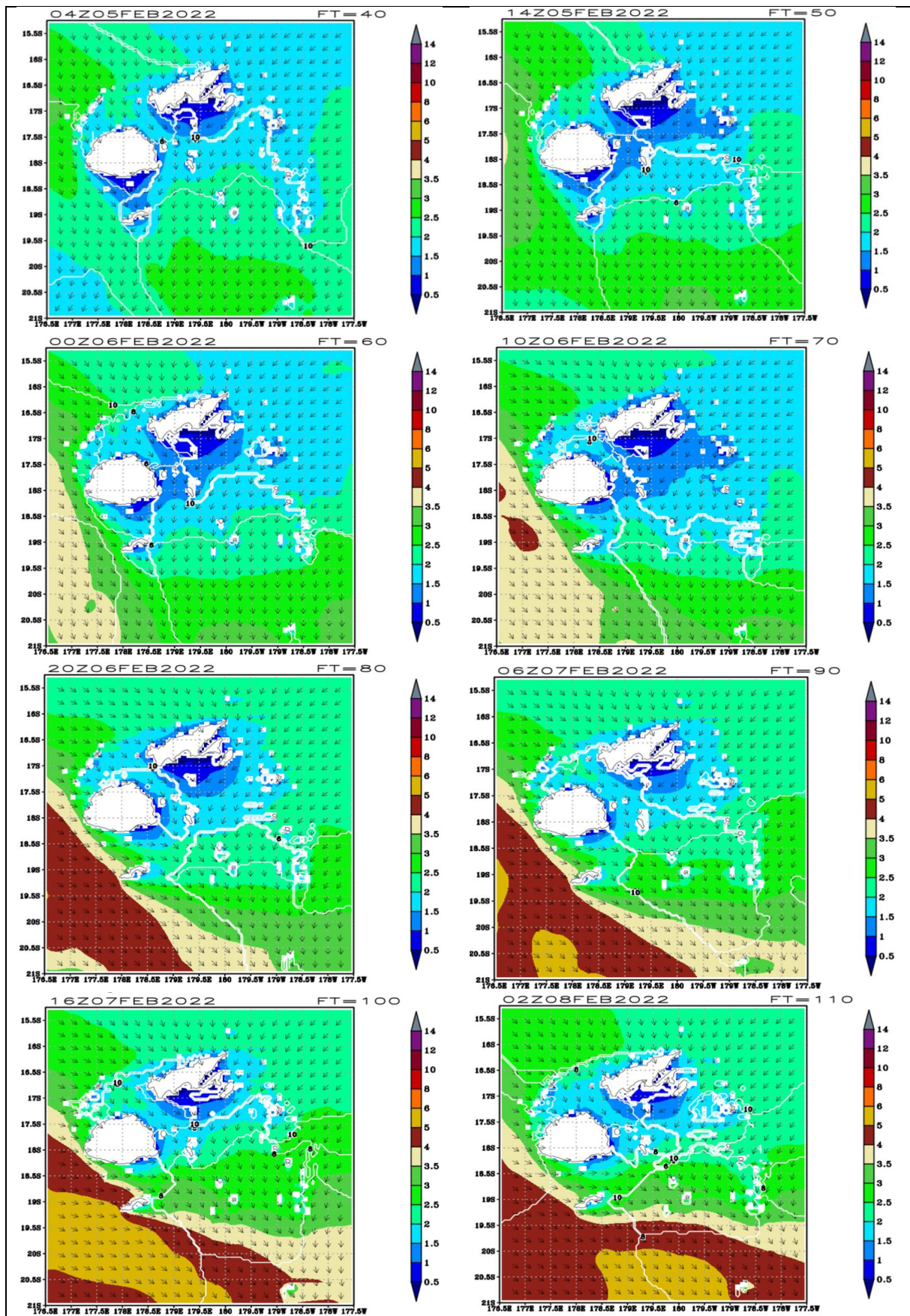
Figure 4-11 Wave forecasting system in the Southwest Pacific region

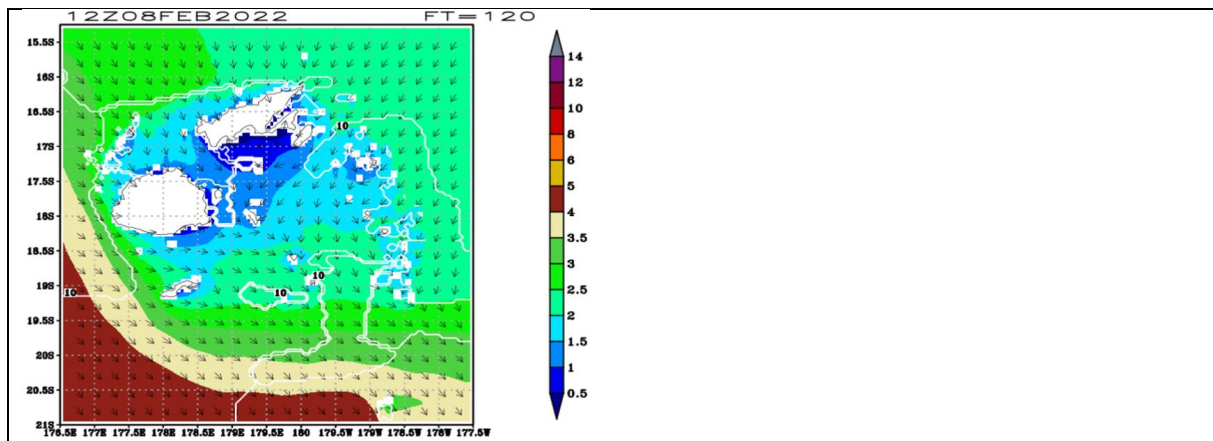


Source: Development of a Wave Forecasting System for the Southwest Pacific and Fiji region

Figure 4-12 Wave forecasting system in the Fiji region

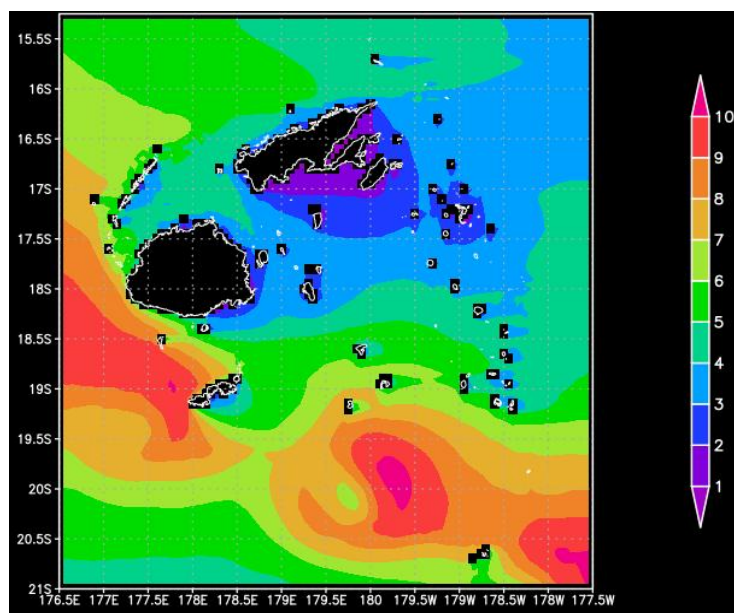






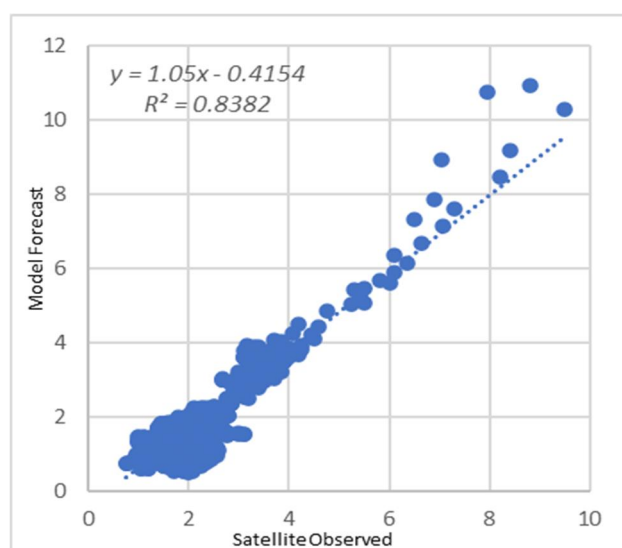
Source: Development of a Wave Forecasting System for the Southwest Pacific and Fiji region

Figure 4-13 Sample results of Fiji Wave



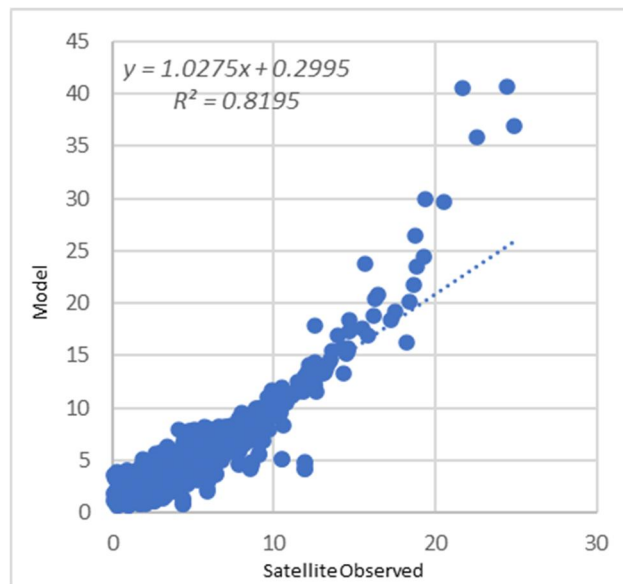
Source: Development of a Wave Forecasting System for the Southwest Pacific and Fiji region

Figure 4-14 Sample results of Fiji Wave



Source: Development of a Wave Forecasting System for the Southwest Pacific and Fiji region

Figure 4-15 Wave heights (m)



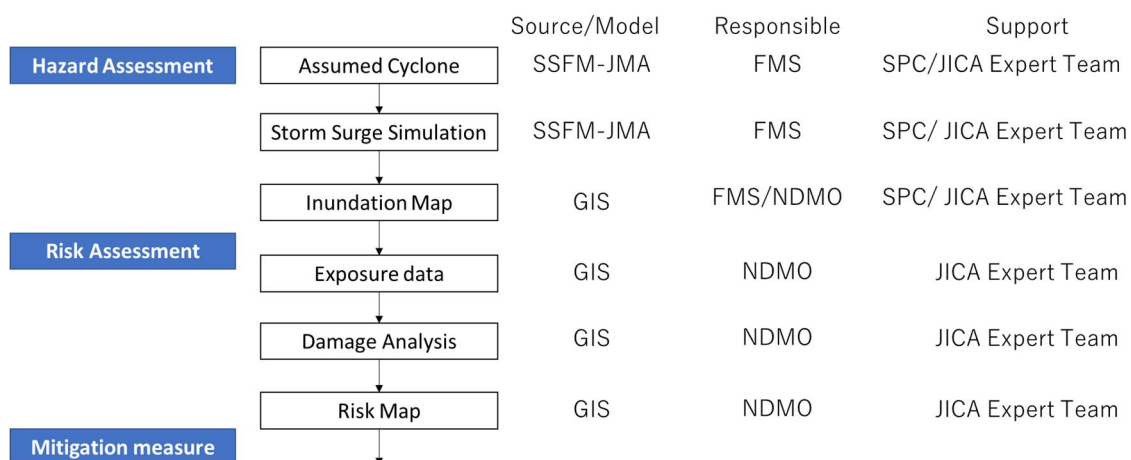
Source: Development of a Wave Forecasting System for the Southwest Pacific and Fiji region

Figure 4-16 Wind speed (m/s)

4.3 Storm surge simulation by Storm Surge Forecasting Model (SSFM-JMA)

4.3.1 Overall flow of storm surge assessment

FMS has several models related to coastal disasters. Using these models, NDRMO & FMS jointly conduct hazard & risk assessment with JICA.

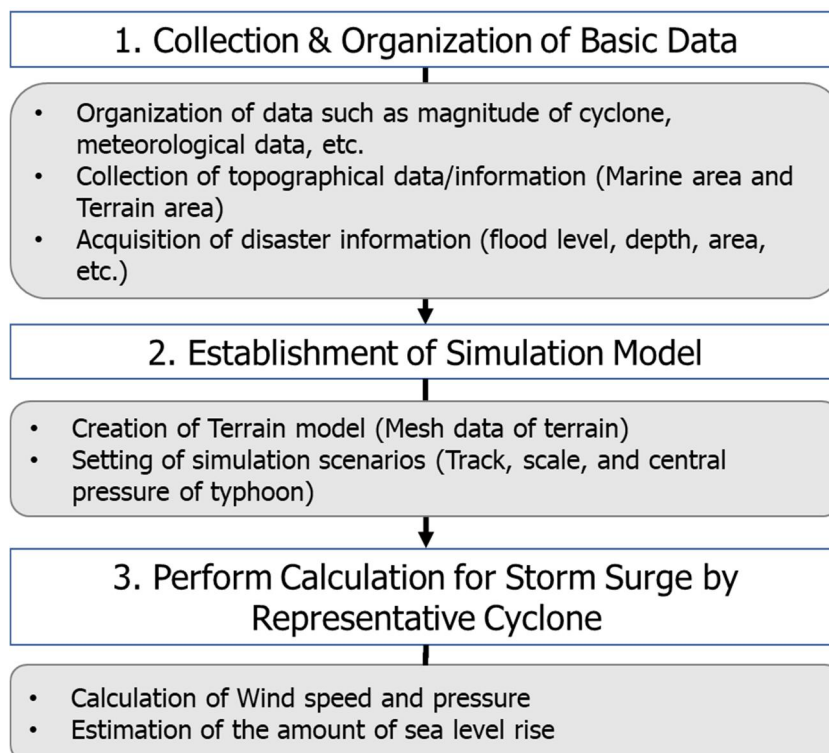


Source: JICA Expert Team

Figure 4-17 Hazard and Risk assessment of storm surge in the project

The simulation of storm surge involves a systematic flow comprising data collection, establishment of a simulation model, and the calculation of storm surge using representative cyclones. The storm surge simulation flow is as follows.

1. Collection & organization of basic data
2. Establishment of simulation model
3. Perform calculation for storm surge by representative cyclone

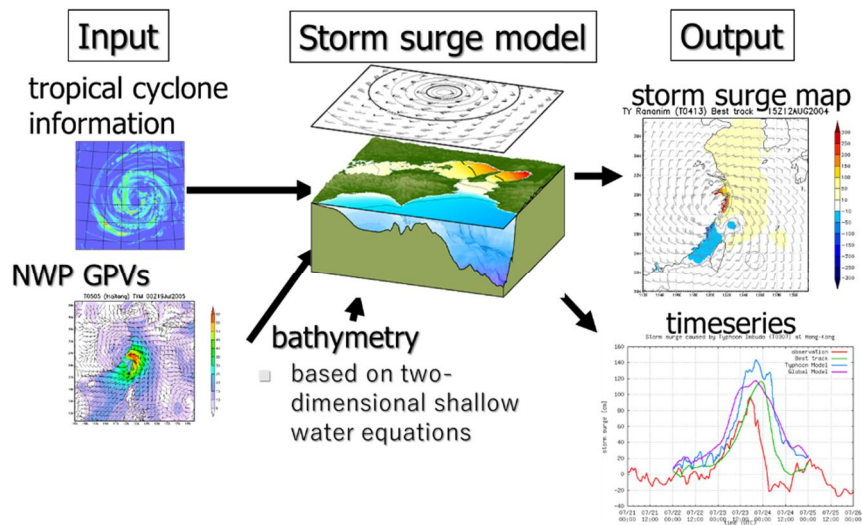


Source: JICA Expert Team

Figure 4-18 Storm surge analysis flow

4.3.2 Model description

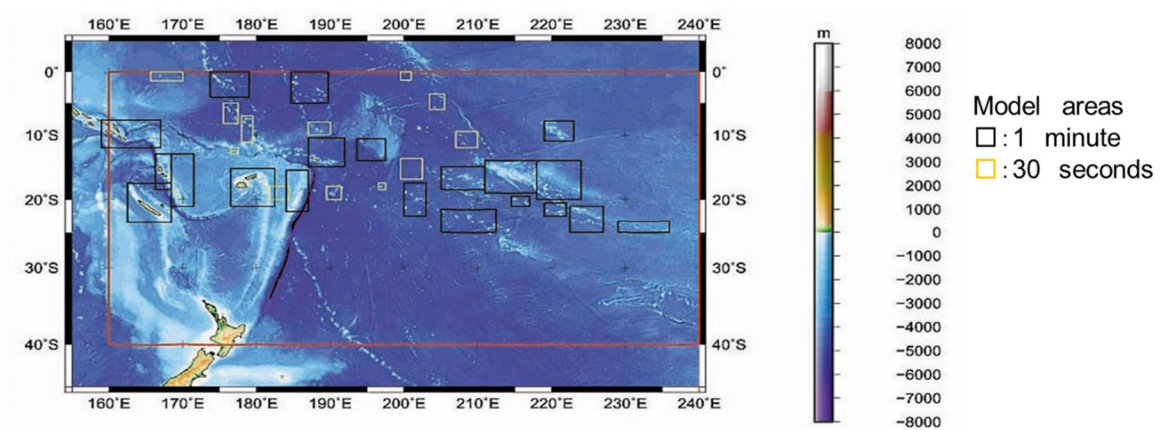
(1) Overall system



Source: storm surge forecasting by RSMC Nadi

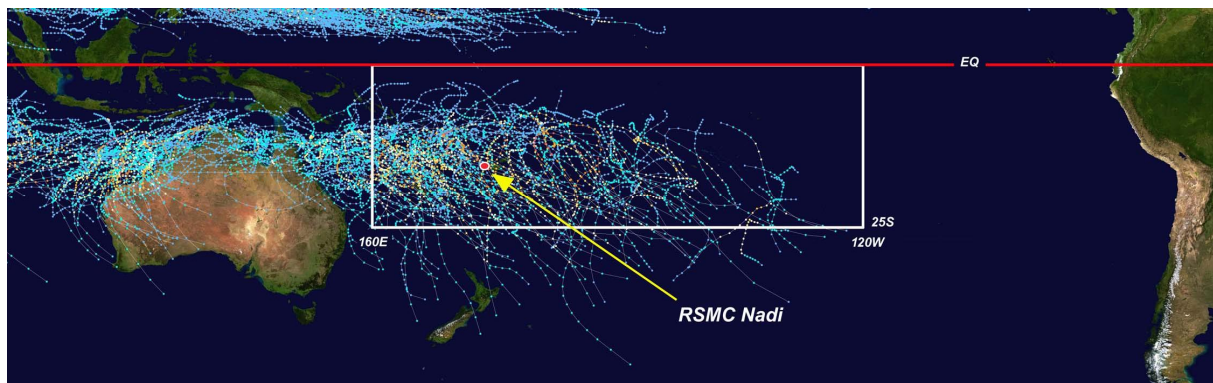
Figure 4-19 Storm surge forecasting model introduced by JMA

(2) Establishment of simulation model



Source: storm surge forecasting by RSMC Nadi

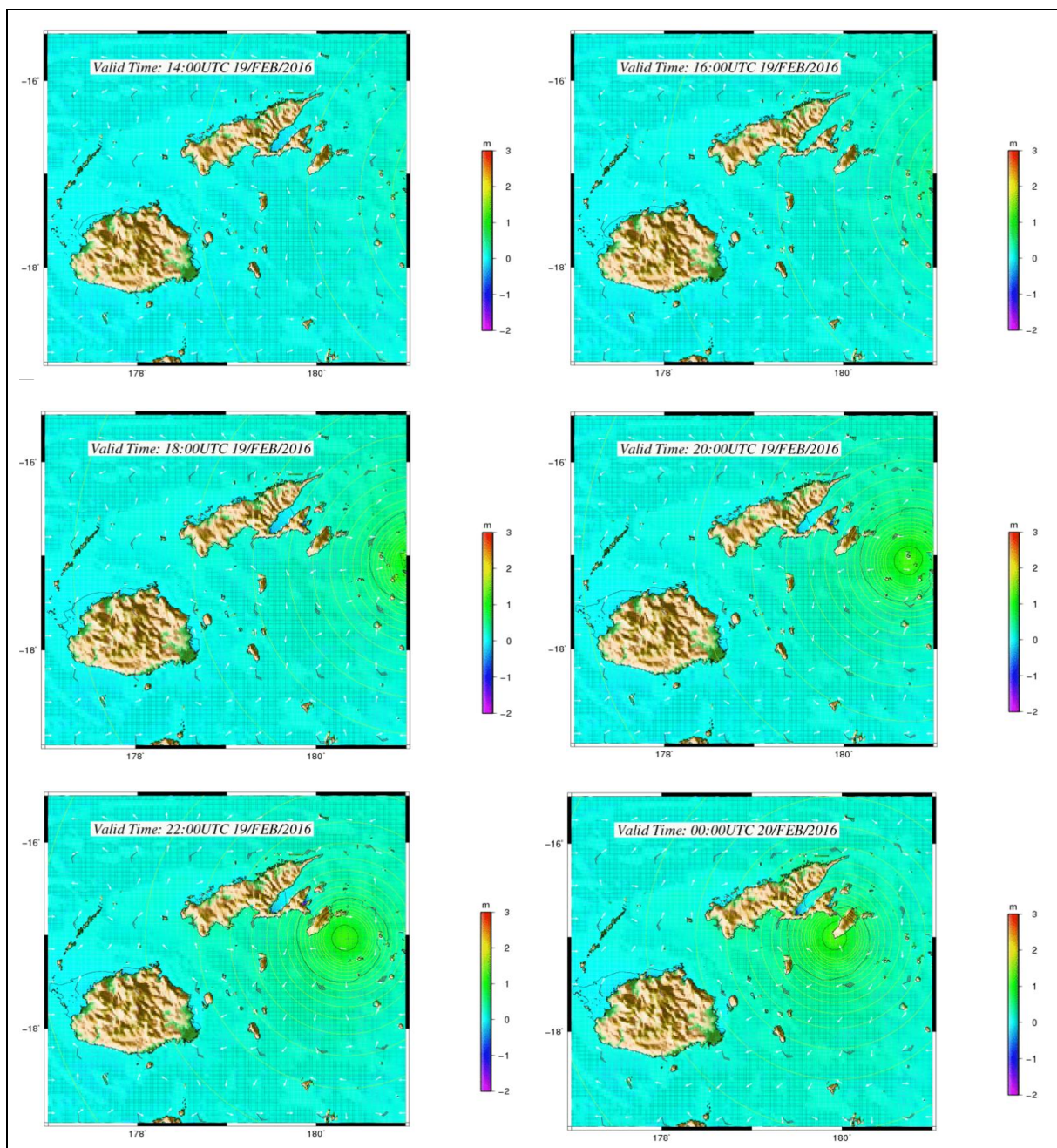
Figure 4-20 Storm surge forecasting model areas

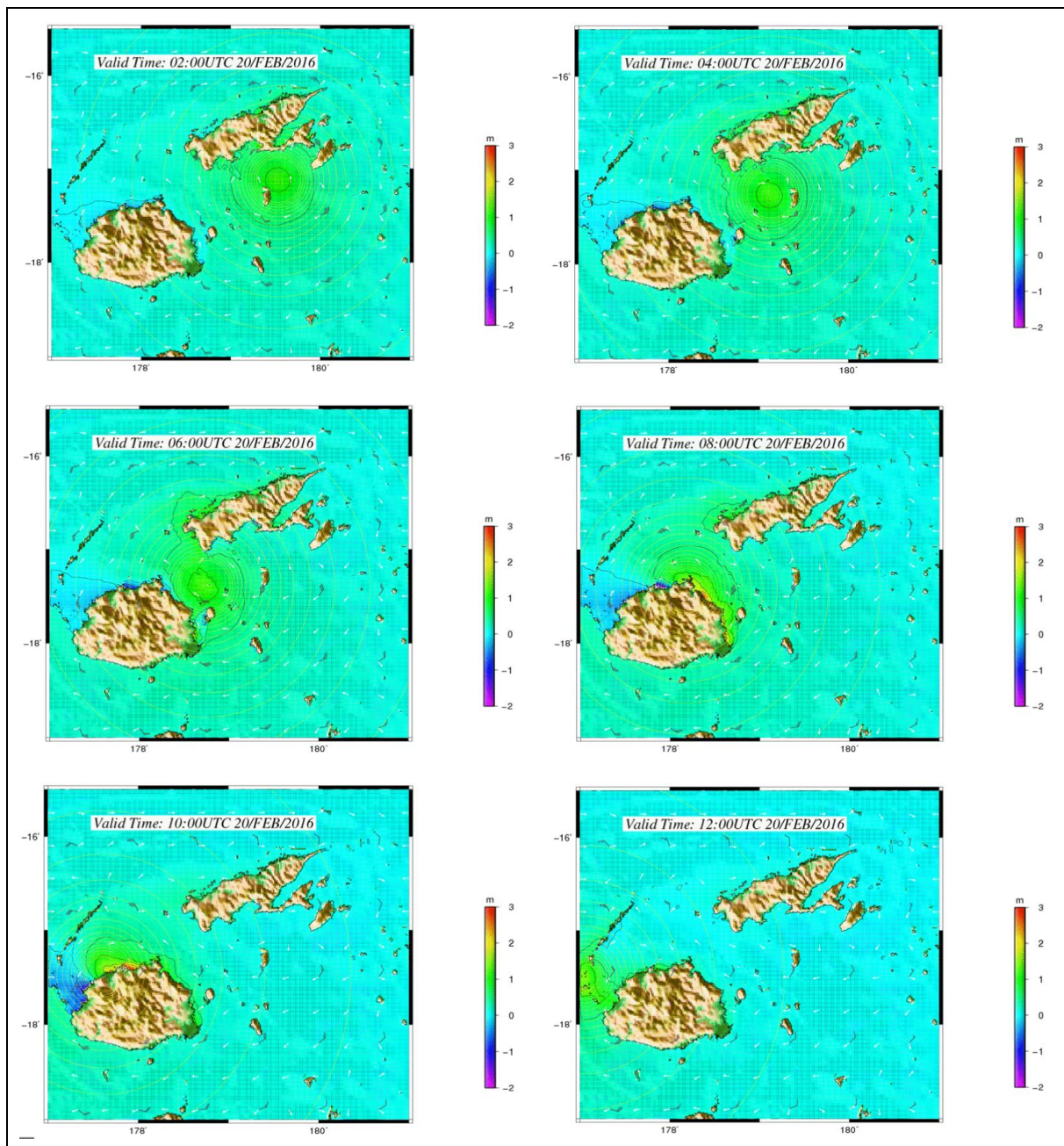


Source: storm surge forecasting by RSMC Nadi

Figure 4-21 Location of RSMC in Nadi, Fiji

(3) Perform calculation for storm surge by representative cyclone





Source: storm surge forecasting by RSMC Nadi

Figure 4-22 Storm surge forecasting model introduce by JMA

- Highest winds
 - 10-min sustained: 233 km/h (Gust: 306km/h)
 - minute sustained: 285 km/h
- Lowest pressure: 929 hPa (mbar)

Chapter 5. Inundation Analysis

5.1 Purpose

Inundation analysis in this guideline involves studying the potential extent and impact of flooding caused by tropical cyclone and storm surge. It encompasses the assessment of areas likely to be affected by floodwaters, including determining the depth and flow velocity of water, and mapping out the potential flood zones. The results of inundation analysis provide crucial information for disaster risk reduction efforts, enabling authorities to identify high-risk areas, enhance preparedness, evaluate infrastructure vulnerability, inform insurance decisions, support land-use planning, and guide climate change adaptation strategies.

5.2 Analysis Flow

The flow of inundation analysis is as follows. At first, the storm surge height at the coastline of Nadi is estimated, followed by setting the target hazard level at the target site. By using the fill level method, storm surge inundation map will be developed.

1. Evaluation of Expected Storm Surge Height at the coastline of Nadi
2. Target Storm Surge Level for Hazard Map
3. Inundation Analysis by Fill Level Method
4. Storm Surge Hazard Map

5.3 Evaluation of Expected Storm Surge Height at the coastline

The maximum storm surge height would be obtained by a series of simulations from the above simulations.

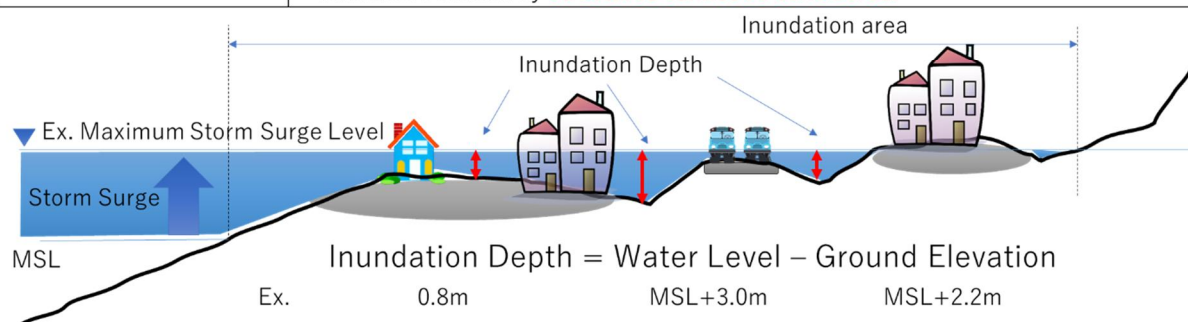
5.4 Target Storm Surge Level for Hazard Map

By accumulating the estimated maximum storm surge height obtained by Simulation from the above evaluations and highest astronomical tide (e.g., Lautoka tide station: MSL + 1.142m), total estimated storm surge elevation of target coast can be evaluated.

5.5 Inundation Analysis by Fill Level Method

Following the estimated maximum storm surge level (target level for hazard map), inundation analysis can be evaluated by using different ways of approach. It involves predicting the extent and depth of flooding or inundation caused by a storm surge event. In the present project, inundation analysis is performed by Fill Level Method to access the inundated area or depth of the target zones.

	Contents
Items can be assessed	➤ Inundated area/ Inundation depth
Major Necessary Data	➤ Sea side target level/ DEM
Characteristics (●Pros, ×Cons)	● If there is a water level between DEM and the sea side, it can be easily evaluated. ● The inundation depth in each mesh of DEM can be evaluated. × The effect of detailed topography, etc. cannot be considered. × Influences caused by structures cannot be considered.



Source: JICA Expert Team

Figure 5-1 Inundation Analysis by Fill Level Method

Chapter 6. Case Study in Nadi/ Lautoka

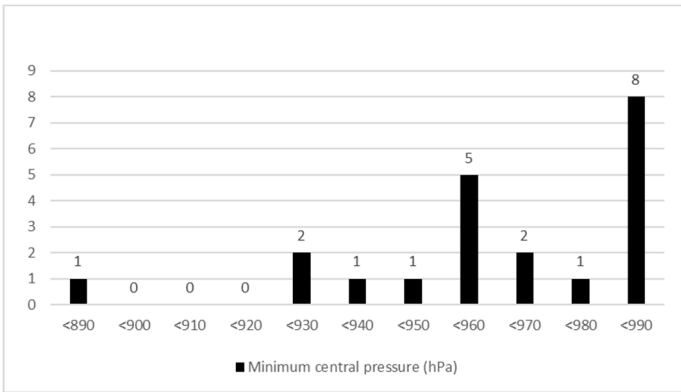
6.1 Selection of Representative Cyclone

6.1.1 Data Analysis

Once the data on tropical cyclones has been collected, the next step is to analyze the gathered data to derive meaningful insights. The analysis process involves examining the various parameters and characteristics of the cyclones to understand their behavior and impacts.

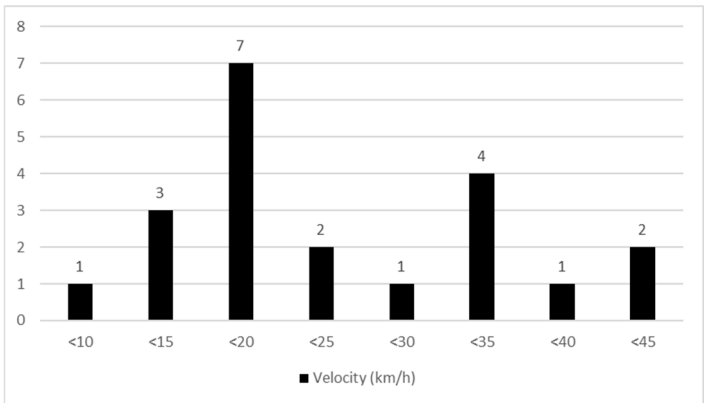
Plot histograms to visualize the distribution of minimum central pressure, velocity, direction or other parameter necessary for the study.

The histograms created for the sample case in Lautoka is shown below.



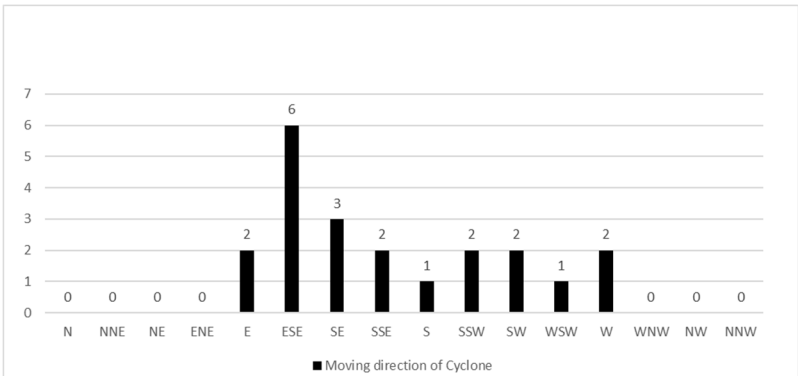
Source: Created by JICA Expert Team based on NOAA IBTrACS

Figure 6-1 Minimum central pressure of tropical cyclones in Lautoka from 1959 to 2022



Source: Created by JICA Expert Team based on NOAA IBTrACS

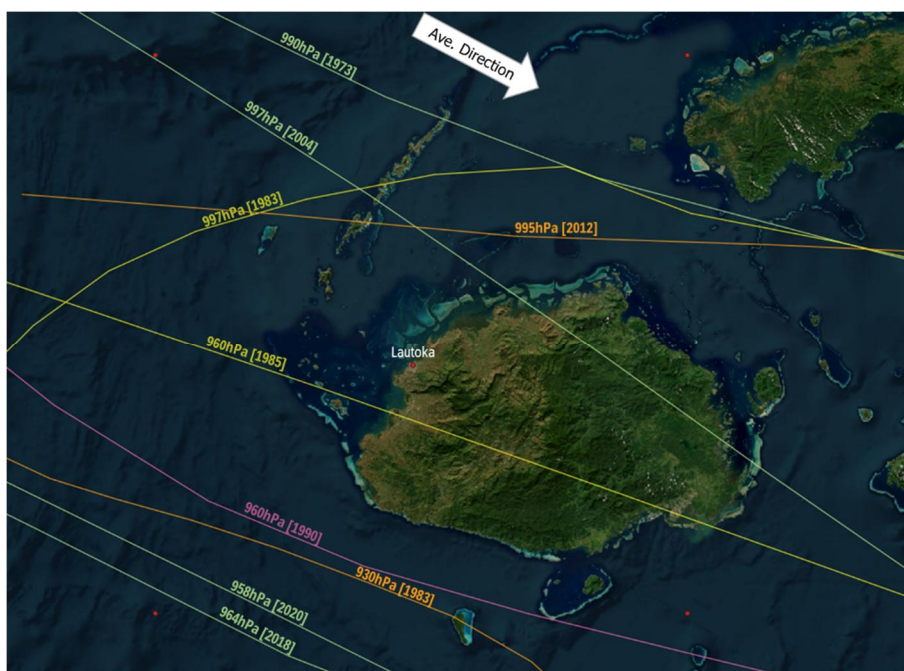
Figure 6-2 Velocity of tropical cyclones in Lautoka from 1959 to 2022



Source: Created by JICA Expert Team based on NOAA IBTrACS

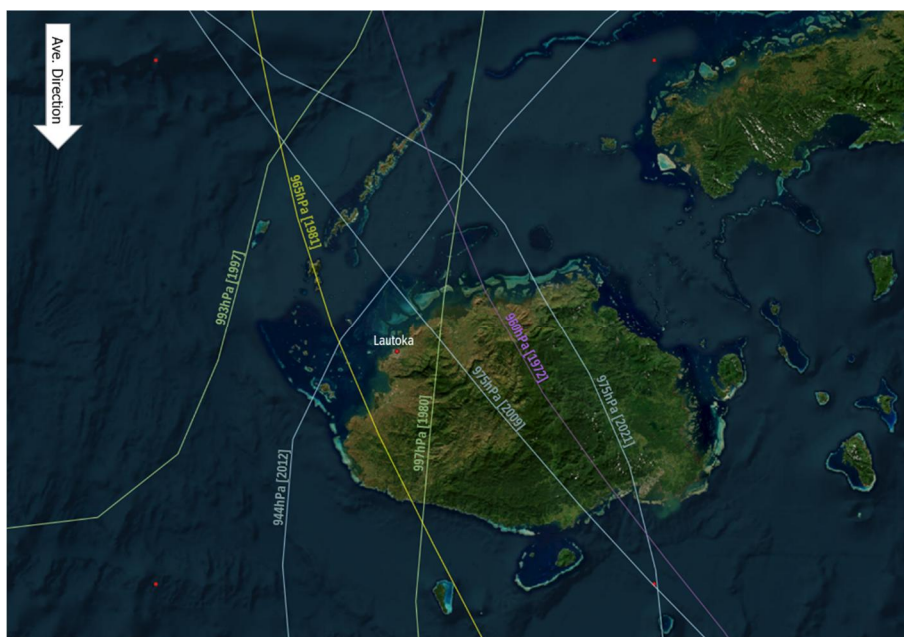
Figure 6-3 Moving direction of tropical cyclones in Lautoka from 1959 to 2022

Plot the latitude and longitude of the tropical cyclone to investigate their tracks. In the sample case in Lautoka, tracks were plotted per average direction of typhoons. The typhoon track maps are shown below.



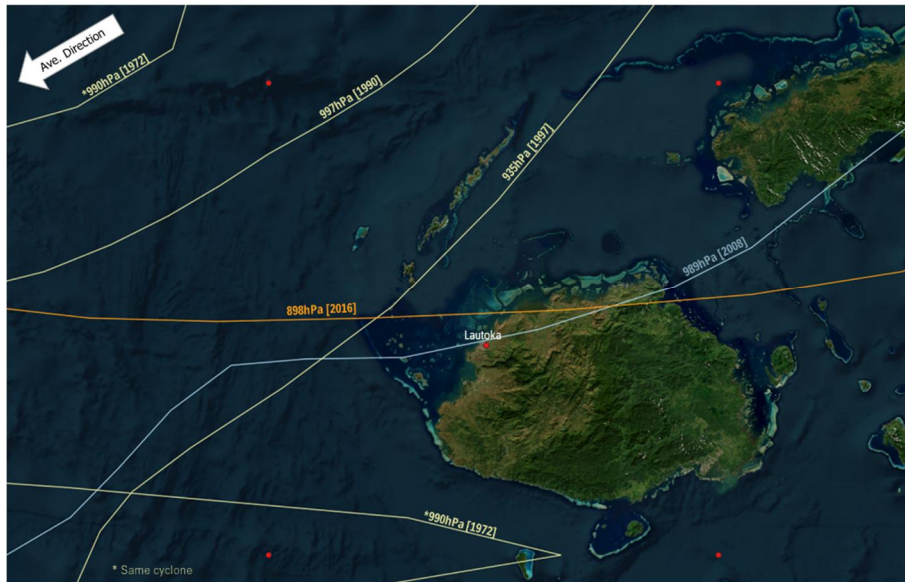
Source: Created by JICA Expert Team based on NOAA IBTrACS

Figure 6-4 Tropical cyclones moving eastward in Lautoka from 1959 to 2022



Source: Created by JICA Expert Team based on NOAA IBTrACS

Figure 6-5 Tropical cyclones moving southward in Lautoka from 1959 to 2022



Source: Created by JICA Expert Team based on NOAA IBTrACS

Figure 6-6 Tropical cyclones moving westward in Lautoka from 1959 to 2022

The data analysis of tropical cyclones involves examining various parameters and characteristics to gain insights into their behavior and impacts. This includes plotting histograms to visualize the distribution of parameters such as minimum central pressure, velocity, and direction. Additionally, analyzing the tracks of cyclones by plotting their latitude and longitude provides information on their movement patterns. The analysis helps understand the behavior and trends of cyclones over time, and it can provide valuable insights for further research, risk assessment, and decision-making in areas prone to tropical cyclone impacts.

6.1.2 Setting criteria for representative tropical cyclone

After analyzing the collected data on tropical cyclones, the next step is to establish criteria for selecting a representative tropical cyclone. These criteria will help ensure that the chosen cyclone accurately reflects the typical behavior and characteristics of cyclones in the study area.

Thoroughly examine historical data on tropical cyclones in the study area or similar regions. Analyze past storm surge events, their impacts, and associated cyclone characteristics. Identify recurring patterns, critical variables, and parameters that significantly influence storm surge and inundation.

Identify key parameters that contribute to storm surge and inundation. Prioritize factors that have a strong correlation with past surge events or are known to have significant impacts on coastal areas.

Assess the availability and quality of data for the identified parameters. Ensure that sufficient and reliable data exist for the selected cyclone candidates.

6.1.3 Evaluation

Once the criteria for selecting a representative tropical cyclone have been established and potential candidates have been identified, it is important to evaluate the chosen cyclones to ensure they meet the desired objectives and accurately represent the behavior and characteristics of cyclones in the study area.

6.1.4 Selecting the representative tropical cyclone

After evaluating the potential candidates based on the established criteria, the final step is to select the representative tropical cyclone that best reflects the typical behavior and characteristics of cyclones in the study area.

As for the sample case in Lautoka, three tropical cyclones are chosen as representative aiming to select a low central pressure typhoon from each cyclone track direction which is shown in the table below.

Table 6-1 Representative tropical cyclones selected in Lautoka

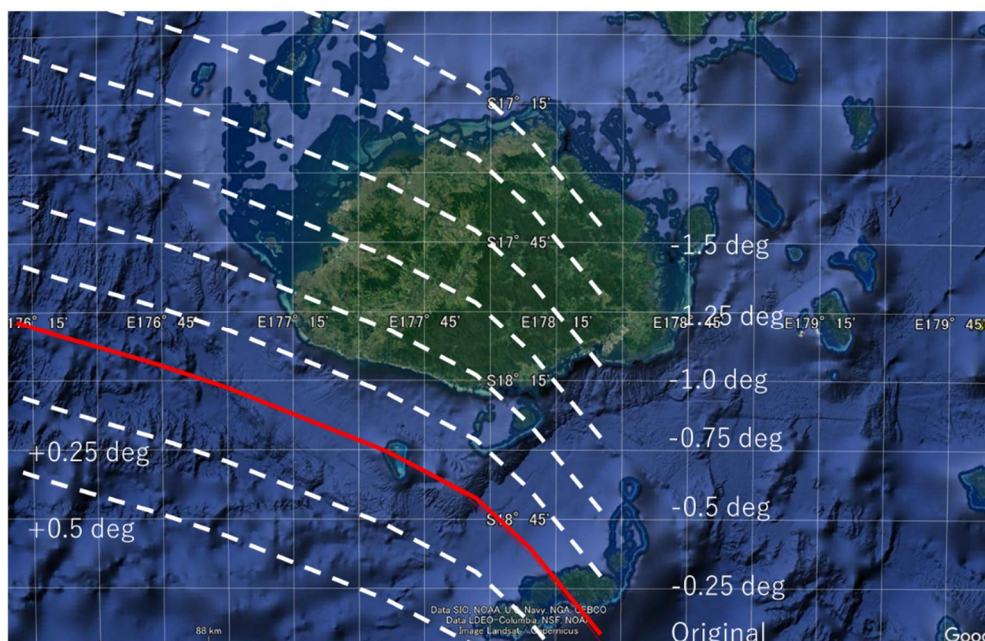
Tropical Cyclone Name	Date Occurred	Min. Central Pressure (hPa)	Direction
Oscar	February 1983	930	ESE
Evan	December 2012	944	SSW
Winston	February 2016	898	W

Source: JICA Expert Team

6.2 Storm Surge Simulation

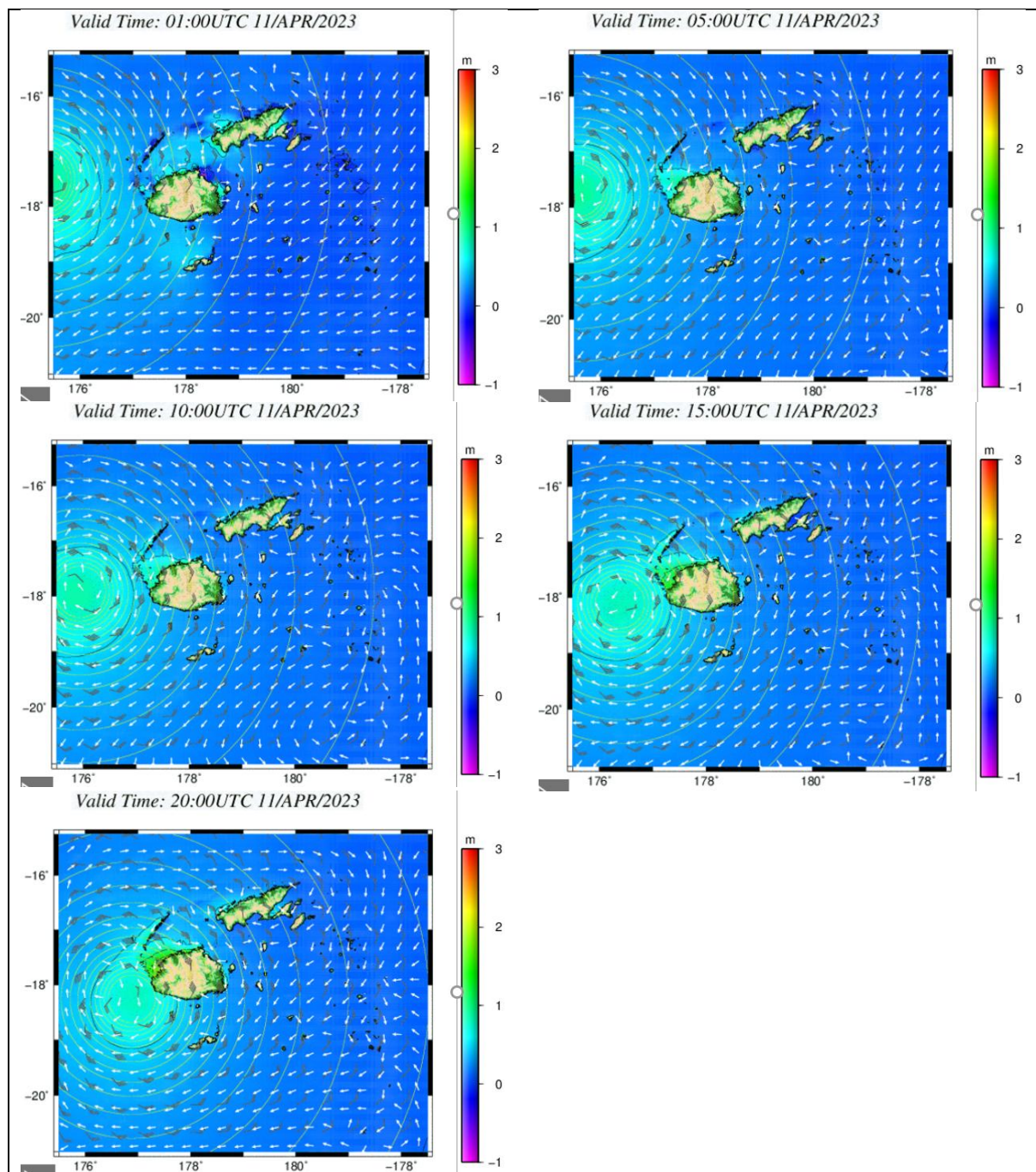
In order to develop a comprehensive understanding of cyclone impacts in Fiji, the sample consider the historical tracks of Cyclone Oscar, Evan, and Winston as representative cyclones. These cyclones have been selected based on their intensity, direction, and impacts on the region. To create scenario cyclones, a parallel shift approach is employed, assuming similar tracks to the selected actual cyclones.

6.2.1 Cyclone Oscar



Source: JICA Expert Team

Figure 6-7 Cyclone Oscar 1983 (930hPa)



Source: JICA Expert Team

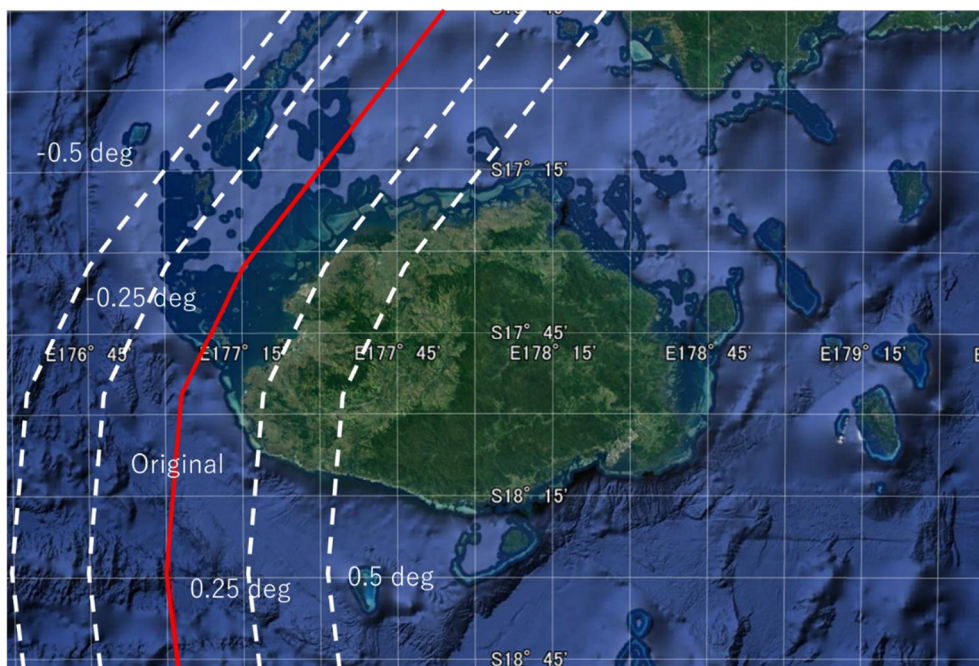
Figure 6-8 Cyclone Oscar storm surge distribution

Cyclone Oscar, which occurred in 1983, is a notable cyclone that impacted Fiji with a minimum central pressure of 930 hPa. Cyclone Oscar exhibited unique characteristics, making it a significant event to analyze within the context of storm surge simulation and risk assessment.

The SSFM-JMA (Storm Surge Forecasting Model by the Japan Meteorological Agency) is employed to study the storm surge generated by Cyclone Oscar.

During Cyclone Oscar, the maximum storm surge height recorded was 1.9 meters at Lautoka, while Nadi experienced a maximum storm surge of 1.75 meters. These measurements represent the peak surge levels observed at these specific locations during the cyclone event.

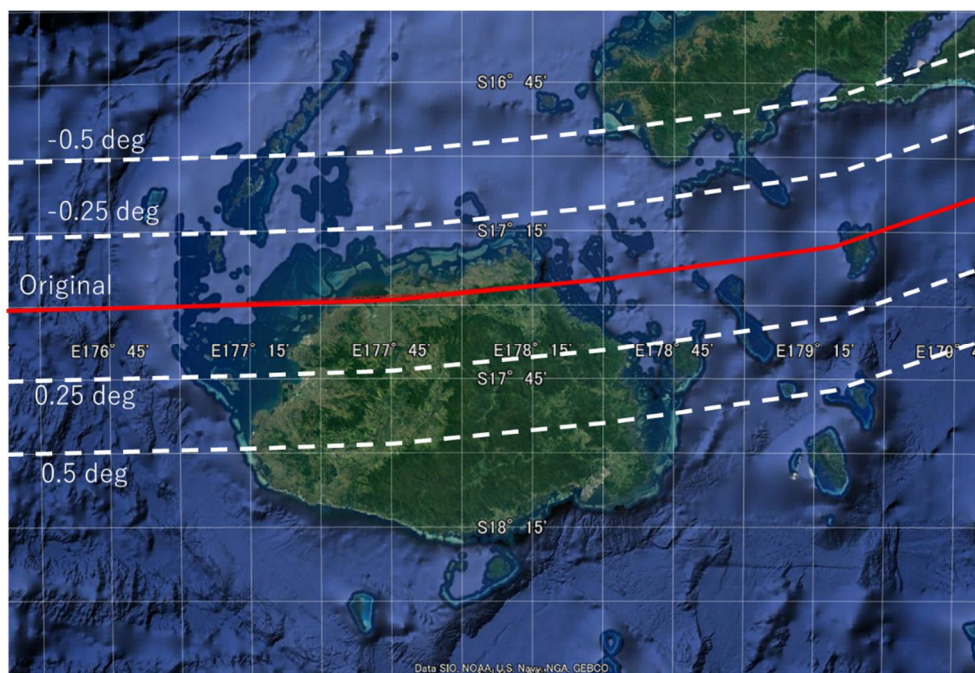
6.2.2 Cyclone Evan



Source: JICA Expert Team

Figure 6-9 Cyclone Evan 2012 (944hPa)

6.2.3 Cyclone Winston



Source: JICA Expert Team

Figure 6-10 Cyclone Winston 2016 (898hPa)

6.2.4 Scenario of cyclones assumed by actual cyclones in Lautoka

To assess the potential impacts of cyclones on storm surge and inundation in the Western Division of Fiji, the guidelines consider three representative cyclone tracks: Cyclone Oscar, Evan, and Winston as stated in Chapter 3 selection of representative cyclone.

In this scenario, the sample incorporate the concept of parallel shift tracks. This approach involves assuming that the cyclone tracks of Cyclone Oscar, Cyclone Evan, and Cyclone Winston are shifted parallel to their original paths while maintaining their intensity characteristics. By employing parallel shift tracks, the guideline enable the assessment of various actual cyclone scenarios, which allows for a comprehensive analysis of storm surge risks.

The figure below presents the potential storm surge heights generated by the selected cyclones across the western division. The storm surge levels depicted in the y-axis of the figure correspond to the maximum surge heights projected at specific locations along the coastline.

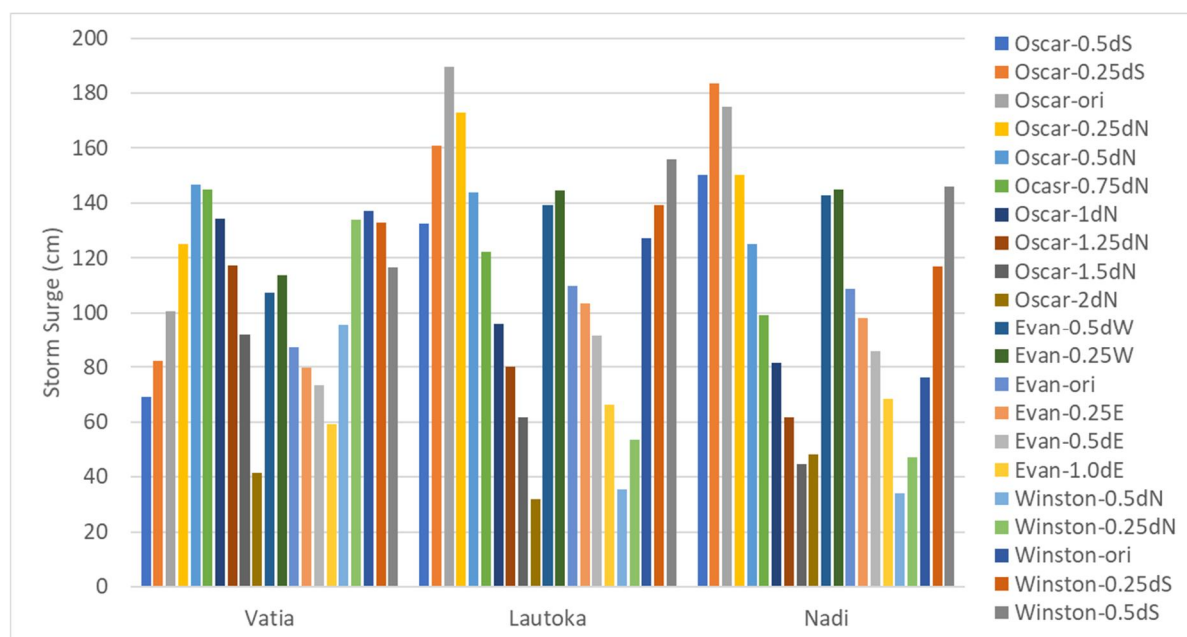


Figure 6-11 Maximum storm surge with several assumed cyclones in the Western division

6.3 Inundation Analysis

At first, the storm surge height at the coastline of Nadi is estimated, followed by setting the target hazard level at the target site. By using the fill level method, storm surge inundation map will be developed.

1. Evaluation of Expected Storm Surge Height at the coastline of Nadi
2. Target Storm Surge Level for Hazard Map
3. Inundation Analysis by Fill Level Method
4. Storm Surge Hazard Map

6.3.1 Evaluation of Expected Storm Surge Height for Western Division

The maximum storm surge height obtained by simulation from the above case studies is as follows:

Table 6-2 Highest Storm Surge Height

No.	Cases	Vatia	Lautoka	Nadi
1	Oscar-0.5dS	69.0	132.6	150.2
2	Oscar-0.25dS	82.4	160.9	183.4
3	Oscar-ori	100.5	189.6	175.1
4	Oscar-0.25dN	124.9	172.9	150.2
5	Oscar-0.5dN	146.9	143.9	125.0
6	Ocasr-0.75dN	144.9	122.3	99.3
7	Oscar-1dN	134.1	96.0	81.4
8	Oscar-1.25dN	117.2	80.0	61.6
9	Oscar-1.5dN	91.8	61.5	44.8
10	Oscar-2dN	41.4	31.7	48.2
11	Evan-0.5dW	107.5	139.3	142.8
12	Evan-0.25W	113.8	144.7	145.1
13	Evan-ori	87.0	109.9	108.9
14	Evan-0.25E	79.8	103.6	98.0
15	Evan-0.5dE	73.2	91.3	85.7
16	Evan-1.0dE	59.3	66.1	68.2
17	Winston-0.5dN	95.6	35.4	34.0
18	Winston-0.25dN	134.1	53.4	47.2
19	Winston-ori	137.1	127.3	76.1
20	Winston-0.25dS	132.9	139.1	117.0
21	Winston-0.5dS	116.5	155.9	146.0
	Maximum	146.9	189.6	183.4

Source: JICA Expert Team

6.3.2 Target Storm Surge Level for Hazard Map

By accumulating the estimated maximum storm surge height obtained by Simulation from the above case studies and highest astronomical tide in Lautoka (MSL + 1.142m), total estimated storm surge elevation of Nadi can be evaluated as follows.

Sites	Maximum Storm Surge Height	Highest Astronomical Tide (HAT) in Lautoka	Total Storm Surge Elevation
Lautoka	1.896m	MSL+1.142m	MSL+3.0m
Nadi	1.834m	MSL+1.142m	MSL+3.0m
Vatia	1.469m	MSL+1.142m	MSL+2.6m

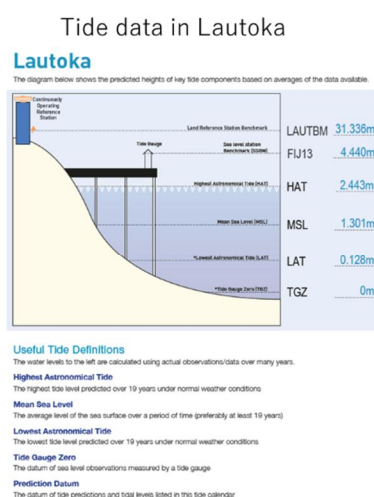
Source: JICA Expert Team

Figure 6-12 Setting target hazard level

6.3.3 Storm Surge Hazard Map of Nadi

Following the estimated maximum storm surge level (target level for hazard map), inundation analysis is performed by Fill Level Method to access the inundated area or depth of the target zones in the present project.

The resulting inundated area or depth can be integrated with LiDAR and SRTM-derived digital elevation model (DEMs) to generate hazard maps with the indication of the inundation depth. The followings are the Storm Surge Hazard Map created by LiDAR and SRTM data for North and South zone of Nadi.



(1) Storm Surge Hazard Map (Nadi) by LiDAR data

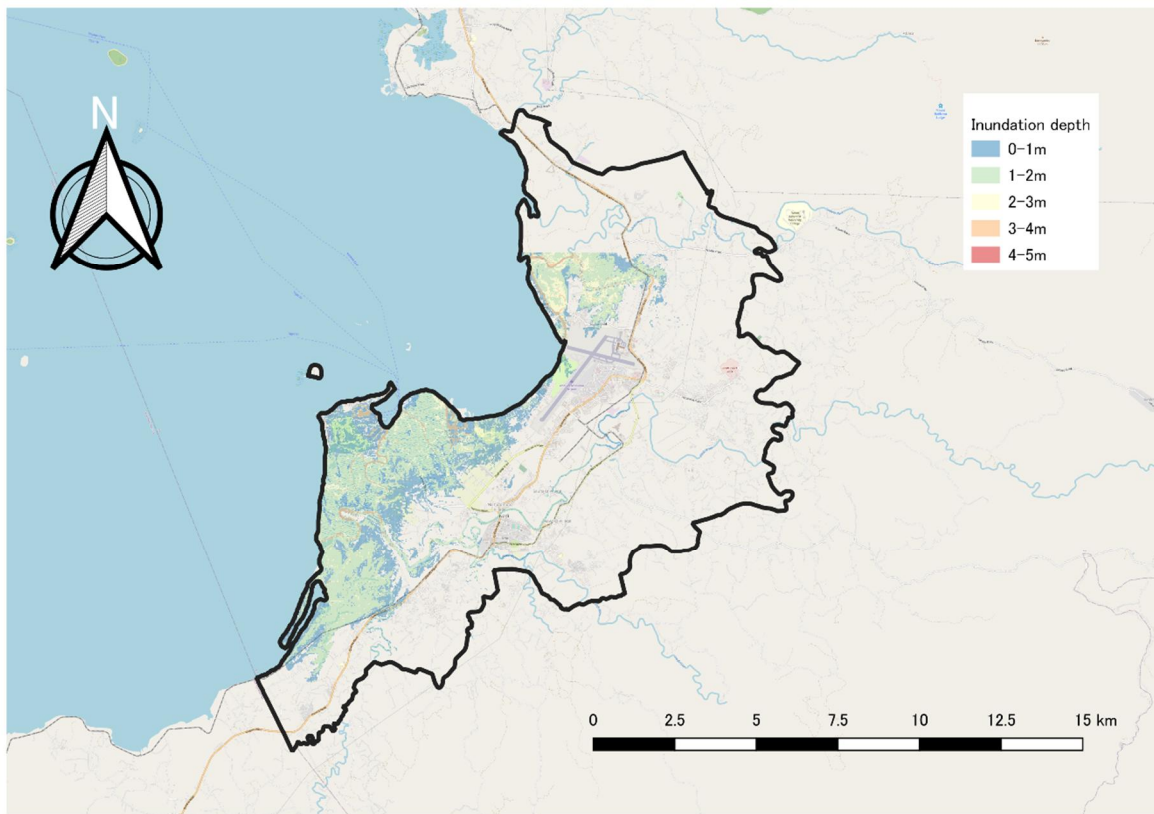


Figure 6-13 Storm surge Hazard Map (Nadi)- LiDAR Data

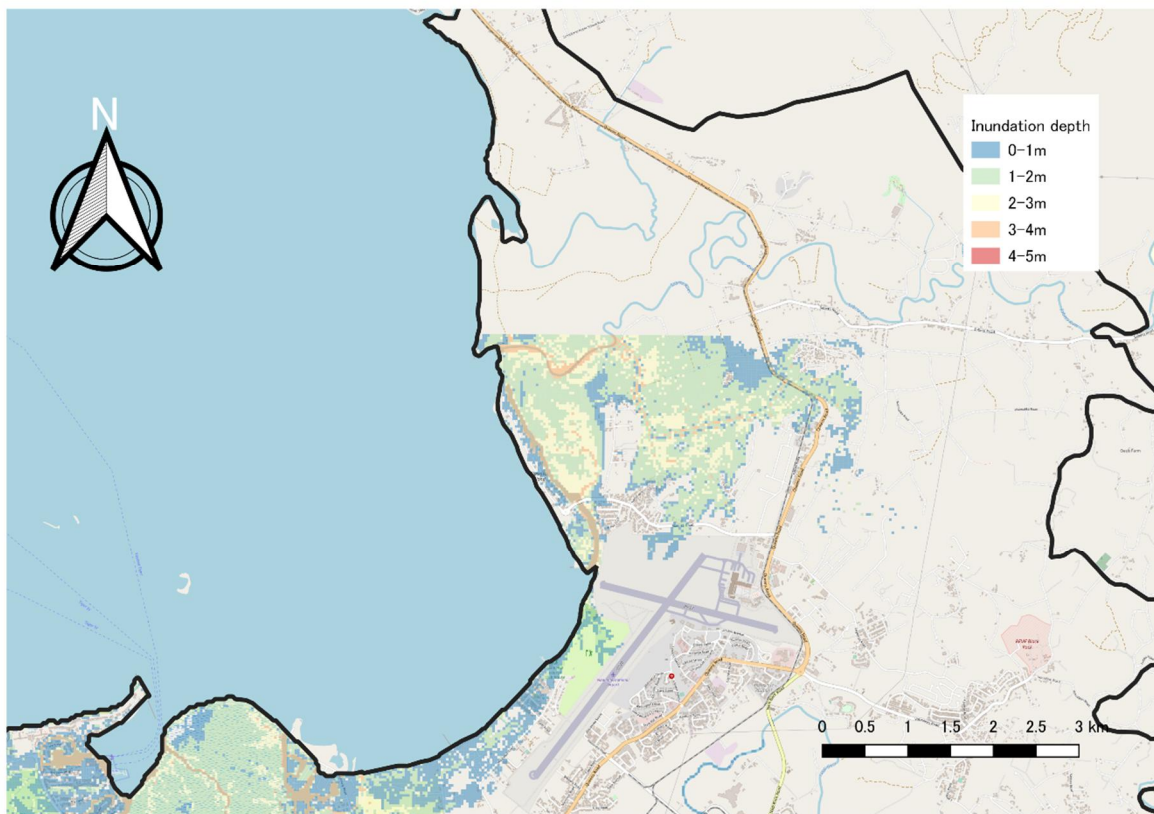


Figure 6-14 Storm surge Hazard Map (Nadi)- LiDAR Data (North)

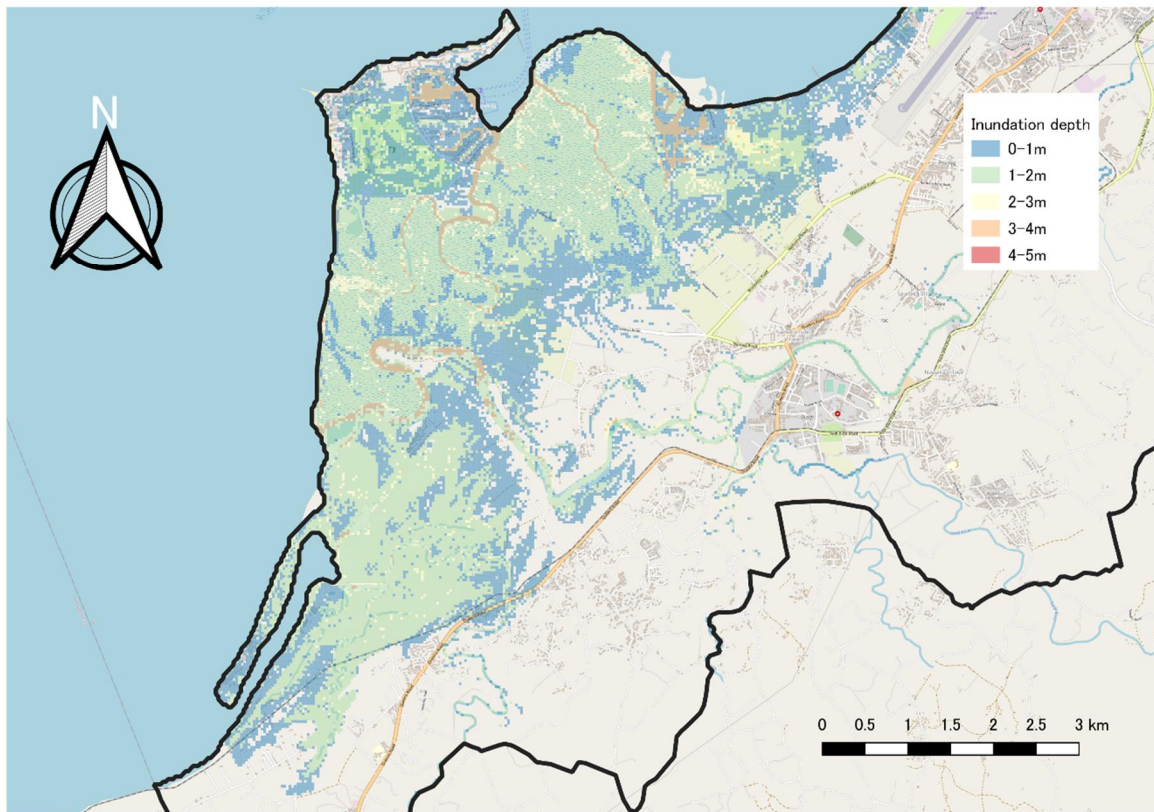


Figure 6-15 Storm surge Hazard Map (Nadi) – LiDAR data (South)

(2) Storm surge Hazard Map (Nadi) by SRTM data

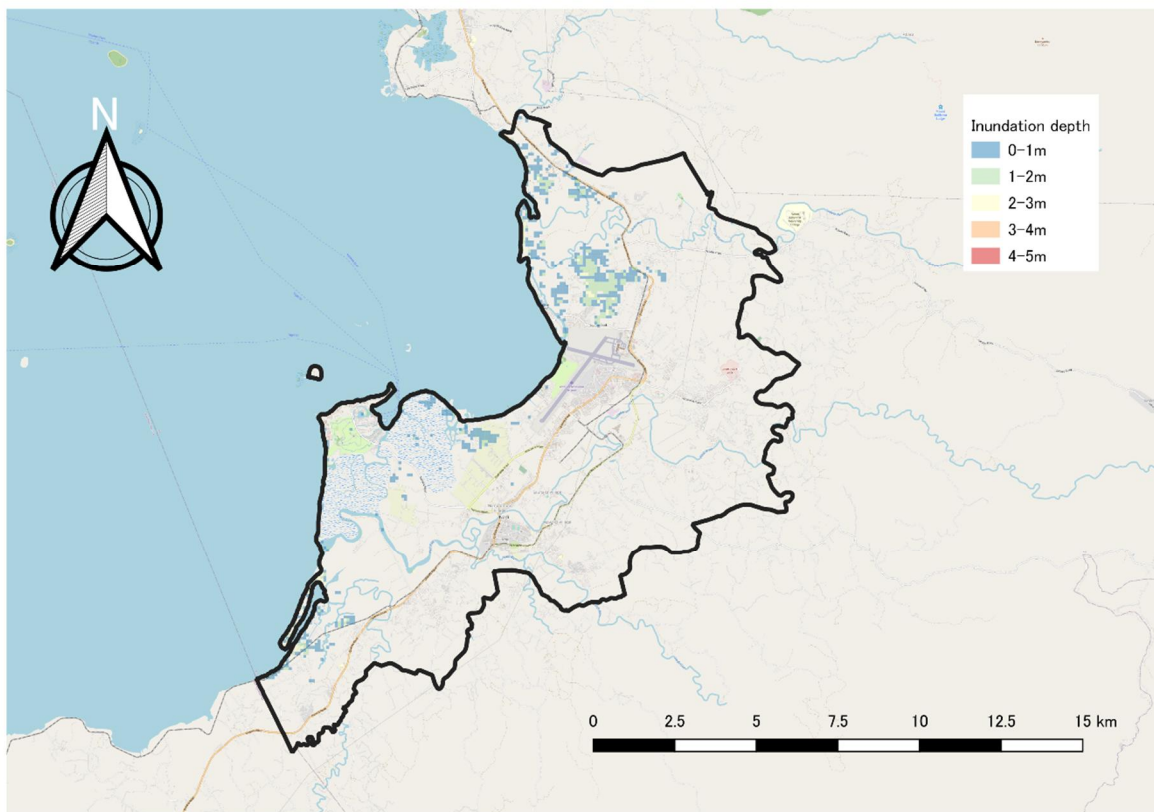


Figure 6-16 Storm surge Hazard Map (Nadi) – SRTM data

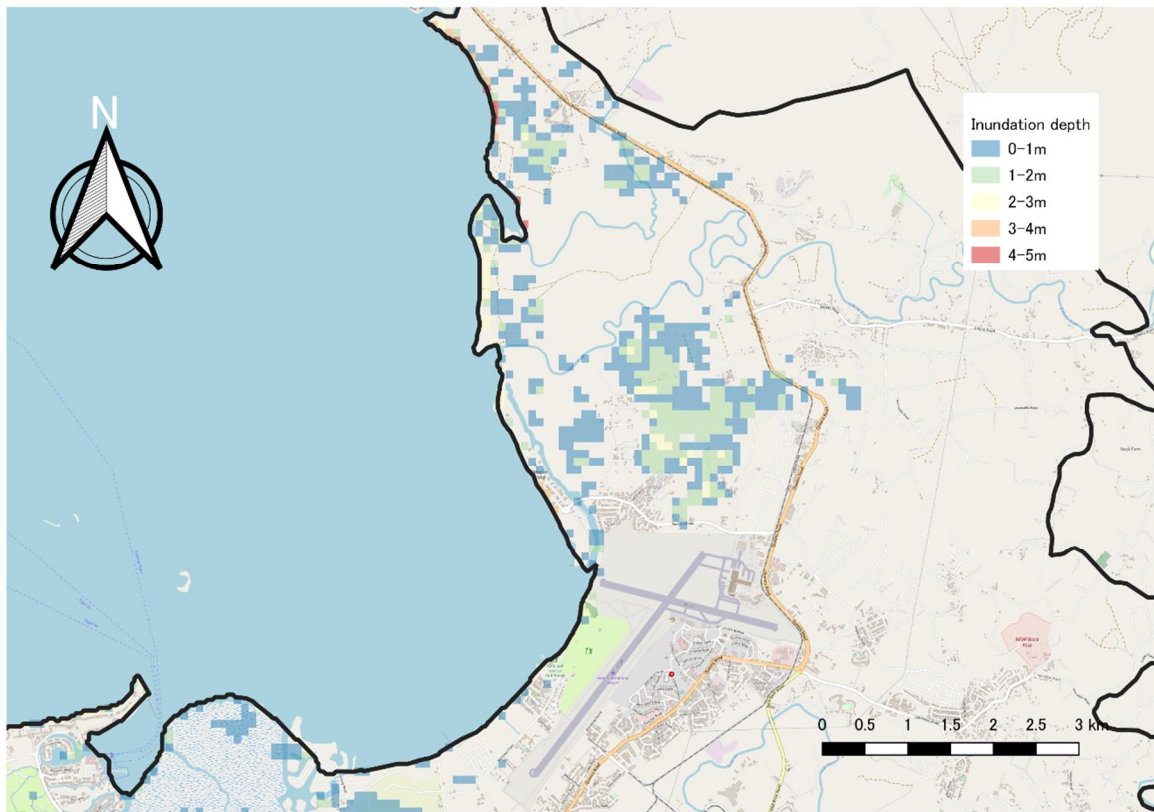


Figure 6-17 Storm surge Hazard Map (Nadi) – SRTM (North)

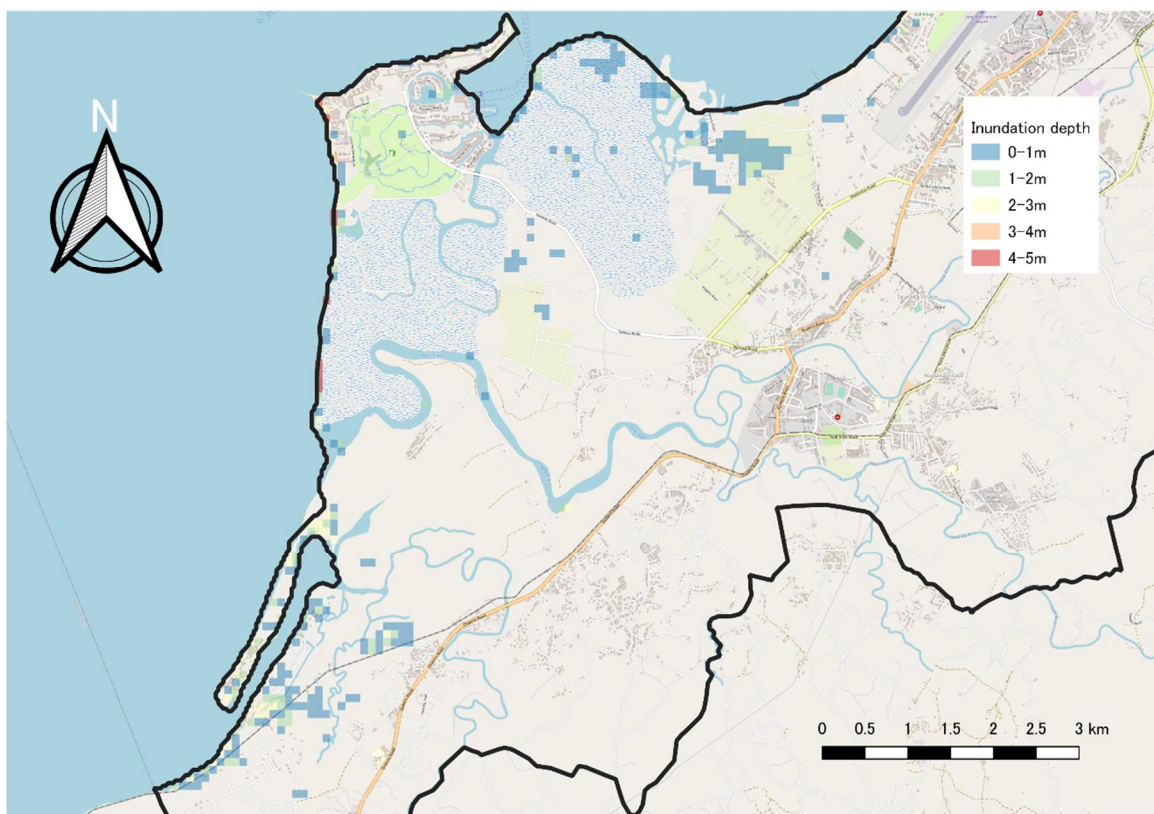


Figure 6-18 Storm surge Hazard Map (Nadi) – SRTM (South)

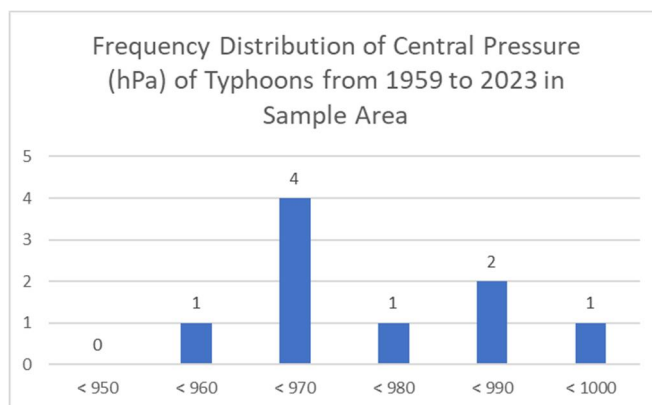
Chapter 7. Case Study in Suva

7.1 Selection of Representative Cyclone

7.1.1 Data Analysis

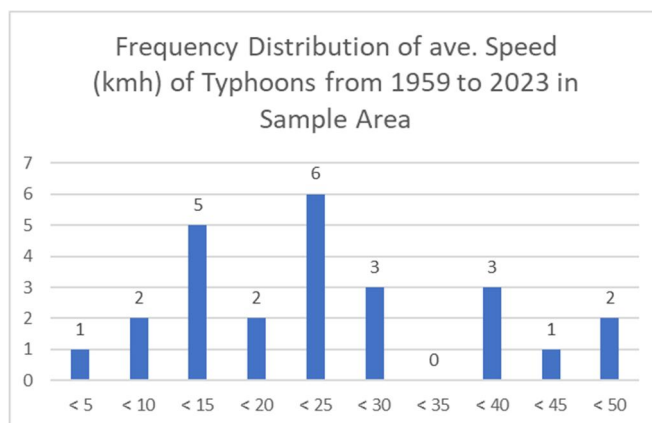
As detailed in Chapter 6, the first step involves analyzing the collected data on tropical cyclones to derive meaningful insights. The methodology includes examining various parameters such as minimum central pressure, velocity, and direction to understand cyclone behavior and impacts. The results specific to Suva are discussed below.

Histograms were plotted to visualize the distribution of these parameters, providing insights into their behavior over time. The histograms created for Suva are shown below.



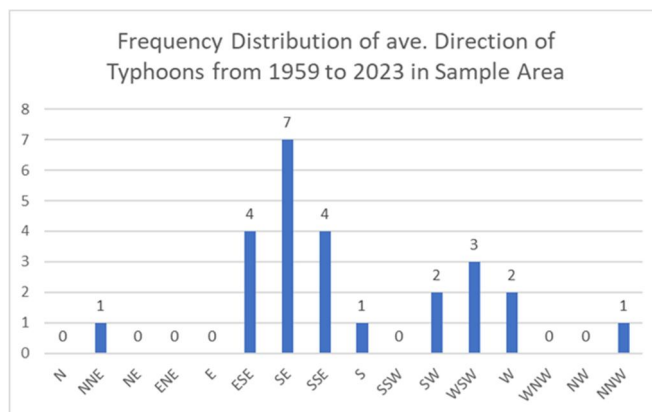
Source: Created by JICA Expert Team based on NOAA IBTrACS

Figure 7-1 Minimum central pressure of tropical cyclones in Suva from 1959 to 2023



Source: Created by JICA Expert Team based on NOAA IBTrACS

Figure 7-2 Ave. Speed of tropical cyclones in Suva from 1959 to 2023



Source: Created by JICA Expert Team based on NOAA IBTrACS

Figure 7-3 Moving direction of tropical cyclones in Suva from 1959 to 2023

In addition, the latitude and longitude of the tropical cyclones were plotted to investigate their tracks. Similar to Lautoka, the tracks in Suva were analyzed based on the average direction of typhoons. The typhoon track maps are shown below.



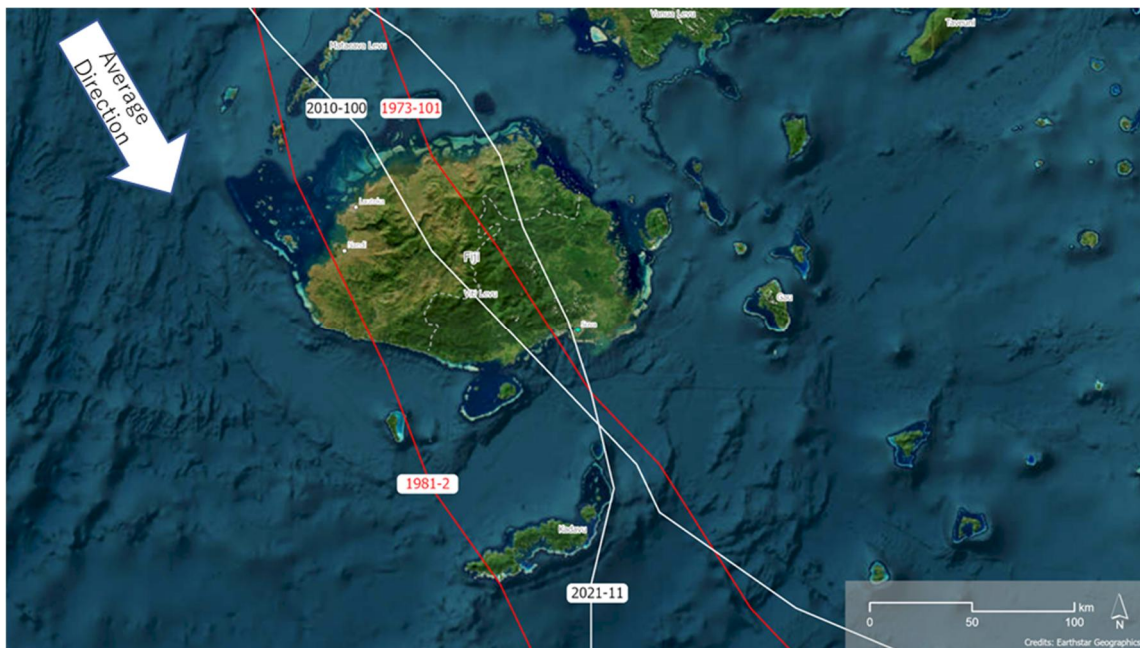
Source: Created by JICA Expert Team based on NOAA IBTrACS

Figure 7-4 Tropical cyclones moving westward in Suva from 1959 to 2023



Source: Created by JICA Expert Team based on NOAA IBTrACS

Figure 7-5 Tropical cyclones moving eastward in Suva from 1959 to 2023



Source: Created by JICA Expert Team based on NOAA IBTrACS

Figure 7-6 Tropical cyclones moving southward in Suva from 1959 to 202

The analysis of tropical cyclones for Suva follows the same principles described for Lautoka, providing a basis for understanding trends and behaviors specific to the Suva area. These insights contribute to further research, risk assessment, and decision-making in cyclone-prone regions.

7.1.2 Setting criteria for representative tropical cyclone

Using the criteria-setting process outlined in Chapter 6, the selection of a representative tropical cyclone for Suva involves the following steps:

- Thorough examination of historical data on tropical cyclones in Suva or similar regions.
- Analysis of past storm surge events, their impacts, and associated cyclone characteristics.
- Identification of recurring patterns, critical variables, and parameters that significantly influence storm surge and inundation.
- Prioritization of factors with a strong correlation to past surge events or significant coastal impacts.
- Assessment of the availability and quality of data for the identified parameters to ensure sufficient reliability for selected cyclone candidates.

7.1.3 Evaluation

Following the criteria established in Chapter 6, the identified cyclone candidates for Suva were evaluated to ensure they meet the desired objectives and accurately represent the behavior and characteristics of cyclones in this study area.

7.1.4 Selecting the representative tropical cyclone

After evaluating the potential candidates based on the established criteria, the final step is to select the representative tropical cyclone that best reflects the typical behavior and characteristics of cyclones in the study area.

As for the sample case in Suve, three tropical cyclones are chosen as representative aiming to select a low central pressure typhoon from each cyclone track direction which is shown in the table below.

Table 7-1 Representative tropical cyclones selected in Lautoka

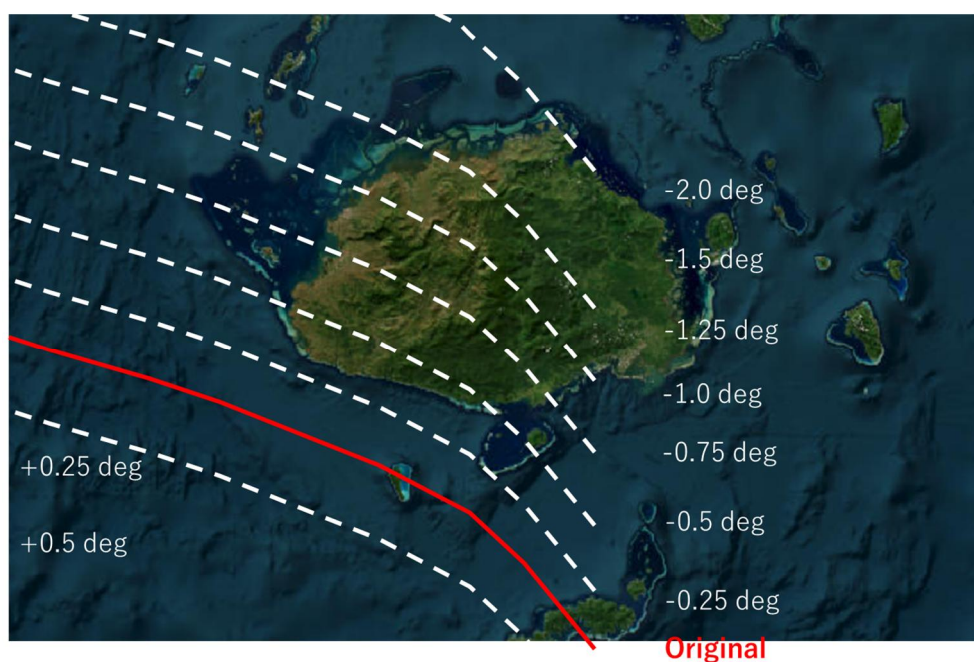
Tropical Cyclone Name	Date Occurred	Min. Central Pressure (hPa)	Direction
Oscar	February 1983	930	ESE
Ana	January 2021	975	SSE
Winston	February 2016	898	W

Source: JICA Expert Team

7.2 Storm Surge Simulation

For the Suva area, the scenario simulations apply the parallel shift approach, assuming the cyclone tracks of Cyclone Oscar, Ana, and Winston are shifted parallel to their original paths while maintaining their respective intensity characteristics. This method allows for an in-depth analysis of storm surge risks and potential inundation levels specific to Suva and its surrounding coastal areas.

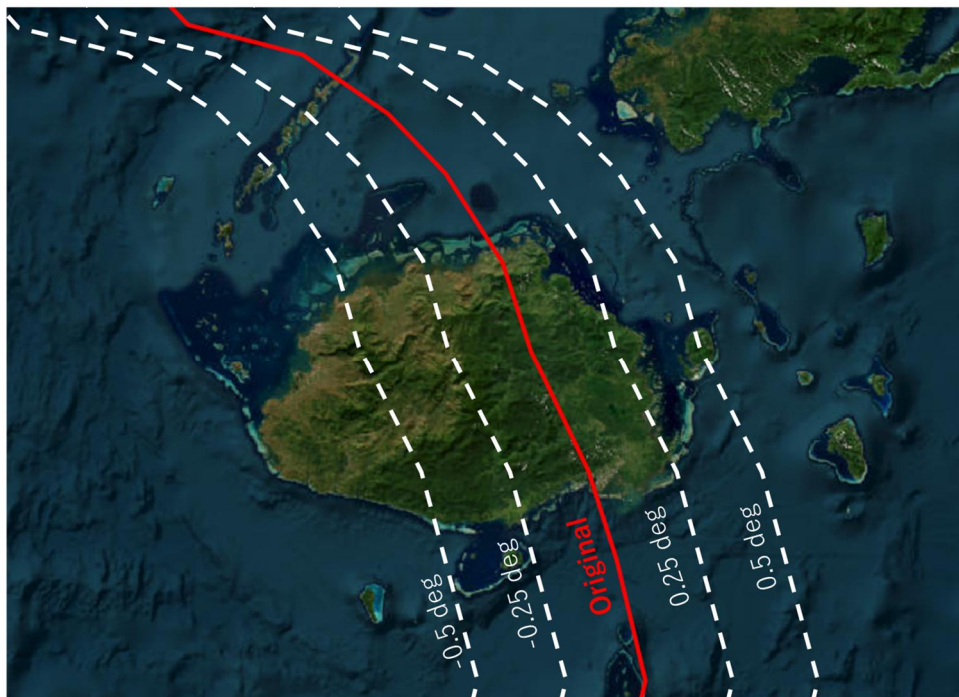
7.2.1 Cyclone Oscar



Source: JICA Expert Team

Figure 7-7 Cyclone Oscar 1983 (930hPa)

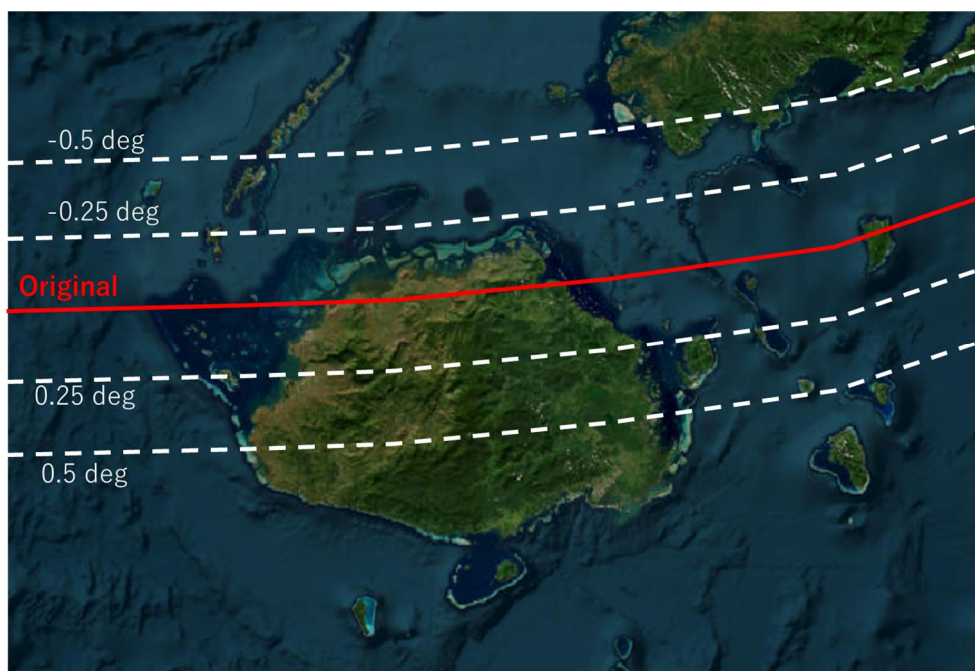
7.2.2 Cyclone Ana



Source: JICA Expert Team

Figure 7-8 Cyclone Ana 2021 (975hPa)

7.2.3 Cyclone Winston



Source: JICA Expert Team

Figure 7-9 Cyclone Winston 2016 (898hPa)

7.2.4 Scenario of cyclones assumed by actual cyclones in Central Division

For Suva, the same representative cyclone tracks—Cyclone Oscar, Cyclone Ana, and Cyclone Winston—were used to assess potential storm surge and inundation. Using the parallel shift approach, the analysis estimated maximum storm surge heights for each scenario.

The figure below shows the projected maximum storm surge heights along the Suva coastline for each cyclone scenario with 1.23m being the highest from the case of 0.75 degree south of the original Winston track.

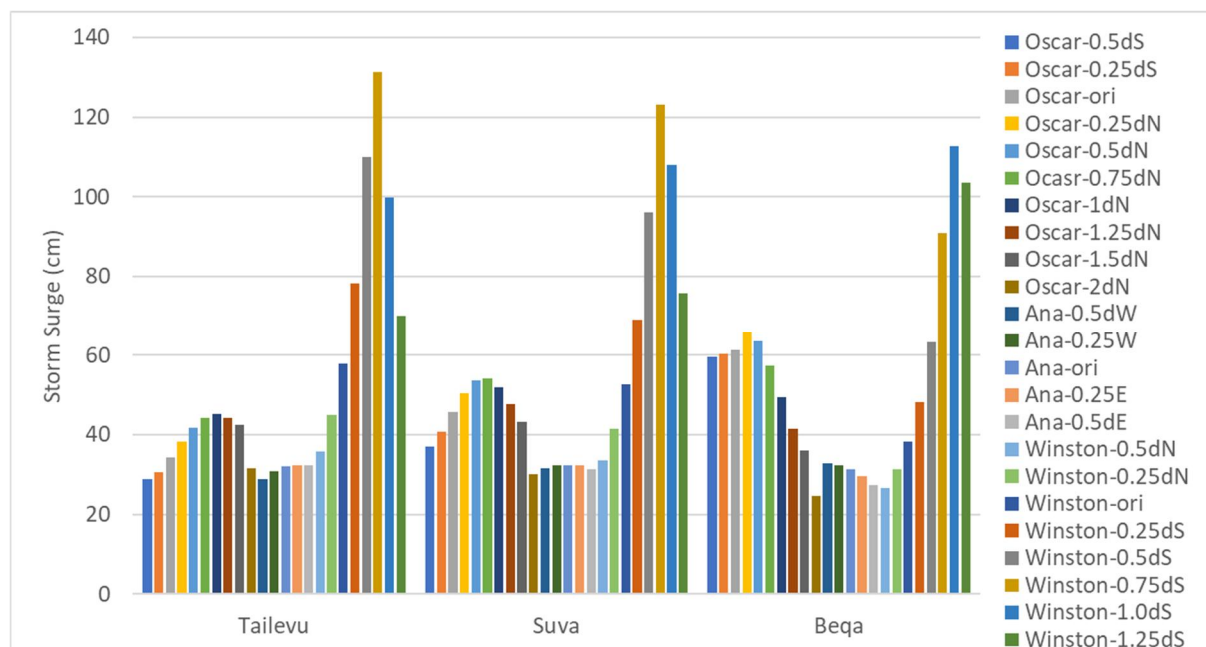


Figure 7-10 Maximum storm surge with several assumed cyclones in Central Division

7.3 Inundation Analysis

Similar to the analysis conducted for Lautoka, the storm surge height at the coastline of Suva was estimated, and the target hazard level was set accordingly. The Fill Level Method was applied to develop the storm surge inundation map for Suva.

1. Evaluation of Expected Storm Surge Height at the coastline of Nadi
2. Target Storm Surge Level for Hazard Map
3. Inundation Analysis by Fill Level Method
4. Storm Surge Hazard Map

7.3.1 Evaluation of Expected Storm Surge Height for Central Division

The maximum storm surge heights obtained from the simulations for Suva are summarized below:

Table 7-2 Highest Storm Surge Height

		Tailevu	Suva	Beqa
1	Oscar-0.5dS	29	37	60
2	Oscar-0.25dS	31	41	60
3	Oscar-ori	34	46	61
4	Oscar-0.25dN	38	50	66
5	Oscar-0.5dN	42	54	64
6	Ocasr-0.75dN	44	54	57
7	Oscar-1dN	45	52	50
8	Oscar-1.25dN	44	48	42
9	Oscar-1.5dN	42	43	36
10	Oscar-2dN	32	30	25
11	Ana-0.5dW	29	32	33
12	Ana-0.25W	31	32	32
13	Ana-ori	32	32	31
14	Ana-0.25E	32	32	29
15	Ana-0.5dE	32	31	27
16	Winston-0.5dN	36	34	27
17	Winston-0.25dN	45	42	31
18	Winston-ori	58	53	38
19	Winston-0.25dS	78	69	48
20	Winston-0.5dS	110	96	63
21	Winston-0.75dS	131	123	91
22	Winston-1.0dS	100	108	113
23	Winston-1.25dS	70	76	104
	Maximum	131	123	113

Source: JICA Expert Team

7.3.2 Target Storm Surge Level for Hazard Map

By combining the simulated maximum storm surge heights with the highest astronomical tide at each location, the target hazard levels were set as shown below.

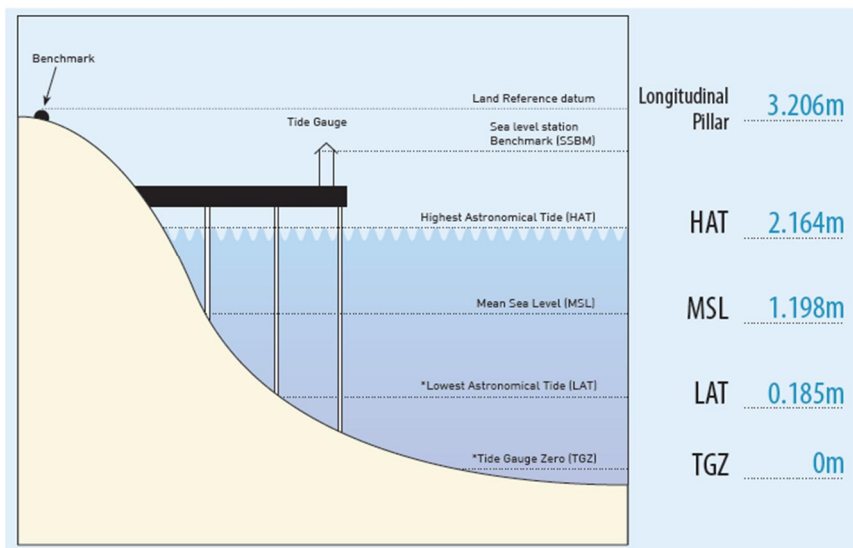
Table 7-3 Storm Surge Water Level with Highest Astronomical Tide

Sites	Maximum Storm Surge Height	Highest Astronomical Tide (HAT) in Suva	Total Storm Surge Elevation
Tailevu	1.314m	MSL+0.966m	MSL+2.3m
Suva	1.232m	MSL+0.966m	MSL+2.2m
Beqa	1.128m	MSL+0.966m	MSL+2.1m

Source: JICA Expert Team

Suva

The diagram below shows the predicted heights of key tide components based on averages of the data available.



Useful Tide Definitions

The water levels to the left are calculated using actual observations/data over many years.

Highest Astronomical Tide

The highest tide level predicted over 19 years under normal weather conditions

Mean Sea Level

The average level of the sea surface over a period of time (preferably at least 19 years)

Lowest Astronomical Tide

The lowest tide level predicted over 19 years under normal weather conditions

Tide Gauge Zero

The datum of sea level observations measured by a tide gauge

Prediction Datum

The datum of tide predictions and tidal levels listed in this tide calendar

Figure 7-11 Tide Data in Suva

Source: JICA Expert Team

7.3.3 Storm Surge Hazard Map of Suva

Using the target hazard levels, inundation analyses were performed. The resulting hazard maps were created



Figure 7-12 Storm surge Hazard Map (Suva)

Chapter 8. Way Forward

8.1 Storm Surge Simulation

This guideline provides a method for conducting storm surge simulations, which involves modeling the behavior and impact of storm surges of actual typhoons in Fiji. This involves using advanced computational models and historical data to simulate the behavior of storm surges based on factors such as wind speed, atmospheric pressure, and coastal topography. By simulating different scenarios, the relevant organizations can better understand the potential magnitude and extent of storm surges, enabling them to develop more effective evacuation plans and response strategies.

8.2 Inundation Analysis

This guideline outline procedures for conducting inundation analysis, which involves assessing the areas at risk of flooding due to storm surges. This analysis considers factors such as coastal topography, land elevation, and the potential impact of storm surge. By conducting inundation analysis, the relevant organizations can identify vulnerable coastal areas and prioritize their efforts in terms of evacuation planning, infrastructure development, and the allocation of resources for disaster response. The methodology of inundation analysis used in this guideline is relatively simple for the organizations. In the future, more accurate simulations are needed for better understanding storm surge hazard and risk.

8.3 Risk Analysis

This guideline does not include risk analysis because the risk analysis is the same as that of the simplified assessment. This analysis will take into account factors such as the vulnerability of coastal communities, the exposure of critical infrastructure, and the potential economic and social impacts of storm surge-related disasters in the future. The results of risk analysis should be shared with the relevant organisations such as FMS, NDRMO and others for better disaster risk management.