Chapter 8 Comprehensive Sediment Management

8.1 Objectives and Flow of Sediment Transport Analysis

In this chapter, the sediment transport of the Nadi River is investigated and studied from the point of view of understanding the current situation.

It is particularly important to understand the amount of suspended sediment such as sand and silt which form the beach. The suspended sediment is estimated to be mainly produced from the surface erosion in the upstream and middle stream basin.

Therefore, we conducted a field research to understand the present state of the outflow of suspended sediment, and the bed variation analysis was performed using the flow analysis model and river sections which were surveyed in this project. Then, based on the analysis results, we calculated the sediment discharge of the river mouth at present and future situation in the river.

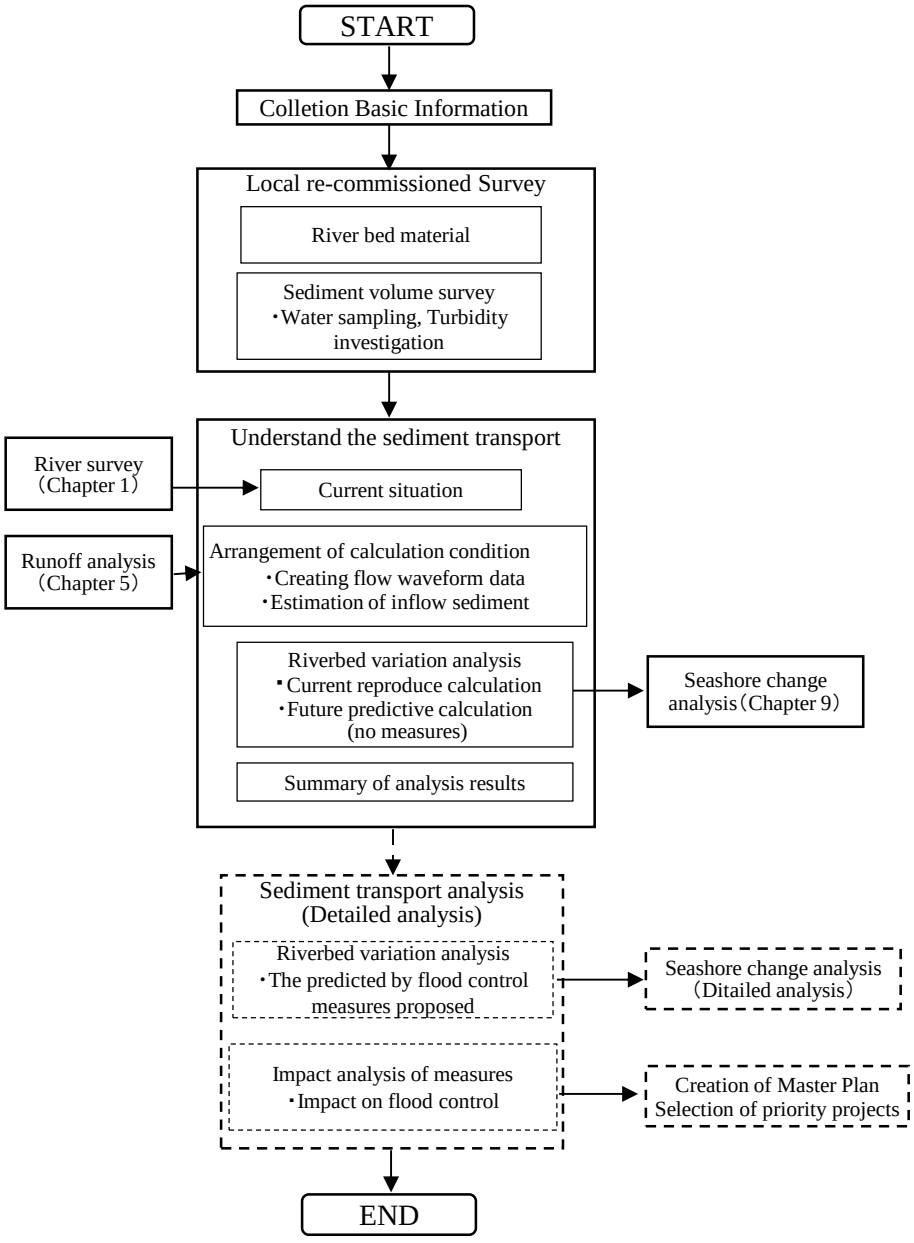

Figure 8-1 Work Flow of Sediment Transport

8.2 Sediment Transport Analysis

8.2.1 Future Prediction Calculation

The results of future prediction calculation are shown in the Figure 8-2. According to these figures and the table the followings are found out.

<Riverbed Fluctuation of Downstream Section>

- The degradation of riverbed in 1m is recognized in the distance post 0 to 4km. This seems to be due to the reason that the special sediment accumulation mechanism in the river mouth is difficult to be considered technically in this model as described in the preceding section of reproduction calculation. In fact, the deposition of the clay and silt component is presumed to be promoted by the waves and chemical action of salt water.
- Except above phenomena the riverbed is relatively stable though the partial upgrade and downgrade of riverbed within about 1m is recognized according to progress of years.

<Riverbed Fluctuation of Middle Stream Section>

- Although the sediment accumulation tendency is recognized slightly in the downstream of the confluence of Namosi River, the middle stream section seems to be also relatively stable within the riverbed variation of 1m.

<Sediment Discharge Load>

- In the future prediction the total volume of clay, silt and fine sand from the main stream and tributaries is 110,000m^3/year and 26,000 m^3/year respectively of which ratio is 4: 1. If there will be no big change in condition of the land use and the meteorology in the Nadi basin, the almost same amount of sediment load will be yielded in future.

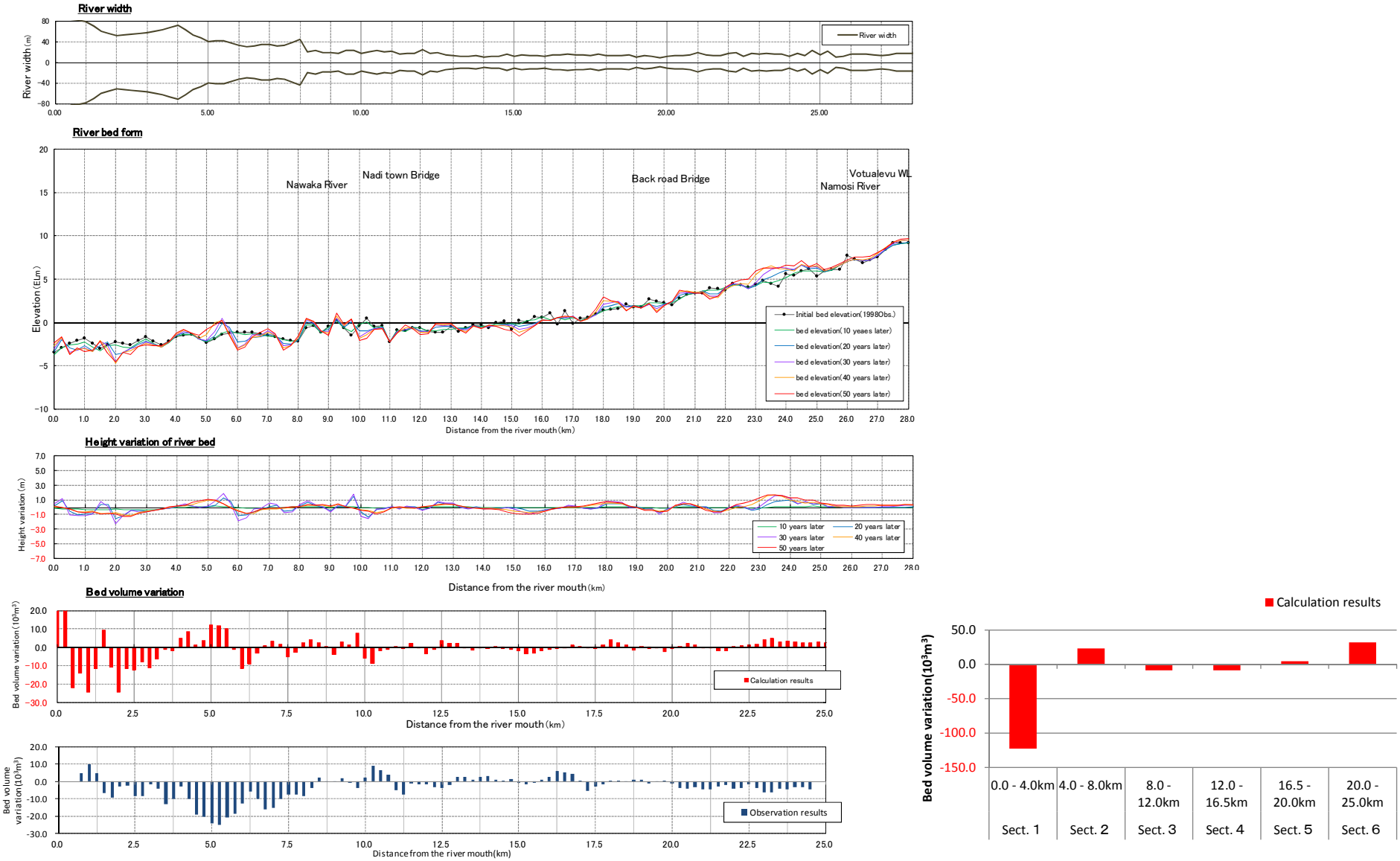

Figure 8-2 Future Prediction (without Flood Control Structures in Nadi main stream)

8.2.2 Summary of Examination Results

The results of this examination are described as shown below.

- It is considered that the riverbed is relatively stable. In the current situation, riverbed decrease in midstream portion is around 1m. In addition, the riverbed of downstream portion in the 4km to 8km interval is decreased 1 to 2m by river dredging which is carried out in 2008-2012 (a total of 1,651 thousand m^3). It should be noted in 0km to 4km interval, the riverbed height is same level of 1998, it is presumed the clay-silt have been redeposit after dredging.
- By reproduce results of the riverbed variation calculation from 1998 to 2014, the sediment runoff at the river mouth is 160 thousand m^3/year, and the particle size is approximately 0.2mm or less of clay, silt, fine sand. These silt and fine sand is considered to form the current beach around the river mouth.
- The results of the prediction calculation in future 50 years shows there is not particular large change of the riverbed topography in the case of not performing the flood control project. The current riverbed is stable and the outflow and inflow of sediment are balanced. Also, the sediment runoff from river mouth has become somewhat less sediment volume than the 139 thousand m3/year of current state.

8.3 Examination of Influence of Flood Control Structures and Mitigation Works

The riverbed fluctuation of selected flood control structures, River Improvement, M-1, was predicted by one-dimensional riverbed fluctuation analysis for 50 years which is equal period to the design period of flood control master plan. And compared with the case without flood control structure, the influence of the River Improvement is extracted and the examination of mitigation works to the influence was examined.

8.3.1 Results of Prediction of Influence of Flood Control Structures and Mitigation Works

The results of prediction are as shown in Figure 8-3, according to which the followings are found out.

<Riverbed Fluctuation of Downstream Section>

- The excavation scale of river channel in the section 0 to 5km is less than the upstream of 5 km. The degradation of riverbed in 1m is recognized in the distance post 0 to 5km. As described in the section 9.3.7, this is the limit of the this model to analyze in detail. In fact, the deposition of the clay and silt component is presumed to be promoted by the waves and chemical action of salt water.
- In the section 5 to 10km, the river channel is enlarged, however the river bed topography has no significant change and seems to be stable.

<Riverbed Fluctuation of Middle Stream Section>

- In the middle stream, the riverbed is lowered in the section upstream of river channel excavation (enlarged) section. This is estimated that due to the lowering of flood water level, the water level in the upstream non-improved section decreases and the velocity of flood discharge increases so that the riverbed degradation is progressed. The degradation section is in 19k to 21k, and maximum lowering depth is approximately 2m. The extent of this influence is examined the next section.

<Sediment Discharge Load>

- In the Countermeasures prediction the total volume of clay, silt and fine sand from the main stream and tributaries (Nawaka River and Malakua Rivers is 110,000m^3/year and 10,000m^3/year respectively. If there will be no big change in conditions of the land use and the meteorology in the Nadi River basin, the almost same amount of sediment load will be yielded in future.
- In the Countermeasures, the retarding basins are planned. According predication calculation, approximately 1,000m^3/year of sediment with particle of clay to medium sand will be trapped in the basins.

8.3.2 Influence Analysis of Countermeasures

Compared the prediction results of the case with Countermeasures with the case without Countermeasures, the influence of the Countermeasures is analyzed in quantities.

(1) Influence on Flood Control

The prediction of the case with countermeasures and the case without countermeasures after 50 years is compared. The results of comparison from the points of view of the average height of riverbed and the variation of riverbed height are as shown in Figure 8-4.

The general influences on flood control are reduce of discharge capacity by the aggradation of riverbed and the influence on flood control facilities such as destruction of bank protection. From the Figure 8-4, the degradation in the section 19k to 23k and the accumulation of sand with fine particles (aggradation of riverbed) are observed as relatively remarkable phenomena so that the influence on flood control of such phenomena are examined.

(i) Riverbed Degradation

The riverbed degradation occurs in relatively wide range in the section 19k to 23k. The maximum average degradation of riverbed is predicted approximately 2 m in 50 years. The maximum depth will be more than this figure which may cause some influence on flood control structures in future. However the degradation will not occur uniformly in all the section. Since the reverbed degradation will progress gradually from the easily erodible section, the necessity of urgent counter measure is likely to be low.

(ii) Riverbed Aggradation

The riverbed aggradation may occur in the section 0k to 5k. Although there is no difference in the variation of riverbed height in the both cases with and without Countermeasures, the dredging work was implemented in this section in the past.

Compared the passing sediment discharge at the river mouth with the both cases, they are 139 x 10^3 m^3/year in the case without Countermeasures and 138 x 10^3 m^3/year in the case with Countermeasures which means the Countermeasures will not contribute to the increase of sediment discharge. Therefore the dredging in the section of river mouth is not considered necessary for the influence of the countermeasures.

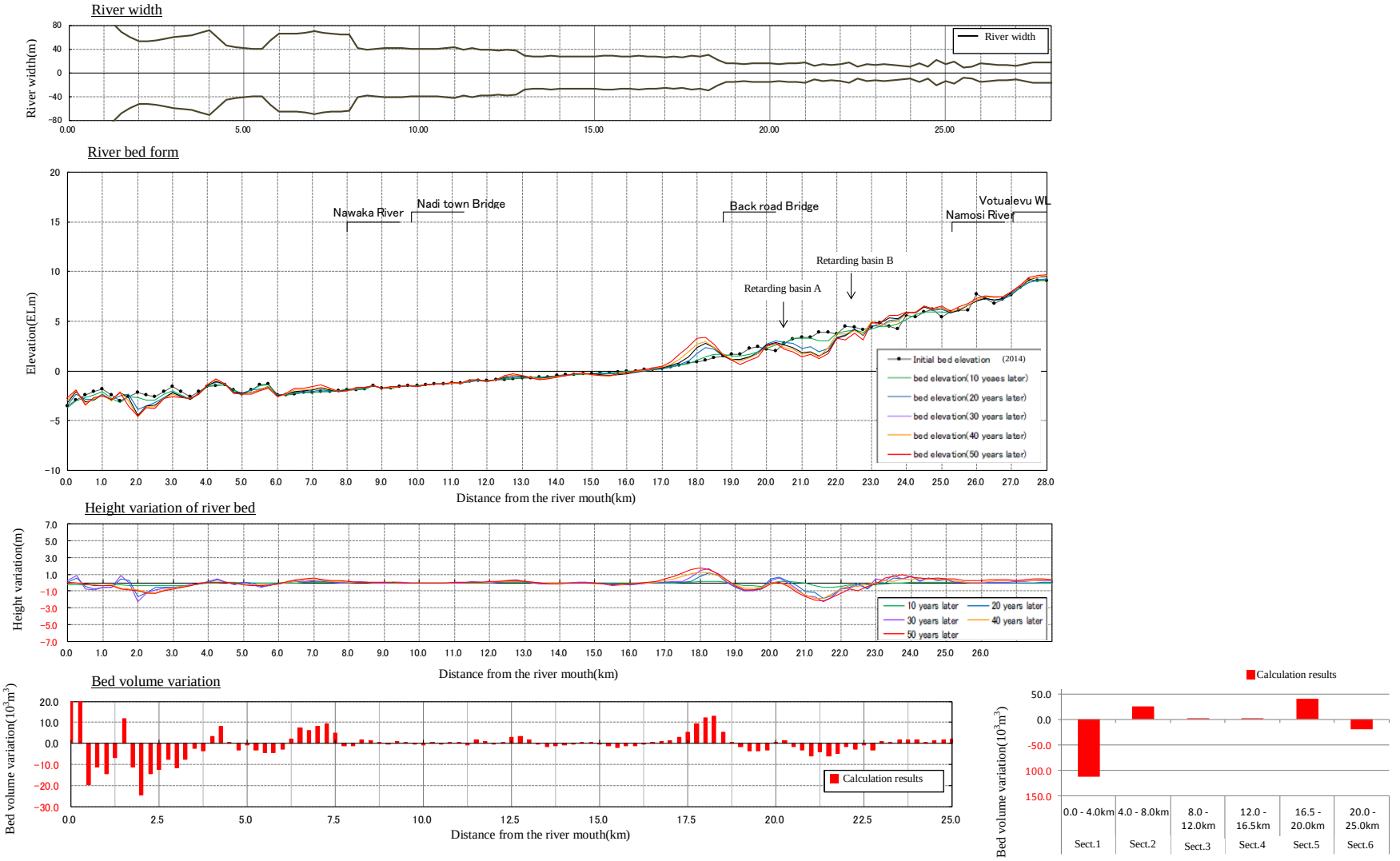

Figure 8-3 Prediction Results with Countermeasures: Nadi main stream

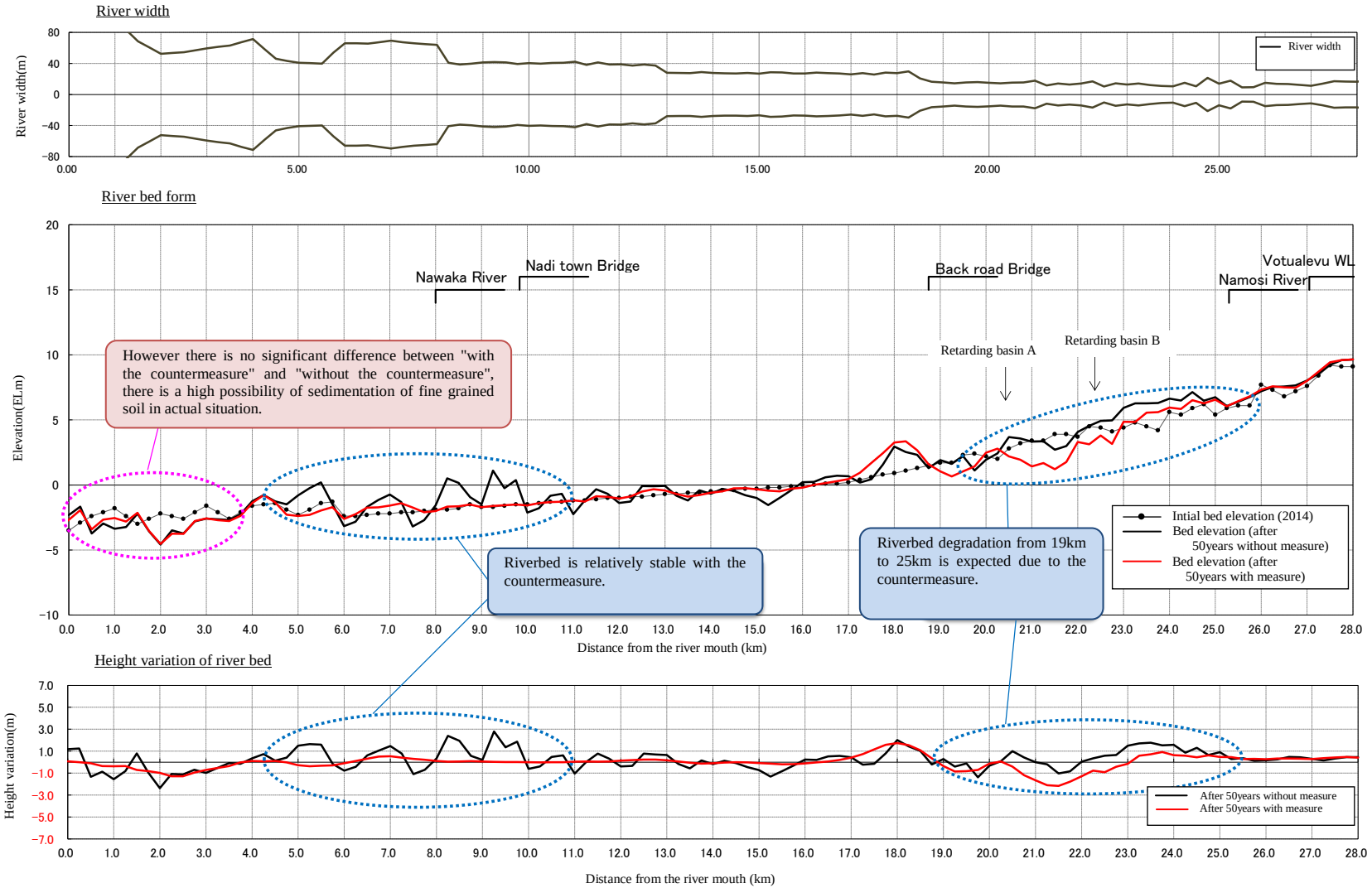

Figure 8-4 Comparison of Riverbed Change in Both Cases with and without Countermeasures

8.3.3 Examination of Mitigation Works

Based on the influence analysis of flood control Countermeasures, the problematic locations are identified and the necessity of mitigation works is considered, then the mitigation Countermeasures in future is examined

(1) Identification of Problematic Location

According to the influence analysis of Countermeasures, the relatively remarkable influence is found out in the riverbed degradation section from 19k to 23k. The reason is due to variation of flood flow conditions caused by the river channel enlargement, of which phenomena possibly occur qualitatively as generating mechanism.

(2) Necessity of Mitigation Works

The necessity of mitigation works is examined on the riverbed degradation section identified in the clause above.

The situation of riverbed degradation is confirmed referring to the results of riverbed fluctuation analysis as shown below (refer to Figure 8-5):

- ✓ The degradation of riverbed will occur approximately by 1m in the section around 22k after 10 years of completion of Countermeasures.
- ✓ The degradation will be extended toward the downstream of 22k and the deep scouring will reach approximately 2 m after 20 years of completion of Countermeasures.
- ✓ The scale of riverbed degradation section will be almost stable after 30 years of completion of Countermeasures.

According to the above the riverbed degradation is not a type in which the phenomena will not occur in short period but gradually occur and develop.

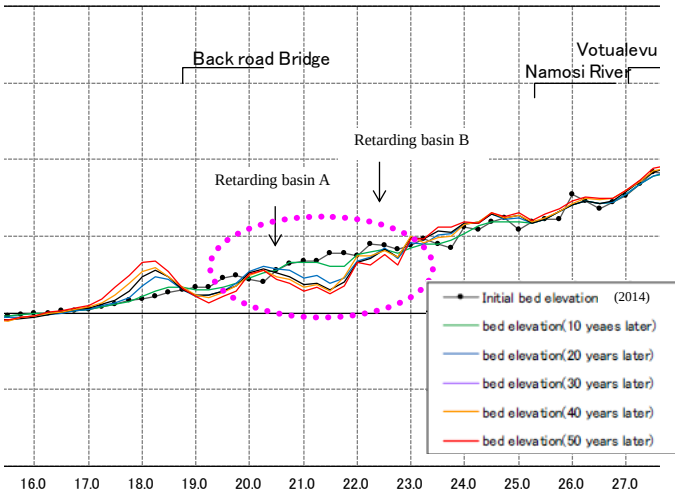

Figure 8-5 Riverbed Change in Problematic Location

One of the Countermeasures for the riverbed degradation is generally ground sill. There is such description as “The ground sill is required in case that the riverbed is unstable and the degradation tendency continues in long period” in the “Manual of Structure Design of Ground Sill, Japan Institute Country-ology and Engineering, November, 1998”.

The counter measure for riverbed degradation includes uncertainty which is difficult to estimate beforehand. The riverbed degradation above is a phenomenon developing gradually so that the Countermeasures are to

be taken basically after occurrence of the degradation.

In conclusion, the mitigation works in the problematic location will not be implemented together with the flood control project, and will be implemented according to the change of riverbed topography in that location

(3) Response Policy to Problematic Location

As to the problematic location identified in the Comprehensive Sediment Management, which is the riverbed degradation section, the urgent mitigation work is not to be implemented as mentioned above, the response such as the monitoring the topographic change and limitation of gravel quarrying causing the direct riverbed degradation are likely to be appropriate.

Table 8-1 Response to Problematic Location

Problematic Location	Problem	Relation with Flood Control Project	Necessity of Mitigation Work	Response Policy
19k to 23k	Riverbed degradation	Change of flood flow conditions by river channel enlargement.	Urgent necessity is low.	・Periodical monitoring of riverbed topography ・ Limitation of sand quarrying in this section.

CHAPTER 9 Sea Coast

9.1 Purpose and Work Flow of Study

The comprehensive bed load sediment management is to manage totally the issues of sediment transport in continuous each area from river basin to river mouth and sea coast, which is one of important view point to establish the flood control master plan in Nadi River basin.

In this chapter, the influence of erosion and deposition caused by littoral drift sand transport after implementation of the flood control plan is predicted by calculation model of Sea coast Profile Change. And the most appropriate flood control plan is determined and its influence is assessed.

The study is divided into three (3) steps," Field Investigation of Sea coast", "Reproduction Analysis of Present Situation" and "Prediction calculation on Flood Control plan", as shown Figure 9-1.

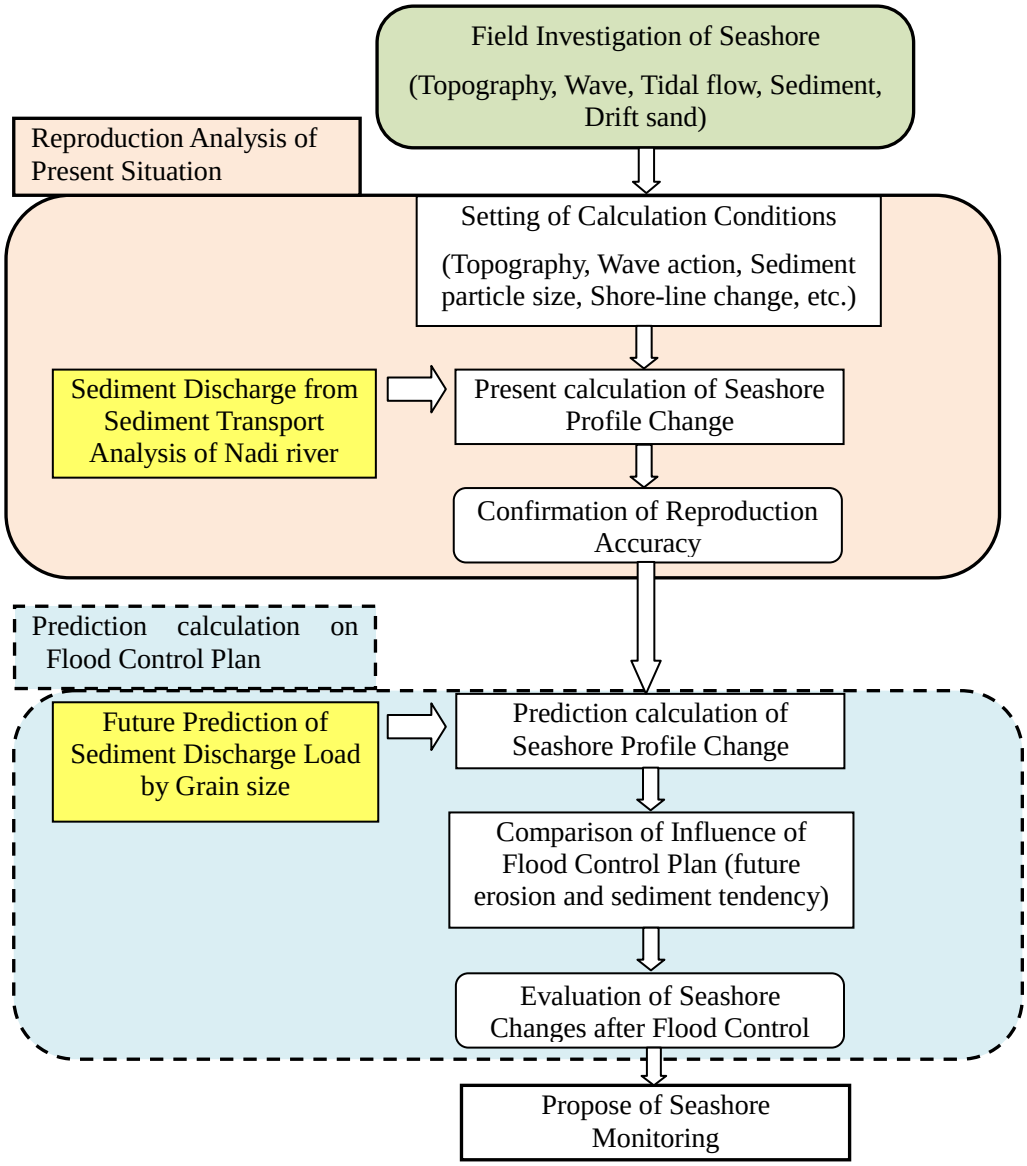

Figure 9-1 Work Flow of Sea Coast Profile Change

In the Field Investigation of Sea coast, the topographical survey, wave and tidal flow, sediment, littoral drift sand are investigated in two times of dry season and rainy season.

In the Reproduction Analysis of Present Situation, the calculation model of sea coast profile change is carried out by inputting sediment discharge data under the present conditions, for confirmation of reproduction accuracy. The sediment data are estimated by Sediment Transport Analysis at river mouth in Nadi River from the past to present.

Future change of sea coast profile after flood control, the future change is calculated based on the sediment discharge of each flood control plan, and the erosion and sediment tendency is compared with each other for evaluation of the influence to sea coast.

According to the evaluation, the effective management method is proposed for the sustainable sea coast management such as monitoring observation in the sea coast with tendency of erosion and so on, if necessary.

9.2 Reproduction Analysis

9.2.1 Forecasting Results

(1) Changes in the Contour Lines

Figure 9-2 show the results of the forecasting of the changes in the 10-, 20-, 30- and 50-year periods respectively on the assumption that there will be no change in the existing facilities and the meteorological and oceanographic conditions.

These figures show that the predominant directions of the sediment transport will remain the same as those observed in the reproduction of the current state. In reality, a large quantity of sediment is discharged from the river at its estuary at the time of flooding. However, it was assumed that sediment was discharged evenly throughout the year in the forecasting. Therefore, the changes in the contour lines were forecast to be gradual and uniform so that no significant changes were forecast in the 10- and 20-year periods. Therefore, the forecast in 50-years is examined to be understandable in Figure 9-2.

a) Nadi River Mouth

The result forecasts the trend that continuous deposition of sediment discharged from the Nadi River at the River mouth terrace continually to offshore direction. Dominant sediment transport direction of South of Cape Denarau is south, this situation makes erosion of shoreline continually in the area of south of Cape Denarau.

b) Regression of Shoreline around Cape Denarau

Tourism development around cape Denarau is active so that sand beach is important as tourism resources. The nourishment of beach is likely to be conducted in recent year. According to the forecast, shoreline (depth 0 m) at south and north side of the cape has a tendency of erosion gradually. In the calculation future nourishment of beach is not considered.

There are no major changes in North shore of Cape Denarau, but it is considered that the seabed materials in the north shore of the Cape will transport to northern side. At the north edge of the Cape, there is one jetty. The transported seabed materials will accumulate behind of the jetty.

c) Nadi Bay

The changes of Nadi Bay area are smaller than Nadi River mouth. Localized erosion of shoreline is observed, but in total, location of shore line is not changed. Gradual sediment accumulation is observed in the deeper area, where the area of less than -2m.

As the purpose of this forecasting was to study the influence of the Nadi River on the changes in the topography of the sea coast, the influence of the sediment discharged from other rivers flowing into Nadi Bay was ignored in the forecasting. Therefore, it should be noted that the sediment deposition in Nadi Bay may have been underestimated in this forecasting.

2) Amount of the Sediment Carried away to the Offshore Zone

Table 9-1 shows the data including the forecast annual average sediment discharge from the Nadi River at its estuary and the amount of sediment carried away to the offshore zone. The values in the table forecast that approx. 27 % of the sediment will contribute to the changes in the contour lines, while the remaining approx. 73 % will be carried away to the offshore zone.

Table 9-1 Amount of Sediment Deposited and Contribution Ratio

Contour line (m)	Discharge from the river at its estuary (m^3/year)	Contribution ratio	Amount of deposit at the depth of the contour line (m^3/year)	Amount of the sediment carried away to the offshore zone (m^3/year)
1.0	1,449	1.00	1,449	0
0.0	1,449	1.00	1,449	0
-1.0	10,034	0.90	9,031	1,003
-2.0	7,339	0.70	5,137	2,202
-3.0	10,017	0.50	5,009	5,009
-4.0	12,695	0.40	5,078	7,617
-5.0	15,374	0.30	4,612	10,762
-6.0	18,051	0.20	3,610	14,441
-7.0	20,729	0.10	2,073	18,656
Amount of the sediment carried away from the analysis area	42,200	0.00	0	42,200
Discharge from the river at its estuary	139,337	0.37	37,448	101,889

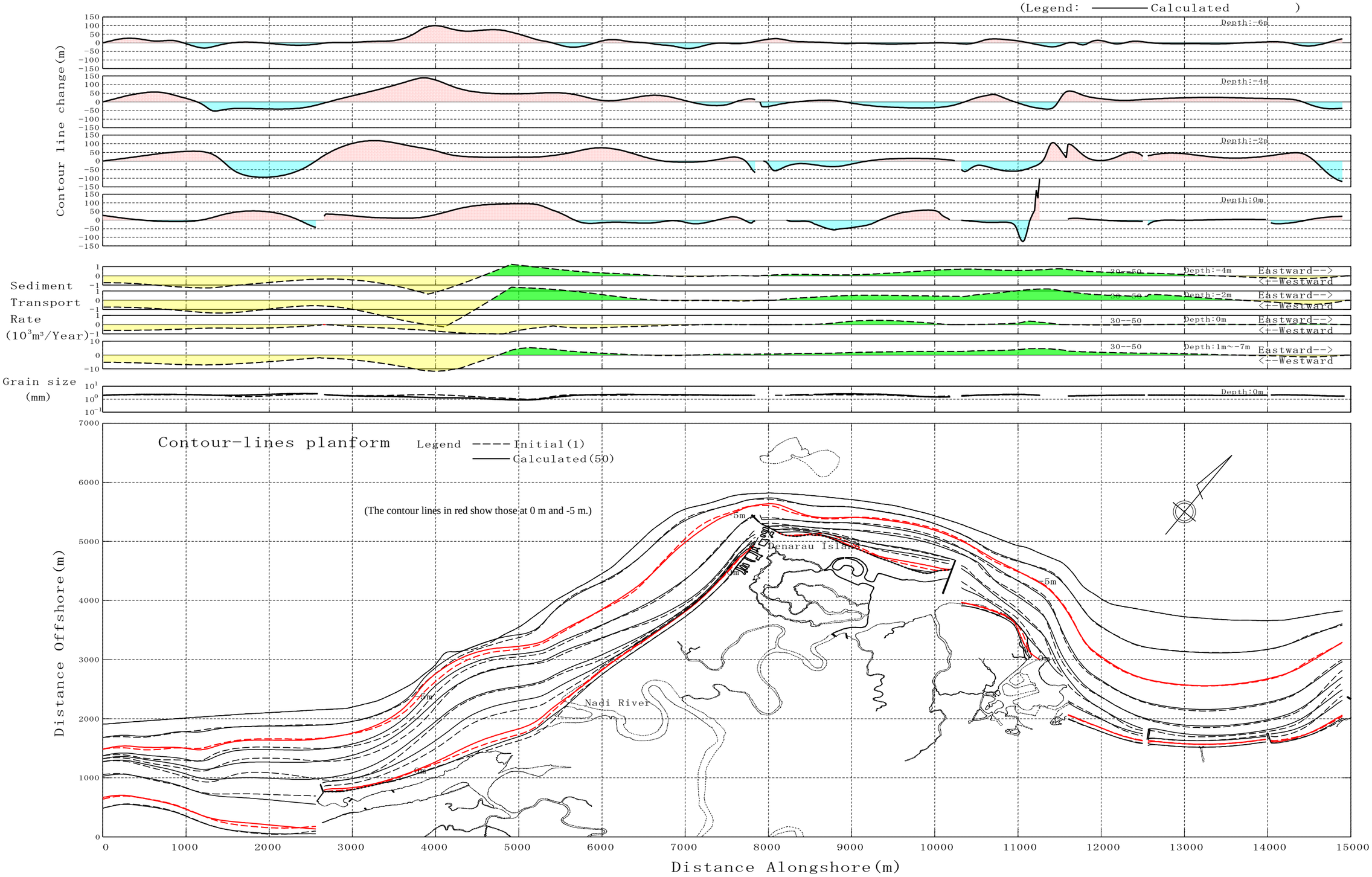

Figure 9-2 Result of the Forecasting of the Contour Line Changes (in the 50-Year Period)

9.3 Influence of Flood Control measures and consideration of Mitigation measures

9.3.1 Prediction Calculation of Flood Control Measure

Hereafter, the prediction calculation is carried out for variation of depth contour line in case that the River Improvement is constructed. The calculation conditions are same as Case-1, without flood control structure in the present river channel except for the sediment discharge at the river mouth. And the present depth contour line (2014) is used as initial condition which was obtained in the reproduction calculation of the present situation.

9.3.2 Calculation Results

The characteristics of depth contour line change by construction of the River Improvement are summarized below:

i) The drift sand will transport continuously toward present direction in future.

ii) The sediment discharge by the River Improvement will not change so much with the present situation Case 1, without structures, so that the influence to the seashore is nil.

iii) In the both side of seashores of Cape of Denarau, the recession of sea shore line (erosion of depth 0m) have no difference compared with Case 1, without structures, therefore no difference of erosion by the construction of the River Improvement is observed.

9.3.1 Evaluation of Influence of Flood Control Structures

In the previous section, the variation of sea shore topography was calculated from present to 50 years after in the case of River Improvement (Case-3, M-1). In the conclusion, the terrace at the mouth of Nadi River will expand according to elapsing of years; however the difference to the Case 1, without structures is almost nil. The reason is that the sediment discharge from Nadi River is decreased by 1 % in annual average in the River Improvement.

As described above, the influence of the River Improvement (Case 3, M-1) to the seashore topography is almost same as that of Case 1, without structures, so that the mitigation works for the River Improvement is not necessary.

(1) Issues in Future

The mitigation work for decrease of influence to the seashore required by the River Improvement is not necessary, however the issues at present will continue after completion of the River Improvement.

1) Dredging of Rive Mouth

The dredging of 165.1 x $10^3 m^3$ was implemented at Nadi River, from river mouth, 0 km to 7km from 2008 to 2012. In future the maintenance work of dredging is likely to be required in the tidal reach where the sedimentation occurs in normal river flow

2) Sand Bar at River Mouth

As to the sand bar at river mouth, due to accumulation of fine particles and acting of low wave with height less than 1.0m, the river mouth terrace (accumulated under sea surface) will mainly expand and the sand bar over sea surface will be not likely to develop and clog the river mouth. This is confirmed by observation that there is no formulation of sand bars which clog the river mouth at present and in the past

The height of sea bed around the river mouth is estimated visually as EL+0.8m at highest and EL-1.0m at lowest, and L.A.T. (Lowest Astronomical Tide) is -1.05m. Since the riverbed lower

than L.A.T is lower than lowest height of river terrace, and the sea surface is always higher than L.A.T.so that the zone less than L.A.T. is to be dead zone for effective river flow section. In dredging of river channel, if the zone with less height than L.A.T. is excavated, the zone will not contribute the enlargement of effective flow area. Therefore dredging is to be planned the zone more than L.A.T. -1.05m.

(2) Monitoring Plan

The terrace at river mouth is estimated to expand further by sediment discharge from Nadi River according to the prediction analysis of the contour line change model.

According to the development of river mouth terrace, the depth of water will be more shallow and uniform so that there are some possibilities of enlargement and shape change of river mouth delta, and in some cases river course change when the large amount of sediment is discharged in big flood. Such kind of river mouth change may influence to the flow conditions of floods. However the change is affected by flow condition, partial erosion and sedimentation, so that the prediction of such is difficult.

Therefore it is effective that the monitoring of change of shape and water depth and so on at river mouth is implemented periodically. The monitoring plan is as shown in the Table 9-2. And based on the monitoring, appropriate maintenance works such as dredging and so on, are to be implemented from time to time.

Table 9-2 Monitoring Plan at River Mouth

Item	Method	Timing	Frequency
1)Change of topography	- Aerial photogrammetry (periodical)	- After rainy season	- every 5years
	- Aerial photogrammetry (temporally)	- After big flood (temporally)	- occasionally
2)Change of cross section	- Longitudinal and cross section survey (periodically)	- After rainy season	- every 5years
	- Longitudinal and cross section survey (temporally)	- After big flood (temporally)	- occasionally

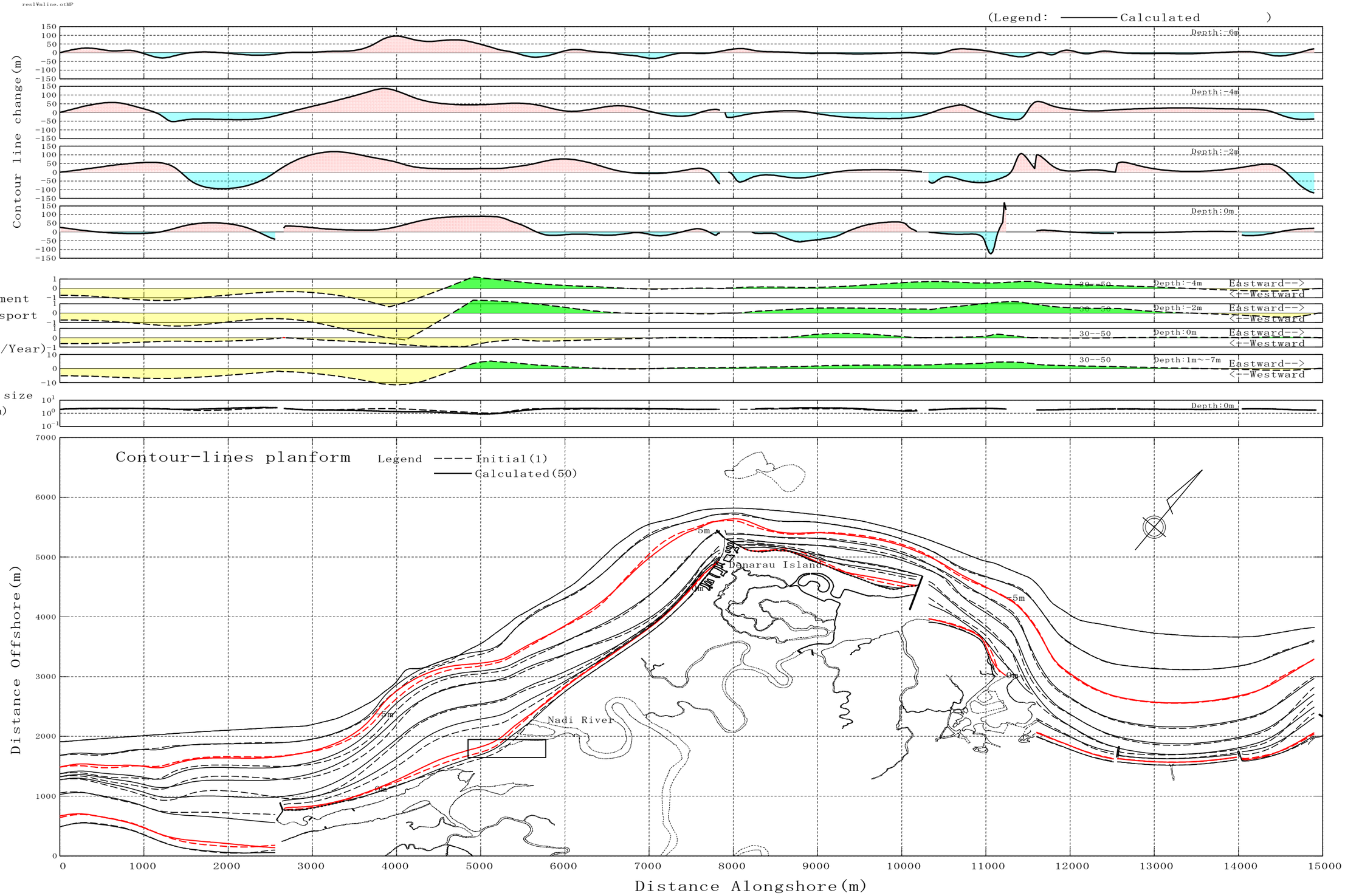

Figure 9-3 Comparison of Depth Contour Line between Present Condition (Case 1) and River Improvement (Case 3) after 50 years

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(Legend: ——— Calculated)

Contour line change(m)

Depth:-6m
Depth:-5m
Depth:-4m
Depth:-3m
Depth:-2m
Depth:-1m
Depth:0m

Difference between Case 1, without structures and Case 3, River Improvement is almost nil.

Contour-lines planform

Legend Calculated-1(50) Present Situation after50 years
Calculated-2(50) River Improvement, M-1 after 50years

Donarau Island
Nadi River
5m
0m

Distance Offshore(m)

Distance Alongshore(m)

Figure 9-4 Comparison of Prediction of Depth Contour Line between Present Situation (Case 1) and River Improvement (Case 3) after 50 year

Chapter 10 Non-Structural Measures

10.1 Classification of Non-Structural Measures

Disaster management can be expressed as a cycle shown in Figure 10-1. There are Structural measures (written in black in Figure 10-1) and Non-Structural measures (written in white in Figure 10-1), which can contribute to the disaster mitigation in each phase, such as "Pre-Disaster", "Disaster Response" and "Post Disaster".

As for Non-Structural Measures in Fiji, National Disaster Management Plan was developed in 1995 and NDMC, NDMO were established. Even though disaster risk management and reduction are mentioned in the plan, disaster response and rehabilitation are one of the main components, and only public awareness and training of disaster risk management are described as the actions in the pre-disaster phase. Actually, these two components are put emphasis on and disaster response is implemented in a systematic and an organized way. Measures in pre-disaster phase are mainly based on the commitment of other donors. On the basis of this situation, conceivable Non-Structural Measures in Fiji are classified as in Figure 10-2.

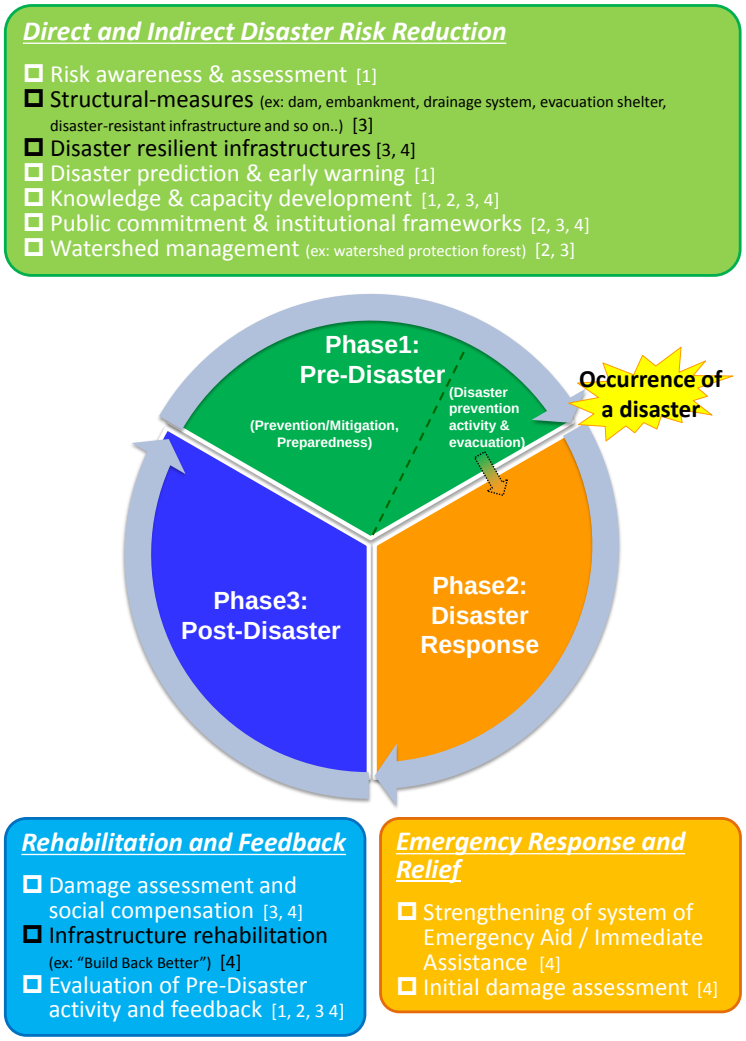


Figure 10-1 Disaster Management Cycle and fields of Non-structural measures in each phase

* The numbers in the figure, such as [1], indicates the number of "Priorities for action on Sendai Framework for DRR"
The measure written in black indicates the Structural Measures and written in white indicates the Non-Structural Measures
Source: JICA Project Team made based on Sendai Framework for Disaster Risk Reduction 2015-2030, 2015

10.2 Current situation and issues of Non-Structural Measures

10.2.1 Pre-Disaster Phase

A) Strengthening of understanding flood risk with flood hazard map

	Field	Current Situation	Issues	Expected Measures
Pre-Disaster Phase	Risk awareness & Assessment	➢ The flood-hazard area, the risk and the evacuation center and so on are not recognized properly.	➢ Implementation and completion of the priority project might invite the misunderstanding among the public, such as no flood damage after the project. ➢ There is a risk of inundation even after the river improvement. ➢ If the frequency of disaster is reduced because of the completion of Structural Measures, losing past good practices, knowledge and experiences learned regarding disaster prevention will be a concern. Moreover, it will cause the extent of damage if the cases of any floods over the target flood.	**Development of flood hazard map and holding workshops**
	Disaster Prediction & Early Warning	➢ Lopsided distribution (Especially in Malakua and Nawaka Rivers Catchments)	➢ Flood forecasting and issuing the warning for both tributaries cannot be implemented	**Installing of rainfall gauge, water level gauge and real-time monitoring camera**
		➢ Limited methods to distributing especially for tourists	➢ Limited methods to collect disaster information by the tourists and disaster risk awareness to the tourists are one of the concerns	**Disaster information board and distribution of the hazard map**

B) Strengthening flood forecasting technology

	Field	Current Situation	Issues	Expected Measures
Pre-Disaster Phase	Qualitative improvement of forecasting system/technology	➢ Current flood forecasting and early waring are based on the past experience and knowledge of flood. ➢ Hydrology section has just been unified under FMS in 2013 and task regarding flood forecast does not become established.	➢ Since there is no long-term compiled data of observed flood water level and flood discharge, it is difficult to set the warning standards based on the scientific basis ➢ Since task and technical capability regarding flood forecast does not become established as an actual practice at the moment, it is difficult to conduct operation of the system and flood forecast	**Strengthening organization (hydrology section of FMS) and personnel regarding flood forecast**
	Qualitative expansion of observation system and network	➢ Flood forecasting system and highly accurate measurement are not introduced.	➢ Technical assistance regarding improvement of forecasting system/technology is required in order to utilize the new technology.	**Introduction of flood forecast system and MP Radar and strengthening operation and management the system**

C) Strengthening disaster management system

	Field	Current Situation	Issues	Expected Measures
Pre-Disaster Phase	Knowledge & Capacity Development	➢ SOP of the National EOC, SOP of CWD, DMP of NTC and DMP of certain communities are developed.	➢ Due to frequent personnel rotation, past expediencies, issues, challenges and good practices are not shared / inherited to the successors	**Development / Update of DMP, SOP and establishment of system for feedback**
	Public Commitment & Institutional Frameworks	➢ Pacific platform had been implemented and there is a donor support such as EDF10 & 11. ➢ Disaster response and rehabilitation were put emphasis on	➢ It requires substantial times for understanding of importance of investment in disaster prevention	**Economic estimation of investment in disaster prevention**
Disaster Response Phase	Emergency Aid / Immediate Assistance	➢ EOC is activated based on SOP and in each governmental level and disaster response is conducted. ➢ NGOs directly distribute the daily necessities to the community aside from EOC's immediate assistance	➢ Even though the EOCs are immediately activated and information distribution and preparation are conducted from pre-disaster phase, immediate assistance requires a lot of time and emergency rescue is difficult due to lack of budget and insufficient resources for disaster prevention, response and rescue ➢ Since daily necessities, such as food, water is often delivered to the communities directly without the mutual consultation with EOC, some assistance will duplicate and it affects to the fair immediate assistance.	**Strengthening of system of Emergency Assistance**

D) Technical assistant for land-use regulation

	Field	Current Situation	Issues	Expected Measures
Pre-Disaster Phase	Risk awareness & Assessment	➢ The flood-hazard area, the risk and the evacuation center and so on are not recognized properly.	➢ Implementation and completion of the priority project might invite the misunderstanding among the public, such as no flood damage after the project. ➢ There is a risk of inundation even after the river improvement ➢ If the frequency of disaster is reduced because of the completion of Structural Measures, losing past good practices, knowledge and experiences learned regarding disaster prevention will be a concern. Moreover, it will cause the extent of damage if the cases of any floods over the target flood.	**Development of flood hazard map and holding workshops** **"Output sharing of A) Strengthening of understanding flood risk with flood hazard map**

	Public Commitment & Institutional Frameworks	➢ There is no land-use regulation regarding flood. ➢ Developing of a process to consider a result of risk assessment in the town development is conducting.	➢ There is a risk of expanding of damage due to no land-use regulation in flood-prone area.	**Development of law (Revision of the National Land Act and Land Use Regulation)**
		➢ There is no recognition / regulations for impact on drainage caused by a large-scale development	➢ Recognition / regulation for impact on drainage caused by a large-scale development shall be considered in order not to provide a negative effect to the surrounding area.	**Setting of drainage standard regarding development**

E) Strengthening river basin management

	Field	Current Situation	Issues	Expected Measures
Pre-Disaster Phase	Risk awareness & Assessment	➢ Details are described in A) Strengthening of understanding flood risk with flood hazard map and D) Technical assistant for land-use regulation		**Development of flood hazard map [A)]** **Development of law (Revision of the National Land Act and Land Use Regulation) [D)]**
		➢ The flood-hazard area, the risk and the evacuation center and so on are not recognized properly. [A)] ➢ There is no land-use regulation regarding flood [D)]	➢ Lack of understanding of risk will delay disaster preparedness and response. [A)] ➢ There is a risk of expanding of damage due to no land-use regulation in flood-prone area. [D)]	
	Watershed Management	➢ Even though the Nadi Basin Catchment Committee (NBCC) was established and watershed management is conducted, not continued after the project completion.	➢ It is difficult to continue the activity after the project, especially for the project conducted by donors. Flood risk reduction by watershed management cannot be continuously implemented.	**Reactivation of NBCC, development of regulation of local government and cooperation with other projects**

10.2.2 Disaster Response Phase

F) Strengthening economic disaster risk management by regional BCP

	Field	Current Situation	Issues	Expected Measures
Pre-Disaster Phase	Public Commitment & Institutional Frameworks	➢ Mainstreaming of disaster prevention for government has been done. ➢ Mainstreaming of disaster prevention for private sector, such as development of BCP, is limited.	➢ Because there is no BCP, it might delay recovery of private sector after the disaster. It is important to minimize the damage to the private sector and accelerate early economic recovery for not only private sector, but also whole Nadi	**Development of BCP / regional BCP and holding workshops**

10.2.3 Post-Disaster Phase

G) Establishing a system of evaluation of Pre-disaster activity / existing measures and feedback

	Field	Current Situation	Issues	Expected Measures
Post-Disaster Phase	Evaluation of Pre-Disaster Activity and Feedback	➢ Current assessment is mainly focus on whether the equipment worked or not during the disaster and whether the equipment got damaged or not. Evaluation and feedback of implemented pre-disaster activity are not conducted.	➢ Impact, effectiveness and contribution of the implemented measures are not evaluated. Therefore, problems and lessons of implemented measures are not recognized and they are not utilized for improvement and feedback.	**Evaluation of Pre-disaster activity / existing measures and feedback**

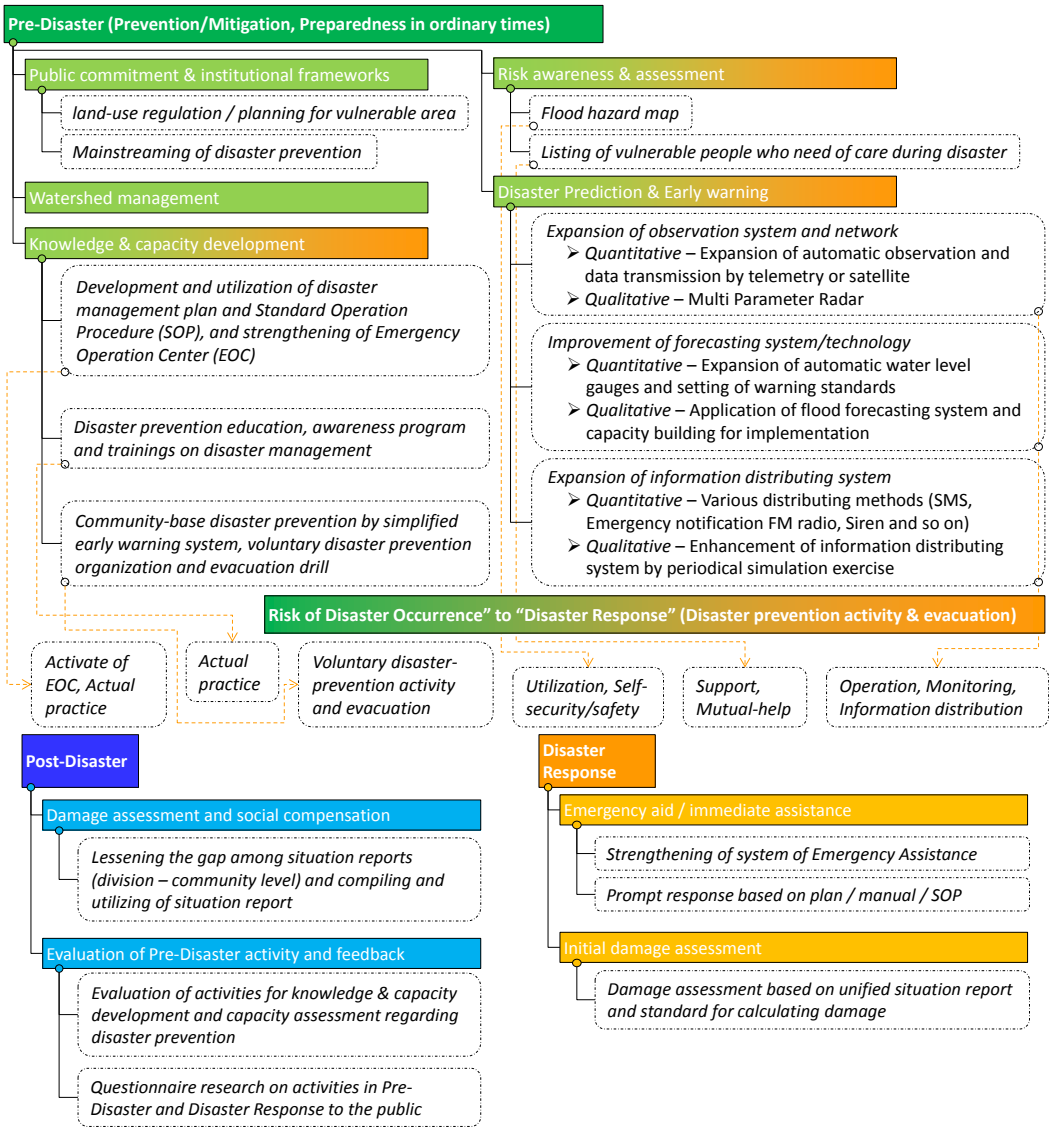


Figure 10-2 Main field of Non-Structural Measures in each phase and Main Measures

10.3 Examination of the Priority Project of Non-Structural Measures

A) Strengthening of understanding flood risk with flood hazard map

Purpose	➢ Understanding of flood risk for the public including tourists with a flood hazard map, which indicates estimated inundation area caused by any floods over the target flood, and disaster information board. ➢ Establishing the system, which can enhance monitoring capability during flood and enables appropriate evacuation, by expansion of rainfall gauges and water level gauges and introducing a monitoring camera.
Programs	1. Installation of hydrological equipment, camera and disaster information board 2. Collection of information regarding disaster prevention resources and development of flood hazard map (Output sharing with D) Technology support for land-use regulations) 3. Distribution of the hazard map and holding workshops for utilization it 4. Simulation exercise using installed equipment in 1. And the hazard map
Assumed implementing agency	NDMO, FMS, DO, Nadi Town Council, Community
Assumed implementing time scale	➢ Risk awareness & Assessment: **[Short-term]** -> Since some of the activities are implemented in this project, it is possible to start in short-term ➢ Disaster Prediction & Early Warning: **[Short-term]** -> Since some of the activities are implemented by FMS and donor, it is possible to start in short-term
Estimated rough cost	➢ Development of flood hazard map and holding workshops: Technology transfer project : More than 1.0 million FJD / year ➢ Installing of rainfall gauge, water level gauge and real-time monitoring camera: Rainfall & Water level gauges : More than 50,000 FJD / gauge Introduction of monitoring camera : More than 60,000 million FJD / camera ➢ Disaster information board and distribution of the hazard map: Disaster information board : More than 0.8 million FJD / board

B) Strengthening flood forecasting technology

Strengthen flood forecasting technology in order to understand flood risk by appropriate flood forecast, to encourage early evacuation, and to avoid the flood risk Moreover, aiming accuracy improvement of flood forecasting and enhance of early evacuation in future, expand the hydrological observation system.

Purpose	Establishing appropriate flood forecasting system and issuing flood warnings by strengthening the technology regarding flood forecast and introducing high accurate observation system in order to enable appropriate evacuation activity during flood.
Programs	1. Unification of hydrological observation system 2. Strengthening of setting /update of warning standards (flood discharge survey, periodical cross-section survey) 3. Establishment of flood forecasting system 4. Development of operation manual of the system and O&M plan of the system 5. Introduction of MP Radar 6. Strengthening data collection, compiling, and utilization of MP Radar
Assumed implementing agency	FMS Hydrology section
Assumed implementing time scale	➢ Qualitative improvement of forecasting system/technology: **[Short-term to Long-term]** -> Substantial time is required for capacity building ➢ Qualitative expansion of observation system and network: **[Middle-term to Long-term]** -> Technical assistance regarding improvement of forecasting system/technology is required in order to utilize the new technology in conjunction with introduction of new technology
Estimated rough cost	➢ Strengthening organization and personnel regarding flood forecast: Technology transfer project : More than 1.0 million FJD / year ➢ Introduction of flood forecast system and MP Radar: Introduction of MP Radar : More than 1.7 million FJD (technology transfer regarding MP Radar is included above project)

C) Strengthening disaster management system

Strengthen disaster risk governance to manage disaster risk and to encourage effective disaster response before the disaster and during disaster. Moreover, encourage early and appropriate evacuation and disaster risk avoidance by effective disaster management and response.

Purpose	Developing and Updating of DMP, SOP and establishment of system for feedback; understanding importance of investment in disaster prevention by economic estimation of investment; and expanding of resources for disaster prevention in order to encourage immediate disaster response.
Programs	1. Establishment and revision of DMP and SOP in each governmental level (based on revised SOP of the National EOC) 2. Periodical simulation exercise involving private sector and community 3. Establishing of data base for the situation report of disaster response 4. Development of feedback system and reflecting lessons learnt from the simulation exercise and actual disaster response on DMP and SOP 5. Model development and implementation of economic estimation of investment in disaster prevention
Assumed implementing agency	NDMO, CWD, DO, Private sector, Community
Assumed implementing time scale	➢ Knowledge & Capacity Development: **[Middle-term]** -> DMP and SOP are partially developed, but substantial time is required for continuous utilization ➢ Public Commitment & Institutional Frameworks: **[Short-term to Long-term]** -> It requires substantial times for understanding of importance of investment in disaster prevention and securing and expansion of resources for disaster prevention. ➢ Emergency Aid / Immediate Assistance: **[Short-term to Long-term]** -> Lack of personal, physical, budgetary resource for emergency aid / immediate assistance. It requires substantial times for securing and expansion of resources for disaster prevention.
Estimated rough cost	➢ Development / Update of DMP, SOP and establishment of system for feedback: Technology transfer project : More than 0.3 million FJD / year ➢ Economic estimation of investment in disaster prevention: Technology transfer project : More than 1.0 million FJD / year ➢ Strengthening of system of Emergency Assistance: Technology transfer project : More than 0.3 million FJD / year

D) Technical assistant for land-use regulation

Understand the flood risk based on the flood hazard map and avoid the risk caused by land development/use in flood-prone area or in retarding basin by land-use regulation. Moreover, mitigate the negative effects of development regarding drainage, and manage and avoid the new disaster risk.

Purpose	Developing / revising the law for land-use regulation especially for flood-prone area and retarding basins; setting of drainage standard regarding development; and Organizing of information of town / development plans with GIS in order to publish to the public in an understandable way.
Programs	1. Development of a flood hazard map (Output sharing of A)) 2. Organizing of information of town / development plans with GIS 3. Zoning based on inundation risk level and setting of regulation for each zone 4. Development of guideline for land-use regulation 5. Setting of drainage standard regarding development 6. Seminar for the regulation and the standard
Assumed implementing agency	Strengthening of understanding flood risk with flood hazard map: NDMO, FMS, Nadi Town Council, Community Land-use regulation: Ministry of Town and Country Planning (MTCP), Nadi Town Council, (Donor, which is implementing the current project)
Assumed implementing time scale	➢ Risk awareness & Assessment: **[Short-term]** -> Since some of the activities are implemented in this project, it is possible to start in short-term ➢ Public Commitment & Institutional Frameworks: **[Short-term to Long-term]** -> Even though it is in place by Org with support of donors, development of law requires substantial time
Estimated rough cost	➢ Technical assistant for land-use regulation: Technology transfer project : More than 1.0 million FJD / year

E) Strengthening river basin management

Plantation in the upstream aiming the prevention of the land from sliding has been conducted by MOA as a part of the river basin management. Flood risk reduction will be enabled by continuous integrated flood management considering the whole river basin and the measures against sediment disaster.

Purpose	Reactivating the Nadi Basin Catchment Committee (NBCC), developing a regulation of local government for river basin management and cooperating with other project (Structural and Non-Structural Measures) in order to enable integrated flood management in entire basin and manage flood risk.
Programs	1. Implementation of activity regarding reactivation and continuity of the NBCC, such as development of regulation on river basin management by local government 2. Output sharing / cooperation with other projects (especially with other Structural Measures, EWS, hazard map and land-use regulation and so on) 3. Implementation of measures regarding rainwater storage and infiltration, such as examination and planning of water conservation forest, introducing and strengthening of facilities for rainwater storage and infiltration at agricultural land and playground (Structural Measure) 4. Implementation of sediment runoff control measure by tree plantation or utilization of flood control tree 5. Seminar for river basin management
Assumed implementing agency	CWD, DO, NTC, NBCC
Assumed implementing time scale	➢ Risk awareness & Assessment: **[Short-term]** -> Since some of the activities are implemented in this project, it is possible to start in short-term. ➢ Public Commitment & Institutional Frameworks: **[Short-term to Long-term]** -> Even though it is in place by Org with support of donors, development of law requires substantial time ➢ Watershed Management : **[Short-term to Long-term]** -> Even though IWRM project was conducted with donor support and the NBCC was established, substantial time is required for continuous implementation of activity by Fiji government
Estimated rough cost	➢ Strengthening river basin management: Technology transfer project : More than 1.0 million FJD / year

F) Strengthening economic disaster risk management by regional BCP

Minimize the flagging economy in the region due to disaster by sharing the measures of disaster prevention and recovery plan among municipality and each sector, and reduce economic damage by economic disaster risk management utilizing BCP and encourage early recovery after the disaster.

Purpose	Developing BCP / regional BCP in order to encourage early recovery of Nadi Town and whole Nadi and to mitigate the economic damage especially for inundation caused by any floods over the target flood.
Programs	1. Workshops of developing of BCP (Private sector and local government) (Including review of existing BCP and lecture by the sector which has already introduced the BCP and so on) 2. Simulation exercise based on the developed BCP
Assumed implementing agency	NDMO, CWD, DO, Nadi Town Council, Private sector
Assumed implementing time scale	➢ Public Commitment & Institutional Framework: **[Short-term to Long-term]** -> Since some activities are in place by certain private sector and other basin, it is possible to implement in short-term. Regional BCP involving local government requires substantial time
Estimated rough cost	➢ Development of BCP and holding workshops: Technology transfer project : More than 1.0 million FJD / year

G) Establishing a system of evaluation of Pre-disaster activity / existing measures and feedback

Enable "Build Back Better" and "Better Disaster Prevention (understanding of disaster risk and management)" by evaluation of Pre-disaster activity / existing measures and feedback, and encourage disaster risk reduction and risk avoidance for the disasters in the future.

Purpose	Establishing the feedback system, which enables Better Disaster Prevention by evaluation of Pre-disaster activity and existing measures, in order to examine improvements and encourage

	better risk understanding and avoidance.
Programs	1. Listing up of conducted / conducting measures 2. Evaluation of impacts / effectiveness of the measures and development of feedback system 3. Examination of improvements 4. Feedback of improvements abstracted in 3
Assumed implementing agency	NDMO, CWD, DO, Nadi Town Council, FMS
Assumed implementing time scale	➢ Evaluation of Pre-disaster activity / existing measures and feedback: **[Short-term]** -> Since similar activity was conducted by donor, it is possible to start in short-term
Estimated rough cost	➢ Evaluation of Pre-disaster activity / existing measures and feedback: Technology transfer project : More than 0.3 million FJD / year

10.3.4 Priority Project (Short-term Measures)

As a priority project of Non-Structural Measures to avoid risks and to mitigate damages will be carried out with regard to protection of human lives for the top priority as well as to understand disaster risks and evacuation, under condition that the progress of structural measures project will be at initial phase.

Even though understanding disaster risk is important / the first step in disaster risk avoidance and reduction, it has room for improvement considering the current situation and issues previously mentioned.

Therefore, activities accompanied with development and disclosure of hazard maps and development of hydrological devices for awareness of flood risks will be implemented. Since the results of the project can be utilized for these components as parts, these components can be implemented from the initial phase. In addition, in order to evaluate the effect of non-structural measures in the past or priority projects, and in order to connect to "Better disaster prevention (improvement of existing non-structural measures)", evaluation and feedback system on the past projects will be designed and built up.

Table 10-1 Phased Implementation of the Measures for the Mater Plan

	Phase	Measures
Non-structural Measures *The number of components is corresponding Table 12-2	i) Priority Project (Short-term Measures)	(1) Understanding disaster risk and risk avoidance A) Strengthening of understanding flood risk with flood hazard map B) Strengthening flood forecasting technology, such as expansion of rainfall gauge, water level gauge and introduction of real-time monitoring camera (5) Evaluation and feedback G) Establishing a system of evaluation of Pre-disaster activity / existing measures and feedback
	ii) Middle-term Measures	(1) Understanding disaster risk and risk avoidance B) Strengthening flood forecasting technology, such as accurate observation equipment and flood forecasting system (2) Enhancing disaster preparedness for effective response C) Strengthening disaster management system (Disaster prevention planning, Development and update of SOP, Economic evaluation of disaster prevention investment, Strengthening of emergency assistance system, etc.) (3) Disaster risk management, risk avoidance D) Technical assistant for land-use regulation E) Strengthening river basin management (4) Economic disaster risk management F) Strengthening disaster risk management for economic damage by development of regional BCP

Chapter 11 Environmental and Social Considerations

11.1 Environmental Policy, Legal and Administrative Framework in Fiji

The current Fiji national environmental policies are based on the principles of sustainable use and development of natural resources through effective environmental management and controls. To identify matters of national importance and to promote development that "meets the needs of the present generation without compromising the ability of the future generations to meet their own needs and implies using resources to improve the quality of human life within their carrying capacity."

The Government of Fiji through the Department of Environment is the regulatory and implementing body of the Environmental legislation. The Department of Environment falls under the Ministry of Local Government, Housing and Environment and is primarily responsible for Environment and National Resource Management.

In addition, Section 3(4) of the Environment Management Act requires that any person performing any function under the Act must have due regard to the traditional owners and guardians of resources. Therefore, to a certain extent, these provisions also support indigenous people and community's governance and management rights.

(1) Environmental Management Act 2005

1) EIA Process

The Fiji Government has provided a legal framework for the EIA process through the passing of the Environment Management Act in 2005. The main purpose of the Environment Management Act (EMA) is to achieve sustainable use and development of natural resources. Part 4 of the EMA 2005 stipulates the requirements of the EIA which basically involves the following:

(1) Screening Process - To determine which Part of Schedule 2 of the Act the development proposal falls under and ultimately whether an Environmental Impact Assessment (EIA) and/or Environmental Management Plan (EMP) is required or not.

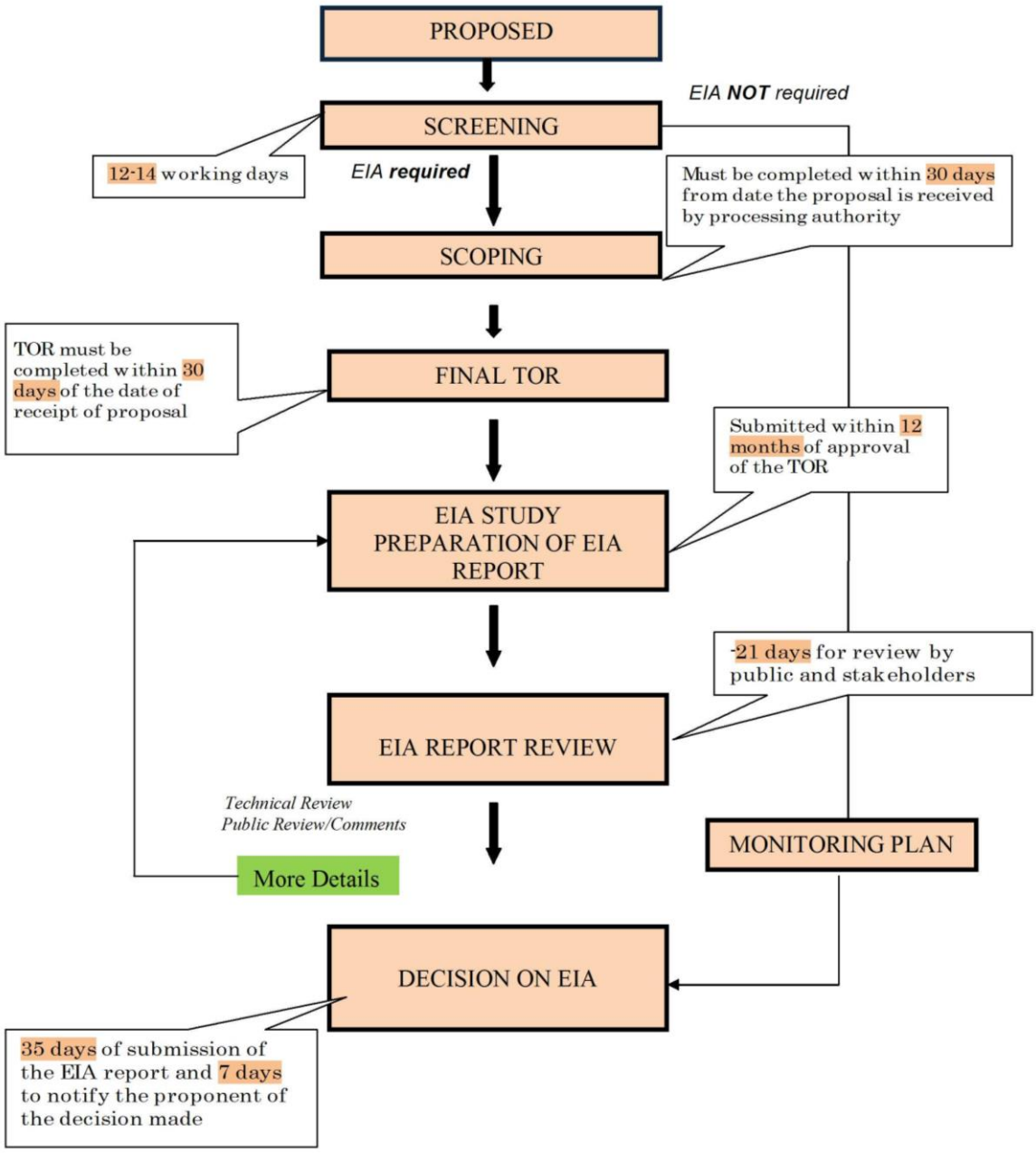
(2) Scoping Process - Once it has been determined that an EIA is required, a scoping exercise and site inspection is required to be undertaken to develop the Terms of Reference (ToR) with the Department of Environment (DoE).

(3) EIA Study - Carry out investigations and reporting including:
   a) Establishing natural and community baseline environments
   b) Identifying and assessing potential impacts
   c) Recommending mitigation and management measures
   d) Recommending the implementation of monitoring programmes

(4) Review of the EIA Report - Once the final EIA report is submitted to DoE with the EIA Processing Application forms and fees, the DoE reviews the EIA report with the assistance of relevant approving authorities and/or established environmental units. The EIA Administrator may also call upon the assistance of specialist/technical experts to review the EIA Report as part of a Review Committee.

(5) Issue EIA Review Decision - EIA approved with conditions, or EIA not approved and subject to further studies will be issued.

EIA process are also described in Environment Management (EIA Process) Regulations 2007 and Environmental Impact Assessment (EIA) Guidelines2012 which shown in later. Figure 11-1 shows flow diagram of EIA process in Fiji.



Source: Environmental Impact Assessment Guidelines (Ed 2), Department of Environment, 2012

Figure 11-1 EIA Process in Fiji.

11.2 Items and Evaluation Method for Environmental and Social Considerations in the Examination for River Improvement Plan

In the examination for river improvement plan, especially concerned items for environmental and social considerations are protected area, ecosystems, resettlement (land owing, number of displaced houses) and proposed development by government and private sector.

Table 11-1 Items and Evaluation Method for Environmental and Social Considerations in the Examination for River Improvement Plan

Major Items	Items	Considerations in Initial Phase			Evaluation Method
		Items can be avoid / mitigate by ingenuity of structure, construction method and other engineering considerations (It is needed to exam in full-scale study)	Items require the impact assessment for decision making toward Initial examination		
			necessity	basis	
Pollution	Air quality	●			
	Water quality	●			
	Waste	●			
	Soil Contamination	●			
	Noise & Vibration	●			
	Subsidence	●			
	Odor	●			
	Sediment	●			
Natural Environment	Protected area		●	It's desirable to avoid projects in a protected areas.	Comparison of location of protected areas and project.
	Ecosystem		●	Impact is greatly depends on area of projects	Roughly grasp the impacts by environmental categories.
	Hydology	●			
	Topography & Geology	●			
	Management of abandoned sites	●			
Social Environment	Land Acquisition and Resettlement		●	Impact is greatly depends on scale and location of projects	Check the land owing type and count the number of houses by aerial photo.
	Poor People	●			
	Living and livelihood	●			
	Cultural heritage	●			
	Landscape	●			
	Tourism	●			
	Outdoor activities	●			
	Governmental and private development		●	To propose realistic plan with a coordination between existing proposed developments	Comparison of locations of existing proposal and project to be implemented.
	Agriculture (included Sugar Cane)	●			
	Ethnic minorities and indigenous peoples	●			
	Water usage	●			
	Existing social infrastructures and social services	●			
	local decision making organizations	●			
	Misdistribution of damages and benefits	●			
	Benefit confliction	●			
	Gender	●			
	Children rights	●			
	HIV/AIDS	●			
	Annual budget for environment management	●			
	Working conditions	●			

11.3 Implementation Outline of Strategic Environmental Assessment (SEA)

The SEA for the Project, the proposed two (2) alternatives were evaluated by following indicators. The result of the examination had been shown in the JCC.

1) Existing social infrastructure
2) Area of improvement of inundation (important protected area and entire the basin)
3) Scale of land to be acquired for the project (Area in ha)
4) Scale of resettlement
5) Topographical variation of coastal line
6) Other major environmental and social check points

Results of evaluation of environmental and social impacts are shown in below.

Table 11-2 Outline of Evaluation of Environmental and Social Impacts in the basic policy of the Project

Item			Zero Option	(1) River Widening	(2) Diversion Channle
Existing social infrastructure		Impact	No changed from current situation	Rebuilding of existing bridge: 2 Bridges (Nadi Town Bridge and Old Queens Road Bridge)	Rebuilding of existing bridge: 1 Bridge (Old Queens Road Bridge) New bridge building: 2 Bridges (Bridge for Queens Road and bypass road (under construction))
		Evaluation	―	Nadi Town Bridge is very close to the central area of Nadi town. There is challenges for preparation of land for bridge and working yard, and countermeasures for noise mitigation. After the rebuilding, flow capacity of Nadi River will be improved. In addition, rebuilding of old bridge comes increasing of safeness against flood etc..	Rebuilding of bridge is only one. But, diversion channel require at least two (2) new bridges for existing road.
Improvement of Inundation Area *1	Important Protected Area	Impact	Inundation is not canceled	Area of Inundation: Before330ha After 0ha	Area of Inundation: Before330ha After 0ha
		Evaluation	Inundation is not canceled and the risk is remained	Both plan can cancel the inundation in the important protected area	
	Entire the Basin	Impact	Inundation is not canceled	Area of Inundation: Before5,129ha After 3,158ha (38% decreasing)	Area of Inundation: Before5,129ha After 3,006ha (41% decreasing)
		Evaluation	Inundation is not canceled and the risk is remained	The area of cancelation of inundation is almost same. There is no major difference form the aspects of effect of flood control.	
Area of the land to be acquired *2		Impact	non	Native Land: 79ha Free Hold Land: 39ha Total: 118ha	Native Land: 60ha Free Hold Land: 62ha Total: 122ha
		Evaluation	―	Total area is almost same, but the ratio of Native Land and Free Hold Land is different. The process of negotiation and consensus making is different.	
Scale of resettlement *3		Impact	non	28 households	40 households
		Evaluation	―	The average of family member in Nadi River Basin is	The average of family member in Nadi River Basin is

			4.65person/household. In this sense, total number of affected person is less than 200.	4.65person/household. In this sense, total number of affected person is more than 200.
Topographical variation of coastal line *4	Impact	Variation of -1.0m depth contour in Nadi River mouth: After 50 ys: 200m forward Variation of -1.0m depth contour in diversion channel river mouth: After 50ys: 20m forward	Variation of -1.0m depth contour in Nadi River mouth: After 50ys without flood control measures: 200m forward After 50ys with flood control measures: 200m forward	Variation of -1.0m depth contour in Nadi River mouth: After 50ys without flood control measures: 200m forward After 50ys with flood control measures: 50m forward Variation of -1.0m depth contour in diversion channel river mouth: After 50ys without flood control measures: 20m forward After 50ys with flood control measures: 140m forward
	Evaluation	Even in case no measures, costal line will forward to off shore direction.	No major changes expected in comparison to no measures case.	Sand will be accumulated at the river mouth of diversion channel. On the other hand, in Nadi River mouth, degree of formulation of terrace will decrease.
Air Quality	Impact/ Evolution	No changes	No major impacts are expected by the Project. From the aspects of Air Quality, there are no major differences.	
Noise and Vibration	Impact/ Evolution	No changes	No major impacts are expected by the Project. From the aspects of Noise and Vibration, there are no major differences.	
River Water Quality	Impact	No changes	No changes for river flow amount. River Widening causes changes of water level, velocity and tidal area.	River flow amount in Nadi River will decrease downstream after the diversion channel. In diversion channel, new estuary area will be created.
	Evaluation	—	An ingenuity for the design of new river section to mitigate the impact can be considered.	Changes from current conditions such as degradation of water quality due to decreasing of river flow, and creation of new habitat, etc. are large.
Water Utilization	Impact	No changes	The project areas are far from sources of	The project areas are far from sources of

			supply water. Changes for underground water is small because, the project not so much changes of river alignment.	supply water. Creation of estuary by dredging of diversion channel causes impact of sea water to the land side.
	Evaluation	―	Changes from current condition is small. The impact of the Project is small.	The influence of sea water will be expected due to the dredging of diversion channel.
Natural Habitat	Impact	No changes	During construction and just after the completion, changes of vegetation is expected due to the changes of river sections. Changes of physical river condition is small since there is no change of river flow amount. In addition, changes of mangrove from current situation is limited.	Due to the construction of diversion channel, habitats on grass land will be damaged and new aquatic habitat will be created. The beach will be divided into two parts by diversion channel. This changes causes variation of coastal flow and topographical changes. On the other hand, new habitat will be created. In comparison with current situation, river flow of downstream will be decrease. This changes causes changes of physical condition such as decreasing of frequency of inundation. In mangroves, frequency of disturbance will be decrease.
	Evaluation	―	An ingenuity for the design of new river section to create new habitat can be considered.	An ingenuity for the design of diversion channel river bank to create new habitat can be considered.
Protected Area and Cultural heritage	Impact	No changes	No protected area and cultural heritage in the project site.	No protected area and cultural heritage in the project site.
	Evaluation	―	Impact is not expected.	Impact is not expected.
Ethnic minorities and indigenous / Land Owning	Impact	No changes	Changes of land owing are expected for Native lands.	Changes of land owing are expected for Native lands.
	Evaluation	―	A land along the Nadi river is needed to be	A land along the Nadi river and land for

			acquired.	diversion channel are needed to be acquired.
Industry and Economic	Impact	Inundation risks are not changed	Result of the project, the level of safeness against flood in the region will be increase and give a positive impact to industries and economy. The negative impact is limited for minor relocations.	Result of the project, the level of safeness against flood in the region will be increase and give a positive impact to industries and economy. On the other hand, due to the construction of diversion channel, decreasing of land price, changes of coastal environment are expected.
	Evaluation	Inundation is not cleared and give a negative impact to the economy.	In the river basin, large positive impact is expected. Negative impact will be limited.	In the river basin, there are large scale changes in social and environment. Therefore, the evaluation is difficult.

*1: Calculated by inundation analysis based on the equivalent flood in January 2012 (1/50 level flood)
*2: Calculated by the land owing data from iTaukei Land Trust Board (TLTB). The calculated area includes the land for additional countermeasures in upstream and downstream.
*3: Counted by aerial photo by SPC/SOPAC in 2012.
*4: Calculated by 50 years depth contour variation analysis. Elevation -1.0m is almost same as the lowest sea level of spring tide.

Chapter 12 Master Plan for Flood Control

12.1 Approaches for the Master Plan

12.1.1 General

The Nadi River runs Nadi Town which is the third largest town in Fiji. Despite this town occupies an important position in Fiji, systematic flood control plan has not been taken except small scaled bank protection works and construction of retention dams.

Under such conditions, JICA implemented the development study "The Study on Watershed Management and Flood Control for the Four Major Viti Levu Rivers in the Republic of Fiji Islands" (hereinafter referred to as the "1998 Development Study") in 1996 to 1998. In this study, master plan targeting the year of 2015 for completion with design scale 1/50 was formulated and the priority project including construction of diversion channel targeting the year of 2005 for completion with design scale 1/20 was also proposed.

However, the priority project proposing diversion channel has passed 16 years without being implementation, economy in the basin has greatly developed, and land use, the asset situations as well as the external force changes such as areal and duration of rainfall have also greatly changed in the basin. Based on the changes in the basin, new issues such as hydraulic analysis on rivers, comprehensive sediment management in the basin, impact on coastal environment and capacity development for relative organization were also confirmed. In recent years, this area was seriously damaged by floods in January 2009, January and March 2012.

Considering drastic changes and the damage potential by flood in the Nadi basin, review of the previous master plan has become the urgent need. According to the statistical analysis on flood scale in this study, flood event in March 2012 is ranked as history's largest flood and generally identified as 1/50 scale.

12.1.2 Comprehensive Flood Control Approach Based on the Integrated Water Resources Management

Since Integrated Flood Management (hereinafter referred to as "IFM" defined by the World Meteorological Organization, WMO) aims at minimizing the losses of life and properties due to flood by looking over an entire river basin, it is important for implementation to combine strategies and measures such as structural measures and non-structural measures as well as short-term measures and long-term measures.

In the present master plan (the "Master Plan"), based on the flood and river basin characteristics as well as properties in the upstream, midstream and downstream of the Nadi River, taking into account measures in an entire basin, comprehensive flood control plan consisting of dams, river improvement including tributaries, retarding basins and ring dikes was proposed. In the selection process for flood control plan, sediment movement (riverbed fluctuation and sediment discharge to the sea) and impact on coastal environment were examined and necessity of mitigation measures was examined. Combination measures with structural and non-structural measures as well as long and short term measures were also taken in consideration for formulation of resilient and sustainable flood control plan.

12.1.3 Combination with Structural and Non-Structural Measures for Flood Damage Mitigation

Taking into account a long term and the large budget to complete the structural measures, and also taking into account the risk due to flood exceeding design scale, perfect protection measures for flood inundation are not feasible. Therefore, flood control should be aimed at mitigation of flood damage. For the implementation of the project including on-going project, it is important to carry out the coordination and complement by applying structural measures and non-structural measures.

Based on the ideas shown above, in the Mater Plan, structural measures such as river channel improvement and retarding basin were proposed and non-structural measures such as strengthening of awareness on flood risk mitigation due to dissemination of hazard maps were also proposed. Non-structural measures play roles not only for complimenting flood prevention function but also for flood damage mitigation function due to flood exceeding design scale.

12.1.4 Set for Priority Protected Areas (Important Protected Areas)

In the formulation of the master plan, it is an important to clarify priority protected areas from the view point of clarification on the contents of flood control plan and addressing the road map for the integration of short, middle and long term flood control plan.

Therefore, "Nadi Town" which is concentrated many properties, Nadi Airport which is the gateway for international tourism, and surrounding urban were designated as the priority protected areas in the flood control plan and these areas were set for important protected areas.

12.1.5 Environmental and Social Considerations and Social Acceptance for Flood Control Plan

Environmental and social considerations have become an important study to formulate the master plan for the project. EIA (Environmental Impact Assessment) system exists in Fiji, and there is a need for the implementation of EIA in accordance with the legal system. On the other hand, it was also found differences in the guidelines between JICA and Fiji. In addition, Fiji has unique land ownership system, buying and selling of land is basically prohibited except for “Free Fold Land” which can free to buy and sell or state government-owned land which owned by the government. In terms of land acquisition of “Native Land”, it is necessary to obtain an agreement from the land owner in long term basis.

In formulation of the master plan, taking into account these situations and social environment, social impacts at IEE (Initial Environmental Examination) level has been identified, based on the strategic environmental assessment, its assessment results was fed back to the alternatives of flood control plan.

With relation to consultation with local stakeholders’, it is necessary to promote harmony with the demands and expectations of residents who live in vulnerable affected area by floods. In order to implement the master plan, as meeting within the governmental agencies, TWG (Technical Working Group) and JCC (Joint Coordination Committee) were held several times. In addition, the PC (Public Consultation) to consult to the opinions from local residents and stakeholders (outside of the government) was also held in Nadi Town. At the PC, social needs, demands, opinions and supports for the project were gathered and discussed, and finally utilized for the decision making on the master plan.

12.2 Planning Conditions for the Master Plan

12.2.1 Basic Policy

Master Plan shall be developed as an integrated plan considering the entire river basin from the upstream to the downstream based on the approaches described above.

There is a central mountain range called Nandrau plateau (more than 1,200masl) in the upstream of the Nadi River basin. West highland and east highland are mainly formed from plates-like terrain with 300 to 600 masl, and the Nadi River basin side is mainly covered with grass and shrubs. Even though there is Vaturu Dam, which is used for water supply, in the upstream of the Nadi River, a few right sites for a flood control dam such as V-shaped or U-shaped valleys can be found in the Nadi River. Narrow alluvial plain and coastal plain in the middle-stream and the downstream of the Nadir River and tributaries uniting at the Nadi Town / property concentration area increase the burden on the Nadi River. Therefore, flood control with only single facility such as dam and retarding basin is not enough.

Considering the above situation, flood control with dam and retarding basin in the upstream of the basin to store flood water, and river widening to raise flow capacity in the low land middle stream where there are a lot of assets, difficulties to acquire land are set as a basic concept of integrated flood control in the Nadi River basin. In the low-lying downstream area, which is a natural retarding basin, the inundation characteristics of this area shall be considered and utilized as a designed retarding basin. In addition, because the appropriate site for dam is also limited in the basin of the tributaries, a series of retarding basins and river improvement to secure the discharge capacity of the tributaries shall be considered as the flood control measures for tributaries in order to reduce the burden on the Nadi River. River widening in the middle stream of the Nadi River is selected as the Priority Project from these structural measures and it is described in the later chapter.

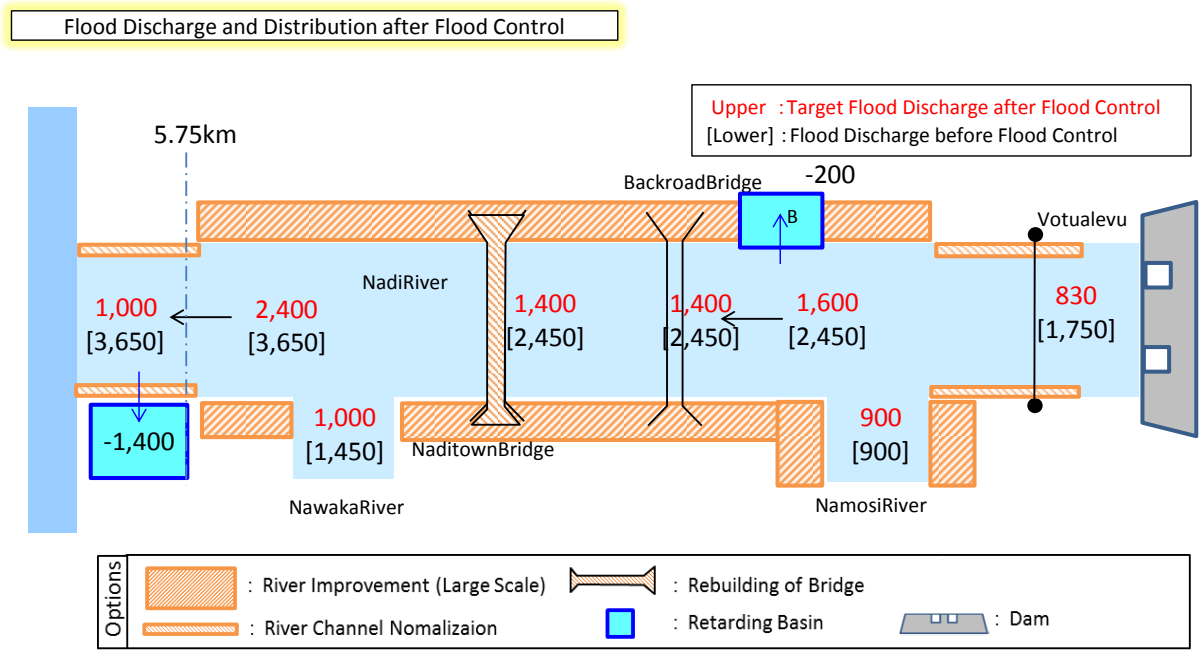
Non-structural measures shall be taken to complement / support the structural measures aiming disaster risk reduction. Following contents are considered as a non-structural measures to be taken in the Nadi river basin considering the pre-disaster phase to post-disaster phase based on the current situation and challenges of non-structural measures: understanding disaster risk and risk avoidance by strengthening of understanding flood risk with flood hazard map and strengthening flood forecasting technology; enhancing disaster preparedness for effective response by strengthening disaster management system, such as disaster prevention planning, development and update of SOP, economic evaluation of disaster prevention investment, and strengthening of emergency assistance system; disaster risk management and risk avoidance in middle to long term by land-use regulation and river basin management; economic disaster risk management by development of regional BCP, evaluation and feedback by establishing a system of evaluation of Pre-disaster activity / existing measures and feedback. Non-structural measures: understanding disaster risk and risk avoidance by strengthening of understanding flood risk are proposed as the Priority Project in order to protect human life, and directly link to people's recognition and evacuation activities and it is described in the later chapter.

12.2.2 Target Area for the Plan

Target area of the master plan is Nadi River Basin with catchment area of 516 km^2.

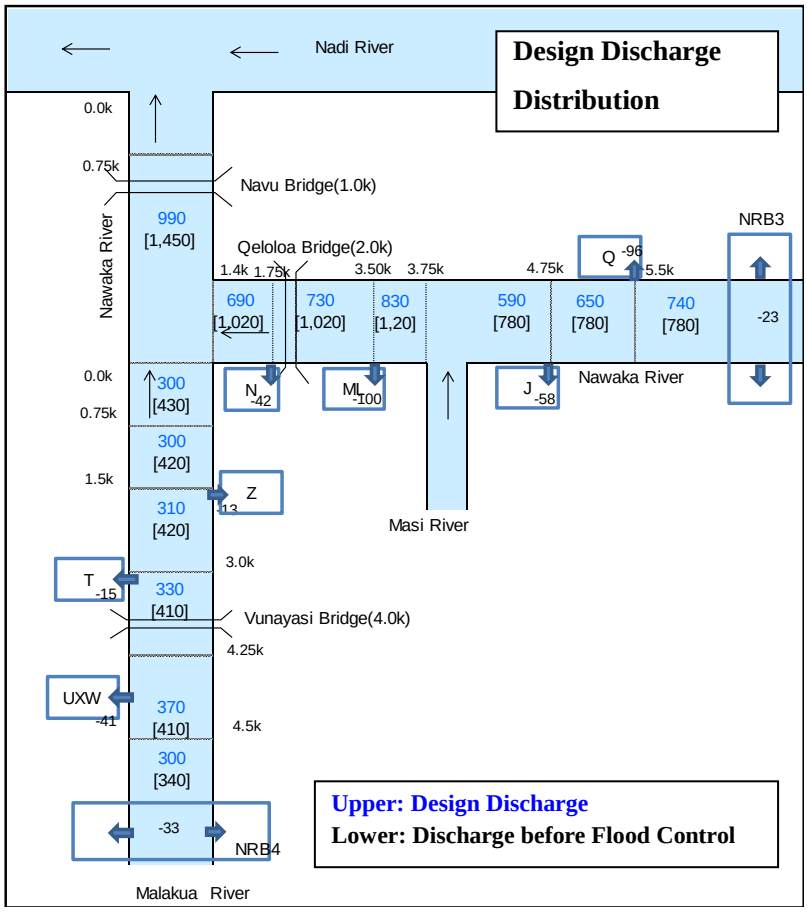
12.2.3 Design Flood Scale and Flood Discharge Distribution

Design flood scale for the master plan is set as 1/50 with regard to previous maximum flood event occurred in March 2012.



Note) Dam and retarding basins in upstream might be substitute by future situation.
Source: JICA Study Team

Figure 12-1 Design Discharge Distribution (Nadi River)



Source: JICA Study Team

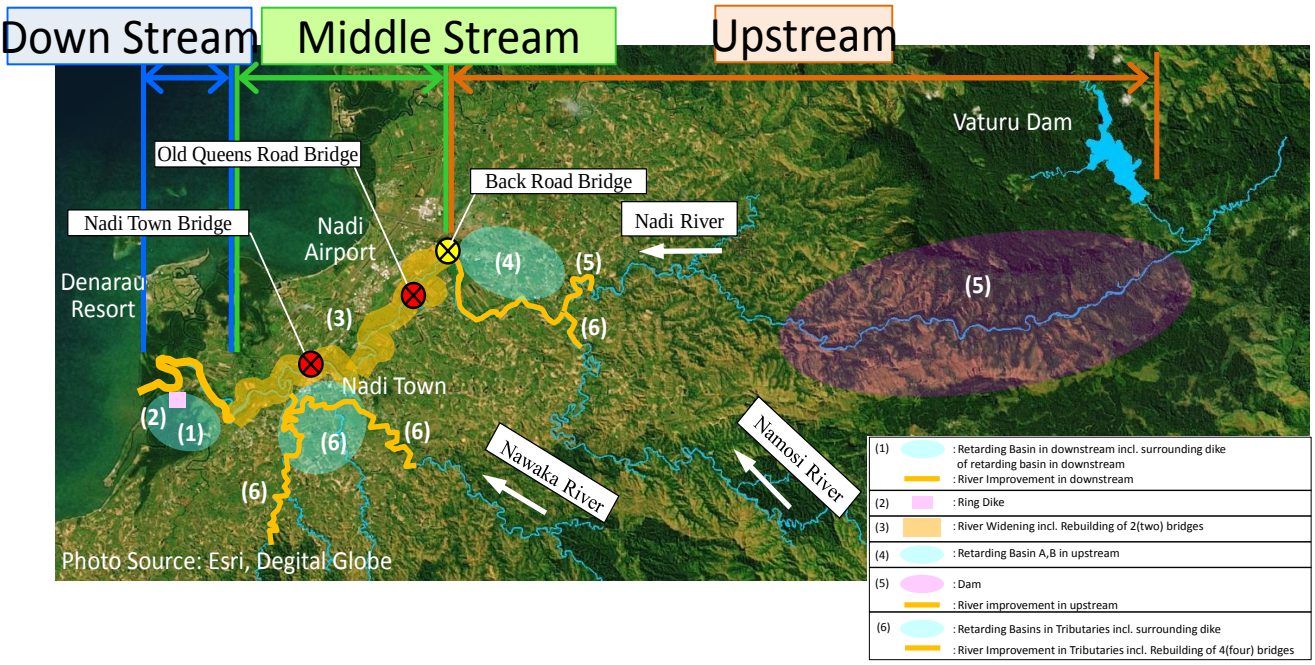
Figure 12-2 Design Discharge Distribution (Malakua & Nawaka River)

12.3 Components of the Master Plan

12.3.1 Description of the Major Component

(1) Structural Measures

In order to mitigate flood damage in Nadi River, following structural measures will be implemented.



Note) Planned dam and retarding basins in upstream might be substitute by future situation.

Source: JICA Study Team

Figure 12-3 Components of the Master Plan (Structural Measures)

Table12-1 Components of the Master Plan (Structural Measures)

	River, Location		Component of the Master Plan		Quantities	Remarks
Structural Measures	1. Nadi River	Downstream	(1)	Retarding Basin and River Improvement in downstream	A=725 ha V=9,715 千m3	—
			(2)	Ring Dike	L=1.8 km	—
		Middlestream	(3)	River Widening[2)]	L=13 km	Including rebuilding of 2 (two) bridges
			(4)	Retarding Basin A	A=35 ha V=795 千m3	
				Retarding Basin B	A=178 ha V=6,920 千m3	—
		Upstream	(5)	Dam and River improvement in upstream	1	
	2. Tributaries	Nawaka Maralua Namosi River	(6)	River Improvement	L=21 km	Including rebuilding of 4 (four) bridges in tributaries
				Retarding Basins (13 sites)	A=340 ha V=11,600 千m3	

(2) Non-Structural Measures

In order to mitigate flood damage in Nadi River, following non-structural measures will be also implemented.

Table12-2 Components of the Master Plan (Non-Structural Measures)

	Effect of Measure (Large Classification)	Major components
Non-Structural Measures	(1) Understanding disaster risk and risk avoidance	A) Strengthening of understanding flood risk with flood hazard map B) Strengthening flood forecasting technology
	(2) Enhancing disaster preparedness for effective response	C) Strengthening disaster management system
	(3) Disaster risk management, risk avoidance	D) Technical assistant for land-use regulation E) Strengthening river basin management
	(4) Economic disaster risk management	F) Strengthening economic disaster risk management by regional BCP
	(5) Evaluation and feedback	G) Establishing a system of evaluation of Pre-disaster activity / existing measures and feedback

12.3.2 Phased Implementation for the Project

In order to improve the flood safety level and mitigate flood damage in the Nadi River basin, clarifying the roadmap for the project, it is necessary to prioritize the component to be implemented by taking into account the necessity and feasibility. For these reasons, the masterplan consisting of components with structural measures and non-structural measures will be carried out by appropriate phased implementation shown as follows.

(1) Priority Project (Short Term Measures)

In order to protect "priority protected areas" from floods, major components for structural measures to be implemented as short term measures, river channel widening in midstream and retarding in upstream section as well as ring and enclosed dikes will be carried out. In this project, area located in the left side of the river in downstream section will be used for retarding basin.

As a priority project of Non-Structural Measures to avoid risks and to mitigate damages will be carried out with regard to protection of human lives for the top priority as well as to understand disaster risks and evacuation, under condition that the progress of structural measures project will be at initial phase.

Therefore, activities accompanied with development and disclosure of hazard maps and development of hydrological devices for awareness of flood risks will be implemented. Since the results of the project can be utilized for these components as parts, these components can be implemented from the initial phase. In addition, in order to evaluate the effect of non-structural measures in the past or priority projects, and in order to connect to "Better disaster prevention (improvement of existing non-structural measures)", evaluation and feedback system on the past projects will be designed and built up.

(2) Middle Term Measures

Major components for structural measures to be implemented as middle term measures, to mitigate flood damage in downstream section and tributaries of the Nadi River, "natural retarding land" located at the left side of downstream section will be planned and designed as retarding basin. River improvement in the tributaries, Nawaka and Malakua River, will be also implemented.

As the major components for non-structural measures in middle-term, applying same measures as short term, measures to avoid risks and to mitigate damages will be carried out with regard to understanding disaster risks and evacuation.

Specifically, strengthening of flood forecasting system and technical assistance on land-use regulation as well as watershed management will be planned to be implemented. Moreover, strengthening of disaster management system and urgent relief system will be designed and implemented as the major

components of non-structural measures for the purpose of rapid assistance due to effective emergency response and relief in the event of disasters as well as damage mitigation.

In addition, as measures that will contribute to reduce economic damage, economic disaster risk management by adopting a wide BCP (Business Continuity Plan) will be also implemented for the purpose of early recovery on economic activities after disaster as well as achievement on reduction of economic damage due to disasters.

(3) Long Term Measures

Major components for structural measures to be implemented as long term measures, to mitigate flood damage, dam will be constructed in upstream section of the Nadi River. Because it takes a long time until the completion of the dam construction, and it is difficult to expect the benefit by the project, this project is positioned as long-term measures. Components for each term of the master plan examined above are summarized as follows:

Table12-3 Phased Implementation of the Measures for the Mater Plan

Measures	Phasing	Components
Structural Measures	i) Priority project (Short-term Measures)	(1) River channel widening works in midstream section (2) Retarding basin works in upstream section (3) Enclosed dike works in Nadi river (4) Ring dike works in Nadi River
	ii) Middle-term Measures	(5) Retarding basin works in downstream section (6) River channel works in tributaries (7)Retarding basin works in tributaries
	iii) Long-term Measures	(8)Dam construction in upstream section
Non-structural Measures (*The number of components is corresponding Table 12-2)	i) Priority Project (Short-term Measures)	(1) Understanding disaster risk and risk avoidance A) Strengthening of understanding flood risk with flood hazard map (5) Evaluation and feedback G) Establishing a system of evaluation of Pre-disaster activity / existing measures and feedback
	ii) Middle-term Measures	(1) Understanding disaster risk and risk avoidance B) Strengthening flood forecasting technology (2) Enhancing disaster preparedness for effective response C) Strengthening disaster management system (3) Disaster risk management, risk avoidance D) Technical assistant for land-use regulation E) Strengthening river basin management (4) Economic disaster risk management F) Strengthening economic disaster risk management by regional BCP

12.4 Implementation schedule of the Master Plan projects

Suggested entire implementation schedule of the Master Plan projects is shown in Table 12-4

Table 12-4 Components of Master Plan and Implementation Schedule (Proposed)

Work Item		20XX-20XX	20XX-20XX																														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	Study on M/P																															
	Detailed Design																															
I. Structural Measures																																
I-A. Priority Project (Short Term Measures)																																
1	**River channel widening works in midstream section**																															
1)	River channel widening works in midstream section, L=13km																															
2	**Retarding basin works in upstream section**																															
1)	Retarding basin (A) works in right bank side in Nadi River, A=35ha																															
2)	Retarding basin (B) works in left bank side in Nadi River, A=178ha																															
3	**Ring dike**																															
1)	Ring dike, L=1.8km																															
4	**Shortcut in tributaries / Surrounding dike works in Nadi River**																															
1)	Shortcut in tributaries, A=0.5km																															
2)	Surrounding dike, L=4.5km																															
I-B. Middle Term Measures																																
1	**Retarding Basin in downstream section (A=km2)**																															
1)	Retarding Basin in downstream section, A=725ha																															
2	River improvement in tributaries																															
1)	Nawaka River, L=8.5km																															
2)	Malakua River , L=8.5km																															
3)	Namosi River , L=4.0km																															
I-C. Long Term Measures																																
1	**Dam construction in upstream in Nadi River (H= m)**																															
1)	Dam construction in upstream in Nadi River																															
II. Non-structural Measures																																
1	**Understanding disaster risk and risk avoidance**																															
1-1)	Strengthening of understanding flood risk with flood hazard map																															
1-2)	Strengthening flood forecasting technology																															
2	**Enhancing disaster preparedness for effective response**																															
2-1)	Strengthening disaster management system																															
2-2)	Strengthening emergency assistance system																															
3	**Disaster risk management, risk avoidance**																															
3-1)	Land use regulations																															
3-2)	Strengthening river basin management																															
4	**Economic disaster risk management**																															
4-1)	Strengthening economic disaster risk management by regional BCP																															
5	**Establishing a system of evaluation of Pre-disaster activity / existing measures and feedback**																															
5-1)	Establishing a system of evaluation of Pre-disaster activity / existing measures and feedback																															

Note: *including loan agreement, EIA, land acquisition, procurement of consultant (D/D, C/S), detailed design, preparation of PQ and tender document and so on.

12.5 Evaluation of Master Plan

12.5.1 Estimation of Damage Reduction (Improvement of Social Vulnerability) Cost and Effect of Projects

(1) Location and Quantity of Structural Measures

Number of work sites and lengths of structural measures are shown above. Out of proposed structural measures, channel improvement in the middle stream section is to be implemented as the priority project (short term measure).

Thus far, comprehensive flood management measure has not yet been implemented in Nadi River Basin. Reduction of flood damage is expected by implementation of proposed structural measures in the master plan.

(2) Flood Damage Reduction Area

By implementing the proposed structural measures with design scale of 1/50, damage reduction area by the master plan and the priority project is estimated as shown in Table 14-7. As the effect of the proposed project, flood disaster of estimated area can be eliminated.

Table 12-5 Estimated Flood Damage Reduction Area

Stage	Flood Damage Area (ha) (Before)	Flood Damage Area (ha) (After)[1)]	Damage Reduction Area (ha)
Priority Project [2)]	5,129 330	3,158 0	1,971 (-38%) 330 (-100%)
Master Plan	5,129	0	5,129 (-100%)

[1)] Inundation area in the proposed retarding basin is excluded.
[2)] Upper figure is inundation area in whole Nadi River Basin while lower figure is that of the priority area

12.5.2 Natural and Social Environmental Considerations

(1) Impacts on Natural Environment

In general, the proposed structural measures are planned so as to maintain current water environment without drastic alternation of river course.

The proposed dam in upstream section is planned as dry dam which stores only flood discharge and functions as ordinary river course for normal discharge. Thus, no sediment is deposited in the reservoir area like storage dam. However, there is a possibility that the proposed structure will be changed to a group of small scale retarding basins in future depending on development of flood control technology, change of social environment in upstream basin and environmental issues.

The channel improvement in middle stream section is mostly widened without change of current riverbed level. Thus, current river environment is maintained in general.

In the downstream section, retarding basin is developed at left side with maintaining current land-use such as mangrove forest or agricultural land. Thus, current river environment is maintained in general.

(2) Initial Environmental Examination (IEE)

Expected environmental impact by implementation of the proposed structural measures in master plan is evaluated as initial environmental examination (IEE) as described in Chapter 12. As the results, environmental impacts can be prevented by optimal monitoring so that implementation of the proposed project is recommended.

(3) Resettlement

The number of resettlement by priority project is estimated as 28 households while that of master plan is 44 households. The projects shall be implemented with consensus with local residents.

(4) Non-structural Measures

As a non-structural measure, watershed conservation is proposed to maintain the natural environment in the basin.

12.5.3 Adaption against Climate Change

Regarding the environmental impacts of climate change, the Fifth Assessment Report (AR5) is published in 2013 to 2014 by IPCC. However, in the Stage-2 of Project, there was no specific assessment result in and around Fiji. Thus, based on the Fourth Assessment Report (AR4), changes of design scale assuming 21% increase and 16 % decrease of precipitation are examined. As described in section 5.5.4, the current design scale of 1/50 will be changed into approx. 1/15 in case of 21% precipitation increase and into approx. 1/200 in case of 16% precipitation decrease.

Under this circumstance, river channel is planned to minimize water level of flood discharge lower than top of bank elevations or natural ground surface out the dyke. By this means, risk of dyke break with higher water level is avoided resulting mitigation of disaster risk by excess floods. Besides, flood safety in surrounding area is also improved by reclamation or embankment of depressions and lowlands near river course. Furthermore, the non-structural measures are also proposed to mitigate flood disaster such as preparation of hazard map.

12.5.4 Relation with Integrated Water Resources Management (IWRM)

Flood control measures shall be discussed as a part of integrated water resources management (IWRM). Through this perspective, promotion of water resources management efficiency is proposed in the master plan such as establishment of water resources management system, water resources potential survey and watershed conservation.

12.5.5 Technical Evaluation

The proposed structural measures composed of the structures and methods which are commonly applied in flood control project. There is no technical difficulty for implementation and O/M.

12.5.6 Institutional Framework

Executing agency of project shall be clearly defined in the government of Fiji. Since the project implementation effects to many aspects, it is recommended to establish a Project Management Unit (PMU) consisting of relevant governmental agencies. It is also recommended to establish an organization and system to conduct O/M permanently.

12.6 Conclusions and Recommendations

12.6.1 Conclusion on Master Plan

In this Study, the flood control master plan is formulated with purpose of flood disaster mitigation in Nadi River Basin, consisting of structural and non-structural measures. It is evaluated as technically and economically feasible. Also, expected social environment issues are evaluated by IEE/EIA.

Table 12-6 Components of Master Plan

Measures	Phasing	Components
Structural Measures	i) Priority project (Short-term Measures)	(1) River channel widening works in midstream section (2) Retarding basin works in upstream section (3) Enclosed dike works in Nadi river (4) Ring dike works in Nadi River
	ii) Middle-term Measures	(5) Retarding basin works in downstream section (6) River channel works in tributaries (7)Retarding basin works in tributaries
	iii) Long-term Measures	(8)Dam construction in upstream section
Non-structural Measures (*The number of components is corresponding Table 12-2)	i) Priority Project (Short-term Measures)	(1) Understanding disaster risk and risk avoidance A) Strengthening of understanding flood risk with flood hazard map (5) Evaluation and feedback G) Establishing a system of evaluation of Pre-disaster activity / existing measures and feedback
	ii) Middle-term Measures	(1) Understanding disaster risk and risk avoidance B) Strengthening flood forecasting technology (2) Enhancing disaster preparedness for effective response C) Strengthening disaster management system (3) Disaster risk management, risk avoidance D) Technical assistant for land-use regulation E) Strengthening river basin management (4) Economic disaster risk management F) Strengthening economic disaster risk management by regional BCP

12.6.2 Recommendations on Master Plan

(1) Steady Implementation of Master Plan

Severe flood risk mainly due to insufficient flow capacity of main channel of Nadi River shall be mitigated by steady implementation of the master plan. Especially, administrative process shall be commenced as soon as possible such as approval of the priority project in the government of Fiji, consensus building within the government and with local residents, financial arrangement, land acquisition and compensation, environmental monitoring and so on.

(2) Review of Master Plan

The master plan shall be reviewed considering change of socio economic and natural conditions of region such as progress of urbanization, flood occurrence and so on.

(3) Study on Proposed Dam in Upstream Section

Dam construction in upstream section and retarding basin construction in downstream and tributaries are proposed as a mid-term measures in the master plan. Further study shall be conducted early for implementation of both construction works.

(4) Land-use Control and Implementation of Non-structural Measures

After completion of the proposed structural measures initiating the priority project, inundation may happen in certain locations before the completion of the master plan. The priority project aims at preventing flood in the priority area including Nadi Town, and flood risk may remain the same along the tributaries such as Nawaka River and Malakua River. Besides, disaster risk against excess floods also remains even if the proposed structural measures in master plan are completed. Thus, land-use control and non-structural measures such as hazard map and early warning system are important especially flood prone areas after the priority project and the locations of retarding basins.

(5) Enhancement of Hydrological Monitoring and Analysis System

Hydrological monitoring system such as rainfall, water level, discharge, sediment flow and so on, shall be improved for future river management, capacity building on hydraulic and hydrological analysis, establishment and improvement of flood forecasting model, early warning system, monitoring and evaluation of flood control measures, and so on.

(6) Recording of Flood Disaster Data

Currently, flood disaster records are collected mainly by Natural Disaster Management Office (NDMO), however, it is not collected by uniform format. Flood disaster records are important basic data for city planning as well as flood control measures. Recording of flood disaster data in a certain manner and its accumulation are necessary.

(7) Drainage and Sewerage Improvement

Nadi Town is located in middle and downstream basin of Nadi River and suffers from inland water inundation as well as river flooding, especially lowland areas. Since the master plan does not cover the countermeasures against inland water inundation, drainage improvement shall be separately required to secure safety against flood disaster. Formulation of a master plan for drainage and sewerage is recommended.

(8) Water Resources

1) Support for the establishment of responsibility-taking organization and related organizations for IWRM

In the Nadi River Basin new development activities and population increase are to be anticipated by the implementation of flood control measures in the Nadi Basin. The necessity of management of water resources (quantity and quality) is to be anticipated to be increase. An integrated water resources management system will be necessary to be established as early as possible because the demand of irrigation water is to be increase due to the national policy to increase agricultural production and irrigation water disputes are possible to increase.

By the issue of "National Water Resources Management and Sanitation Policy", advisory groups such as "National Water Council" and "National Water Committee" and so on are to be established for integrated water resources management. After this the collection of data, information and arrangement of data-base and a secretariat are to be established in order to use effectively the function of the advisory groups and effective deliberations on decision of Ministry to have responsibilities of IWRM is to be possible to be conducted. The following support for arrangement is recommended.

- To promote the establishment of an office to have function of a secretariat of National Water Council and National Water Committee and strengthening of its fun
- To promote the establishment of an office for collection of data/information necessary to make decisions at national level on water resources management and public hygiene.

IWRM is recommended to be conducted by the organization under the Ministry of Infrastructure and Transport (MoIT) which is knowledgeable of planning, implementation and operation / management of public works. Department of Water and Sewage (DWS, under MoIT) is recommended to be a secretariat of National Water Council and National Water Committee since they have a specialty in the fields of water resources management and public health. IWRM is to be managed by two districts of east and west due to the administrative system and IWRM of the Nadi River basin is promoted as a pilot of IWRM.

2) To support effective use of basin water resources

The water resources are to be used effectively based on the grasp of water demand.

In order to conduct effective use of the water resources integrated water resources management (IWRM) of water use sectors are necessary. In order to conduct effective use of irrigation water technical support for increase of agricultural production by water-saving type agriculture through a pilot project is recommended.

3) To support of the promotion of groundwater investigation and management

In the Nadi River Basin there are Fissure type aquifer, Artesian and Meigunyah Aquifer (60 km²) which is promising aquifer for water resources. But detailed groundwater investigation has not conducted yet, and the potential amount of groundwater resources is not grasped. In the Nadi River Basin the groundwater development (irrigation water, domestic water and mineral water) is anticipated to be increasing, and the grasp of groundwater amount and the introduction of groundwater management (monitoring and control of drilling boreholes) are recommended in order to promote optimum groundwater development.

4) To support of the promotion of groundwater investigation and management

In order to reduce pollution loads of the rivers and pollution of groundwater, in an early stage the arrangement of an effluent standard for industries and others is recommended.

Sewerage system is still in the stage of primary treatment, however, WAF has intentions to introduce secondary treatment, examine the quality of waste water discharge from industries, prepare an effluent standard and formulate a M/P for sewerage system, but the country is lack of experiences and technical supports are required.

5) To support for watershed management

Though conservation of the forest area, it is recommended to promote reforestation of thin forest area and grass land area, however, the forest area is all belong to land owners and the reforestation is desired to become sustainable production forest and for the purposes technical support is desired..

(9) Watershed Management

Runoff control in upstream basin is a key component of flood management. In Upper Nadi River Basin, devastation is processed due to surface erosion by slush and burn cultivation or intensive rainfall according to LWRM. Watershed conservation such as reforestation, forest conservation and land-use control is required.

In Middle and Lower Nadi River Basin, retarding basins are proposed in the master plan. Land-use control is important to maintain retarding functions.

By completion of the proposed structural measures in master plan, flood disaster cannot be prevented in certain locations along the main river. Disaster mitigation measures in the basin are also required such as land-use control and heightening of houses and road as second dyke is also required as well as non-structural measures.

(10) Establishment of Permanent Organization and System for River and Basin Management

Currently, river management is partially implemented by Ministry of Agriculture to protect villages and farmlands. Scale of target flood in the master plan is large and affects wide area in the whole basin such as forest areas in upper basin and urban areas in middle and lower basins. Integrated river management covering whole basin is required and permanent organization and systems for river and basin management is inevitable.

(11) Establishment of Management System for River Area

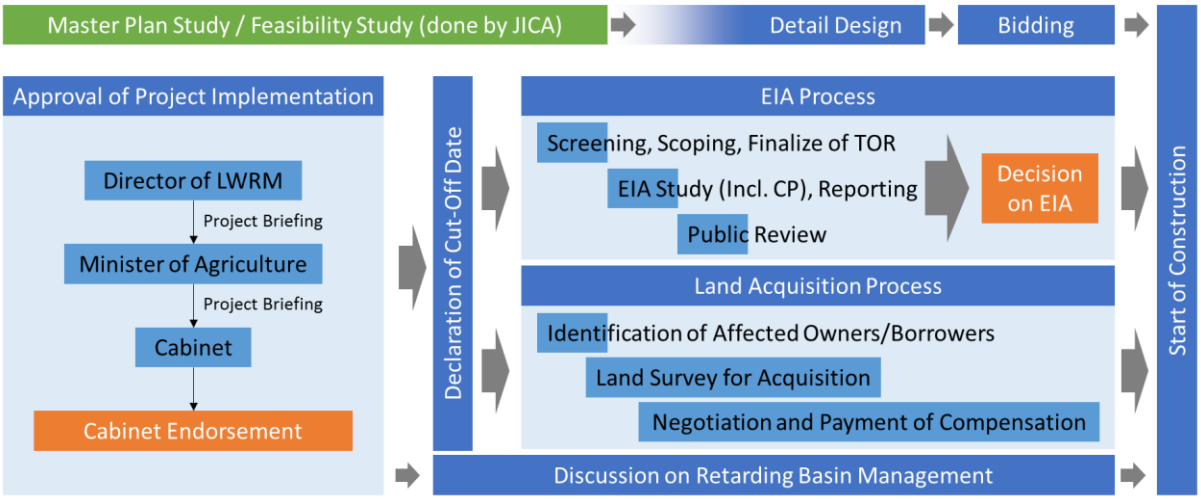
Through this Study, boundary of river area is established in the locations of priority project. The river area within the boundary shall be properly managed and utilization of the river area such as activity, building and land-use control shall be implemented with consensus building with relevant agencies, local governments and residents. Besides, the river boundary shall be clearly defined in the land-use plan of Nadi Town and surrounding areas.

The current river boundaries are set based on normal water levels in rainy season or past highest water levels, and its concept of river boundary setting is different from the concept of boundary setting for the priority project. Thus, current legal system for river boundary shall be reviewed.

(12) Further Process for Project Implementation by Fiji Side

1) Process to Project Implementation

Necessary process for implementation of the priority project is shown in Figure 14-OO which shall be commenced during or after F/S. Especially, EIA and land acquisition process shall be started immediately after approval of project implementation by the government of Fiji.



Source: JICA Study Team based on interview to Fiji Government

Figure12-4 Process for Project Implementation

2) EIA Proecss

Administrative process related EIA is governed by Department of Environment (DOE) of Ministry of Local Government, Housing and Environment and EIA of development project in whole country is handled by three EIA officers in DOE.

As described in Chapter 12, executing agency shall employ the registered EIA consultant for study and reporting related EIA. Screening to judge necessity of EIA, scoping to analyze estimated environmental impacts and to set survey items for EIA, and preparation and approval of EIA TOR can be implemented by executing agency itself.

All the necessary cost for EIA process shall be borne by each executing agency even public works (MOA in this project).

3) Land Acquisition Process

Administrative process related land acquisition is governed by Department of Lands (DOL) of Ministry of Lands and Mineral Resources. DOL provides documents to prove land ownership such as register book and executing agency conducts survey for land acquisition with utilizing private survey company. As to the public works, DOL can implement land acquisition survey by their survey unit when the unit has allowance in resources.

Based on survey results conducted by executing agency, compensation is determined through evaluation of land and building by Valuation Division of DOL and evaluation of crops by MOA. For public works, negotiation with land owners and related administrative process such as discussion with related agencies such as TLTB and Ministry of Town and Country Planning is conducted by DOL while financial arrangement and payment shall be done by executing agency. According to Valuation Division of MOA, half to one year period is required for land acquisition process for the priority project.

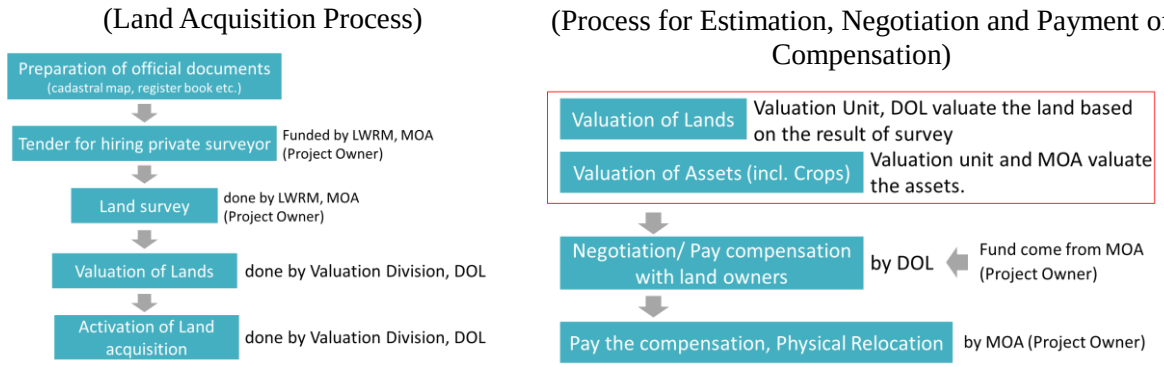


Figure12-5 Process and Responsible Organization for Land Acquisition

4) Management of Retarding Basin

Retarding basin, which is one component of the priority project, is newly introduced to Fiji by the Study and management system shall be established. According to DOL, regarding basins will be managed by LWRM as administrator. It is expected that retarding basin is managed with a guideline under current legal system which would be approved by Director of LWRM through dialogue between LWRM and DOL. Dialogue for establishment of retarding basin management system shall be commenced immediately after project approval. For a reference, examples of retarding basin management in Japan are shown below.

Chapter 13 Selection of the Priority Project

13.1 Structural Measures

Required structural measures were selected as the Priority Project aiming at prevention of flood in the flood protection prioritized area in the Nadi River basin as mentioned in Summary Report Chapter 7.8

Main components of Priority Project which were determined between JICA and Fiji government in JCC meeting is river improvement in middle stream of Nadi river.

However when the flood control measures in the middle stream is implemented as the priority project, the upstream dam proposed in the Master Plan is not yet completed so that the non-regulated flood discharge flow down into the middle stream section causing inundation in that area, therefore the retarding basins A and B are to be implemented for regulation of such flood discharge

After the implementation of flood control measures in the middle stream, the inundation is prevented in most of the area, however the inundation in a part of Nadi town which is important protected area is still left and due to the river widening in the middle stream, the inundation depth in downstream area increase a little bit (so called "negative impact"), therefore as countermeasures to the negative impact, surrounding dike around Nadi town and the ring dike in the downstream area are required.

And when the priority project is implemented, the river improvement and retarding basins in tributaries which are established in the Master Plan are not yet implemented so that the negative impact occurs in the tributaries due to stagnation of flood discharge from Nawaka and Mlakua Rivers at the confluence point of Nadi River and influence by the surrounding dike around Nadi town, therefore in order to reduce such negative impact, the short cut in the tributaries is required.

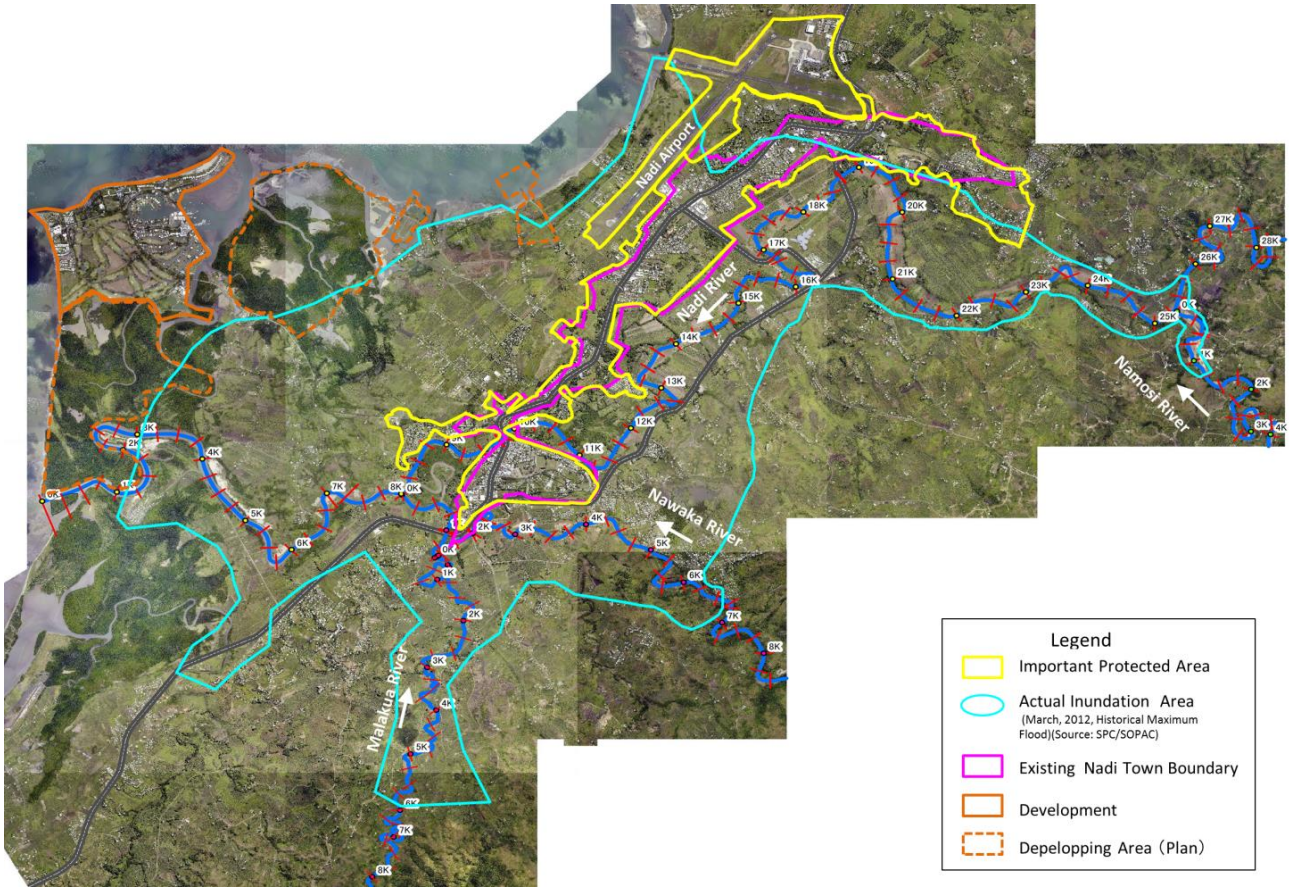


Figure 13-1 Important Protected Area

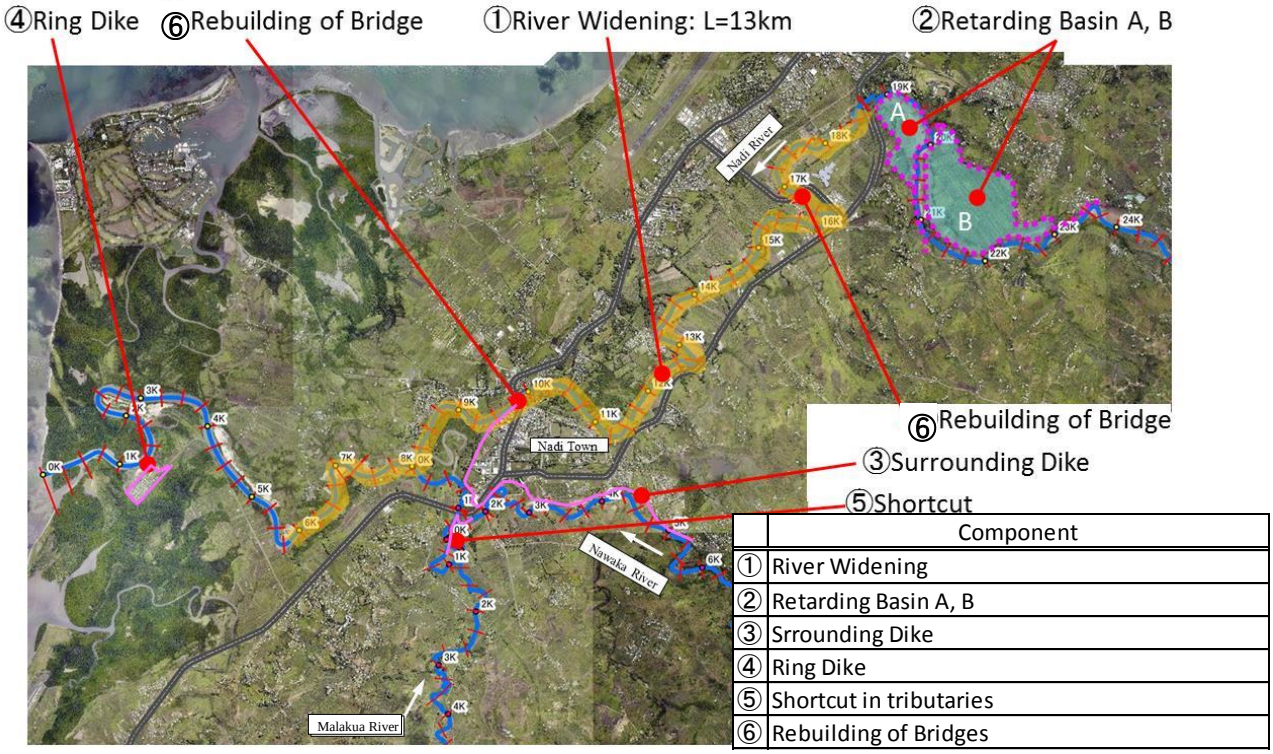


Figure 13-2 Contents of the Priority Project (Structural Measures)

Table 13-1 Contents of the Priority Project (Structural Measures)

	River, Location		Component of the Master Plan	Component of the Priority Project		Remarks
				Main Component	Quantities	
Structural Measures	1. Nadi River	Downstream	(1) Retarding Basin and River Improvement in downstream	—	—	—
			(2) Ring Dike	④ Ring Dike	L=1.8 km	—
		Middlestream	(3) River Widening[2)]	① River Widening Rebuilding of Nadi TOwn Bridge Rebuilding of Old Queens Road Bridge	L=13 km L=108 m L= 96 m	—
			(4) Retarding Basin A	② Retarding Basin A	A=35 ha V=795 千m3	
			Retarding Basin B	② Retarding Basin B	A=178 ha V=6,920 千m3	
		Upstream	(5) Dam and River improvement in upstream	—	—	—
	2. Tributaries	Nawaka Maralua Namosi River	(6) River Improvement	⑤ Shortsut of Tributaries ③-2 Surrounding Dike of Nadi Town	L=0.5 km L=4.5 km	Shortcut and Surrounding dike in tributaries are preceded to construction as part of the master plan
			Retarding Basins (13 sites)	—	—	

13.2 Non-Structural Measures

As mentioned above, protection of human lives, understanding of disaster risks and evacuation are considered as a top priority, under condition that the progress of structural measures project will be at initial phase.

Therefore, activities accompanied with development and disclosure of hazard maps and development of hydrological devices for awareness of flood risks will be implemented. In addition, in order to evaluate the effect of non-structural measures in the past or priority projects, and in order to connect to "Better disaster prevention", evaluation and feedback system on the past projects will be designed and built up.

Table 13-2 Contents of the Priority Project (Non-Structural Measures)

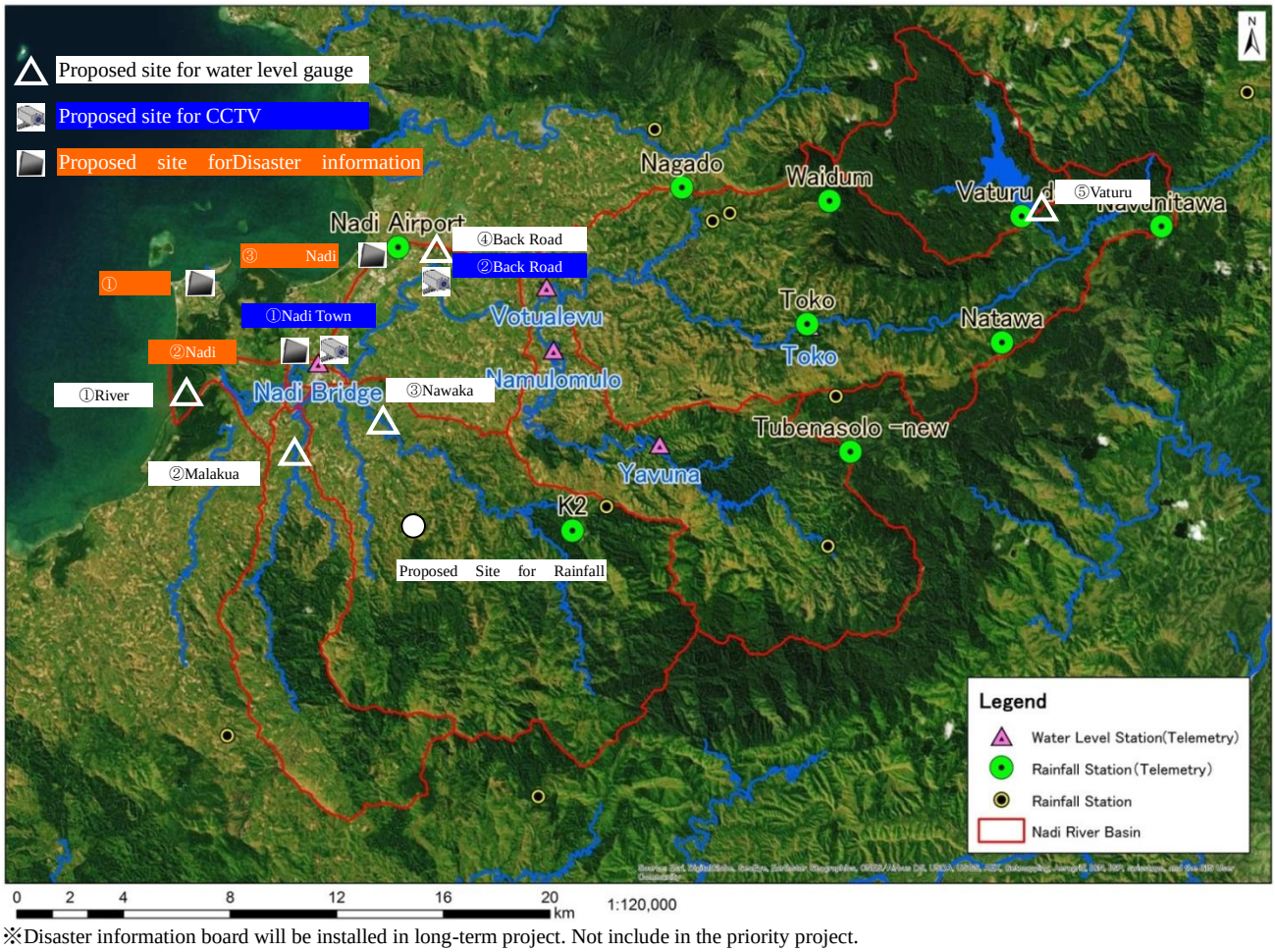
	Phase	Measures
Non-structural Measures	i) Priority Project (Short-term Measures)	・Understanding disaster risk and risk avoidance A) Strengthening of understanding flood risk with flood hazard map B) Strengthening flood forecasting technology, such as expansion of rainfall gauge, water level gauge and introduction of real-time monitoring camera ・ Better Disaster Prevention G) Establishing a system of evaluation of Pre-disaster activity / existing measures and feedback

As Non-Structure Measurement, selects strengthening flood forecasting technology, such as expansion of rainfall gauge, water level gauge and introduction of real-time monitoring camera.

Table 13-3 Summary of Non-Structure Measurement in the Priority Project

Development of Meteor-Hydrological Observation Network				
Equipment	Automatic precipitation gauge	Nos	1	To establish in Nawaka river basin,
	Automatic water gauge	Nos	7	To establish 4 equepments in river and 2 in retarding basin, 1 in dam
	CCTV	Nos	5	To establish 4 equepments in river and 2 in
communication equipment	Base unit for Meteor-Hydrological Observation Network	Nos	0	Use Existing system
Head Office	Base unit for CCTV	Nos	1	FMS
Disaster imformation Board	—	Nos	3	Nadi town, Denarau, Nadi Air port

※Disaster information board will be installed in long-term project ,Not include in the priority project



※Disaster information board will be installed in long-term project. Not include in the priority project.
Source: JICA Study Team

Figure 13-3 Draft Plan to establish Meteor- Hydrological Observation Network

Chapter 14 Components of Feasibility Study

The Components of Feasibility study are as shown in Table 14-1 and Figure 14-1.

The purpose of the Priority Project is to prevent inundation in Important Protected Area, which is located along the Nadi River (see area which is surrounded by yellow line in Figure 14-1)

Table 14-1 Components of the Priority Project

	River, Location		Component of the Master Plan	Component of the Priority Project		Remarks
				Main Component	Quantities	
Structural Measures	1. Nadi River	Downstream	(1) Retarding Basin and River Improvement in downstream	—	–	–
			(2) Ring Dike	④ Ring Dike	L=1.8 km	–
		Middlestream	(3) River Widening[2)]	① River Widening Rebuilding of Nadi TOwn Bridge Rebuilding of Old Queens Road Bridge	L=13 km L=108 m L= 96 m	–
			(4) Retarding Basin A	② Retarding Basin A	A=35 ha V=795 千m3	
			Retarding Basin B	② Retarding Basin B	A=178 ha V=6,920 千m3	–
		Upstream	(5) Dam and River improvement in upstream	—	–	
	2. Tributaries	Nawaka Maralua Namosi River	(6) River Improvement	⑤ Shortsut of Tributaries ③-2 Surrounding Dike of Nadi Town	L=0.5 km L=4.5 km	Shortcut and Surrounding dike in tributaries are preceded to construction as part of the master plan
			Retarding Basins (13 sites)	—	–	

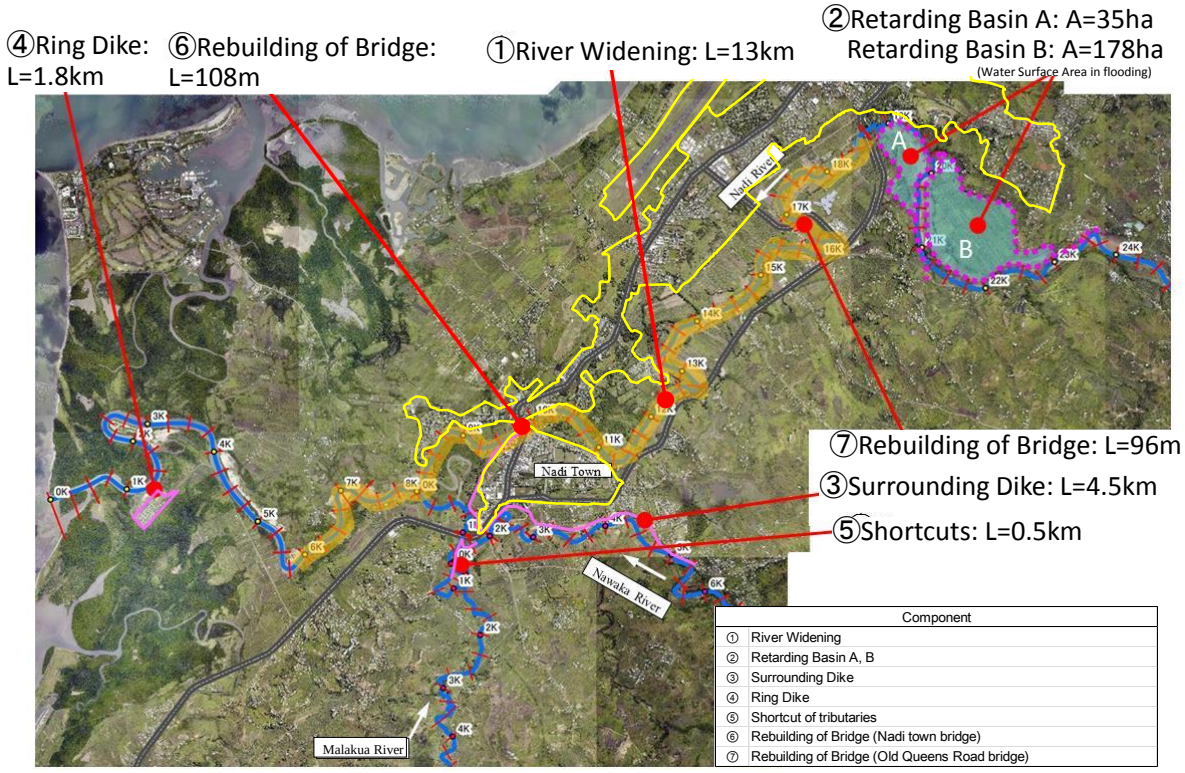


Figure 14-1 Components of the Priority Project