No.

MINISTRY OF DISASTER MANAGEMENT AND HUMAN RIGHTS

DEPARTMENT OF IRRIGATION OF THE MINISTRY OF IRRIGATION AND WATER MANAGEMENT

COMPREHENSIVE STUDY ON DISASTER MANAGEMENT IN SRI LANKA

FINAL REPORT

(MAIN REPORT)

MARCH 2009

JAPAN INTERNATIONAL COOPERATION AGENCY

ORIENTAL CONSULTANTS CO., LTD.

ASIAN DISASTER REDUCTION CENTER

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Foreign Currency Exchange Rates Applied in the Study

Master Plan Study

Currency	Exchange Rate/USD
Sri Lanka Rupee (LKR)	111.11 LKR
Japanese Yen (JPY)	119.64 円

(Averaged Rate from May 1 to August 31, 2007)

Action Plan of Priority Project

Currency	Exchange Rate/USD
Sri Lanka Rupee (LKR)	107.90 LKR
Japanese Yen (JPY)	105.47 円

(Averaged Rate from January 1 to May 30, 2008)

PREFACE

Based on a request from the Government of Sri Lanka, the Government of Japan responded by providing a development study to enhance the capacity of concerned organizations on the disaster management in order to reduce the damage by natural disasters. This study was conducted by the Japan International Cooperation Agency (JICA).

For this study, JICA sent a team headed by Mr. Toshiaki Kudo of the joint venture of Oriental Consultants Co., Ltd. and Asian Disaster Reduction Center, between October 2006 and February 2009. In addition, JICA also set up a monitoring mission to examine the study from specialist and technical point of views.

The team held discussions with the officials of the Government of Sri Lanka. They also conducted field surveys at the study areas. The final report and further studies were performed after the team returned back to Japan.

I hope that this report will contribute to the promotion of the project in Sri Lanka, and also enhance friendly relationships between our two countries.

Finally, I would like to express my sincere appreciations to the officials of the Government of Sri Lanka for their close cooperation extended to the study team.

March, 2009

Ariyuki MATSUMOTO
Vice-President
Japan International Cooperation Agency

March 2009

Mr. Ariyuki MATSUMOTO
Vice-President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

Dear Sir,

We are pleased to inform you that the team has finalized the study for enhancing the capacity of concerned organizations on the disaster management in Sri Lanka. And the final report, "Comprehensive Study on Disaster Management in Sri Lanka" has been submitted.

The study was performed from October 2006 to March 2009 by the joint venture of Oriental Consultants Co., Ltd. and Asian Disaster Reduction Center in accordance with the contracts between the Japan International Cooperation Agency and the joint venture. During the study, the team devoted their best efforts for enhancing the capacity of concerned organizations through conducting flood management planning, early warning and evacuation system planning, community-based disaster management activity, and capacity development activity.

All members of the study team wish to express their sincere appreciations to the personnel of your agency, monitoring mission, and the Embassy of Japan in Sri Lanka, and also to the officials of the Government of Sri Lanka, Ministry of Disaster Management and Human Rights and counterpart organizations such as Disaster Management Centre, Department of Irrigation, Department of Meteorology, National Building Research Organization including other related agencies for their cooperation extended to the study team.

The team sincerely hopes that the results of the study will contribute to the capacity development of concerned organizations on the disaster management in Sri Lanka.

Yours faithfully,

Toshiaki Kudo
Team Leader
Comprehensive Study on Disaster Management in Sri Lanka

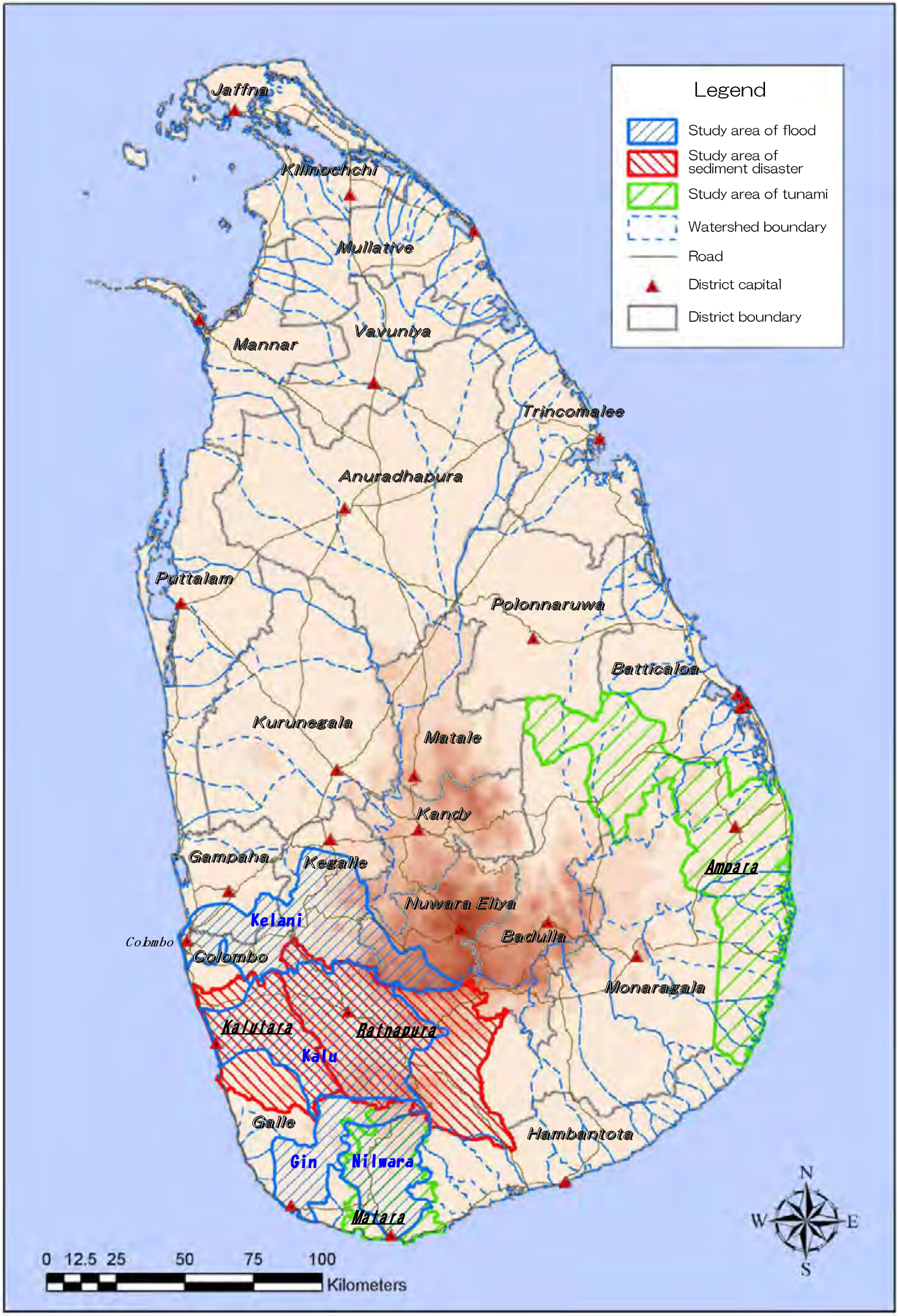


Figure 1 Location Map of Study Area

Figure 2 Location Map of Study Basin

Comprehensive Study on Disaster Management in Sri Lanka
Executive Summary

1. General

The overall goal of the Study is to develop plans to mitigate the damages caused by natural disasters in Sri Lanka such as flooding, sediment disasters and Tsunami, by strengthening the capacity of concerned organizations and communities. As a part of the activities towards achieving the overall goal, the following activities were implemented in this Study.

- To formulate integrated flood management plans for selected river basins in the south-western region of Sri Lanka
- To support the establishment of early warning and evacuation (EWE) systems
- To support community-based disaster management (CBDM) activities
- To strengthen capacity of concerned organizations

2. Flood Management Planning for Kelani, Kalu, Gin and Nilwara Rivers

Principal features of the four river basins are summarized in Table 1.

Table 1 Principal Features of Target Four River Basins

Item	Kelani	Kalu	Gin	Nilwara
Catchment Area (km^2)	2,292	2,719	932	971
River Length (km)	150	101	113	78
Annual Rainfall (mm)	3,800	4,040	3,290	2,890
Discharge Volume at River Mouth (MCM)	3,417	4,032	1,268	1,152
Districts	Gampaha, Colombo, Kegalle, Ratnapura, Nuwala Eliya	Kalutara, Ratnapura	Galle, Ratnapura	Matara, Galle
Population	2,773,000	1,127,000	490,000	459,000
Population in Flood Prone Area (% in Total Population)	150,000 (5.4%)	132,000 (11.8%)	32,000 (6.5%)	100,000 (21.8%)

Source: Prepared by the Study Team based on the information from DOI and other agencies concerned

Based on an overview of the current flood management situation in Sri Lanka, this Study applied the following six principles to review and formulate the flood management master plan:

- Minor floods should be prevented by structural measures and it should be done in short term projects. In order to accrue flood management benefit earlier with limited budget, certain downscaling from full target protection level should be considered by structural measures such as small scale river improvement with channel excavation and flood bund system, etc. in the short term.
- Further to above item, existing facilities should be utilized as much as possible to bring immediate

benefit to the project and to minimize the cost for implementation. However, through verification of current conditions of the existing structures (flood bund, sluices, pumping stations, etc.) in the four river basins, some of them were found to be out of operation due to lack of proper maintenance and/or over-aged facilities. Therefore, repair and/renewal of the existing facilities needs to be prioritized.

- Wetlands, which naturally serve as flood retention areas, should be utilized as retarding basins for major floods or severe floods. The function of such wetlands and marshes needs to be carefully verified and conserved with clear demarcation through flood zoning. In this connection, institutional and organizational strengthening of concerned governmental agencies needs to be incorporated.
- Environmental and social impacts should be minimized when target flood return period for structural measures are determined. Even considering affordability for implementation among stakeholders, environmental considerations and mitigation measures are essentially required. In Sri Lanka, securing concurrence on EIA (Environmental Impact Assessment) is required to implement the project.
- Optimal combination of structural and non-structural measures should be considered. It needs to be recognized that the role of non-structural measures in the current study is to support and enhance the benefit expected by structural measures. In this respect, appropriate menu of both measures needs to be examined based on particular conditions in the four river basins.
- Future climate changes need to be considered by means of enhancement of meteorological and hydrological monitoring networks. In addition, management of flood risk from severe floods mainly by non-structural measures will be inevitable to secure livelihood and human life of inhabitants in the flood prone area.

The definition and schedule of "Short Term Plan" and "Long Term Plan" in the proposed maser plan are shown below.

- Short Term Plan: Priority project to be implemented urgently (Schedule: 5 – 7.5 years)

- Long Term Plan: Project to be implemented in the mid-long term
  (Schedule: 9 – 15 years including short term plan period)

Flood Management Master Plan for Four River Basins

Structural Measures

Table 2 Major Structural Measures in Kelani River

	Kind of structure	Major dimensions
Short Term Plan	1. Improvement of existing sluices	Improvement of existing sluice gates (9 nos.), canal lining (L=200 m), bank protection (L=200 m)
	2. New sluices	Reconstruction (8 nos.), new construction (1 no.)
	3. Bank protection	L=670 m
	4. Flood bund (5-yr)	Left bank (L=15,060 m, H=3.4m) Right bank (L=19,640m, H=3.8m)
Long Term Plan	5. Flood bund heightening (20-yr)	Left bank (L=15,060m, H=4.6m) Right bank (L=19,640m, H=5.1m)
	6. Retarding basin	7 nos. (A=46.5 km^2)

Source: JICA Study Team

Table 3 Major Structural Measures in Kalu River

	Kind of structure	Major dimensions
Short Term Plan	1. New sluices	24 nos.(Kalutara area), 9 nos.(Ratnapura area)
	2. Ring levee in Ratnapura (10-yr)	Concrete wall (L=6.2 km, H=4.0 m) Embankment (L=6.4 km, H=4.0 m)
	3. Flood bund in Kalutara (10-yr)	Left bank (L=9,625 m, H=3.3 m) Right bank (L=11,730 m, H=3.2m)
Long Term Plan	4. Flood bund (heightening) (20-yr)	Left bank (L=9,625m, H=4.7 m) Right bank (L=11,730m, H=4.4m)
	5. New pump house	13 nos. (Q=3.0 m3/s, H=5.0 m)

Source: JICA Study Team

Table 4 Major Structural Measures in Gin River

	Kind of structure	Major dimensions
Short Term Plan	1. New sluices	9 nos.
	2. Rehabilitation of existing pumps	10 pump houses
	3. Mound dike	A=51,000 m^2 (3 sites)
	4. Flood bund (10-yr)	Left bank (L=8,360 m, H=5.4m) Right bank (L=7,620m, H=5.3m)
Long Term Plan	5. Flood bund (heightening) (30-yr)	Left bank (L=8,360 m, H=6.6m), Right bank (L=7,620m, H=6.3m)
	6. New pump house	8 nos.

Source: JICA Study Team

Table 5 Major Structural Measures in Nilwala River

	Kind of structure	Major dimensions
Short Term Plan	1. New sluices	11 nos.
	2. Rehabilitation of existing pumps	3 pump houses
	3. Mound dike	A=62,000 m^3 (3 nos.)
	4. Flood bund (10-yr)	Left bank (L=9,570 m, H=4.7m) Right bank (L=7,460m, H=4.4m)
Long Term Plan	5. Flood bund (Heightening) (30-yr)	Left bank (L=9,570 m, H=5.9m) Right bank (L=7,460m, H=5.5 m)
	6. New pump house	2 nos. (Q=3.0 m^3/s, H=5.0 m)

Source: JICA Study Team

Non-structural Measures (to proceed in parallel with the short-term plan)

Table 6 Non-Structural Measures to be Promoted

Measures	Major Items
1. Early warning and monitoring system (Four Rivers)	Kelani: 9 rain gauge stations, 3 hydrometric stations Kalu: 6 rain gauge stations, 3 hydrometric stations Gin: 8 rain gauge stations, 5 hydrometric stations Nilwala: 8 rain gauge stations, 6 hydrometric stations
2. Management of flood retarding basins (Kelani)	Delineation and legal designation of the retarding area for flood management Restriction of land use in retarding basin by law Strengthening of penalization against illegal activities in retarding basin
3. Restriction of further development in urban area (Four Rivers)	Management and monitoring of land use Prohibiting housing development in flood prone area Flood zoning with hazard mapping,

Measures	Major Items
4. Promotion of water-resistant architecture (Four Rivers)	Heightening of building foundation Construction of column-supported Housing, change to multi-storied housing Water proofing of wall/housing materials, etc.
5. Promotion of flood fighting activities (Four Rivers)	Information dissemination in the communities, Evacuation to safer area Removal of properties in house/building, etc.
6. Resettlement (Gin and Nilwala)	Mound dike
7. Institutional strengthening of implementing agency (Four Rivers)	Consensus building for project implementation Integration with urban development and land use development plans

Source: JICA Study Team

Selection of Priority Project

Kalu River Basin was selected as the priority river basin based on the evaluation results. Evaluation was made to compare the river basins from the viewpoints of economical, socio-environmental and technical aspects as well as the flood vulnerability

Aside from the Priority Project selected in the Kalu River basin, urgent implementation of repair/rehabilitation of the existing structures and non- structural measures are recommended, and rehabilitation of existing sluice and pumping station and protection works for existing flood bunds and non-structural measures such as early warning system in Kelani, Gin and Nilwara river basins are also identified as priority works.

Priority Project in Kalu River Basin

Outline of Priority Project

Table 7 Outline of Priority Project

River Basin	Selected Alternative	Component of Structural Measures
Structural Measures		
Kalu River	Flood bund system	i) Flood bund in lower reach (L=21,355m) - left(L=9,625m, H=3.3m) - right(L=11,730m,H=3.2m) - new sluiceway (24 nos) ii) Flood bund in upper reach (L=6,400m) - earth levee (L=5,350m, H=2.1-3.5m), - concrete wall (L=1,050,H=3.1m) - new sluiceway (11 nos)
Non-structural Measures		
Kalu River	(1) Early warning monitoring system (2) Restriction of further development in urban area (3) Promotion of water-resistant architecture (4) Promotion of flood fighting activities	・6 rain gauging stations ・3 hydrometric stations ・Management and monitoring of land use ・Prohibiting housing development in flood prone area ・Flood zoning with hazard mapping, ・Heightening of building foundation ・Construction of column-supported housing, change to multi-storied housing ・Water proofing of wall/housing materials, etc. ・Information dissemination in the communities, ・Evacuation to safer area, ・Removal of properties in house/building, etc.

River Basin	Selected Alternative	Component of Structural Measures
	(5) Institutional strengthening of implementing agency	・Consensus building for project implementation ・Integration with urban development and land use development plans

Source: JICA Study Team

Project Cost Estimate

Table 8 Project Costs of Priority Project

(unit: US$, thousand)

Item			Amount		
			FC	LC	Total
I.	Construction cost				
	A	New sluice	3,003	1,153	4,157
	B	Flood bund (Ratnapura)	9,025	3,467	12,492
	C	Flood bund (Kalutara)	8,954	3,020	11,974
	D	Early warning monitoring system	185	46	231
		Sub Total	21,167	7,686	28,854
II.	Land acquisition cost		0	17,920	17,920
III.	Engineering service cost		3,175	1,153	4,328
IV.	Administrative expenses		0	1,022	1,022
V.	Price escalation		3,290	4,751	8,041
VI.	Physical contingencies		2,434	2,778	5,212
VII.	Tax and duty		-	4,977	4,977
Grand Total			30,067	40,287	70,354

Source: JICA Study Team

Operation and Maintenance Cost

Operation and maintenance cost is 289,000 US$.

Implementation Schedule

The construction period of flood bunds in lower (Kalutara area) and upper reaches (Ratnapura area) is assumed 5 years respectively including detailed engineering design. Parallel construction of the two main civil works by dividing into two contraction packages is assumed. The implementation schedule is shown in figure 1.

Project Evaluation

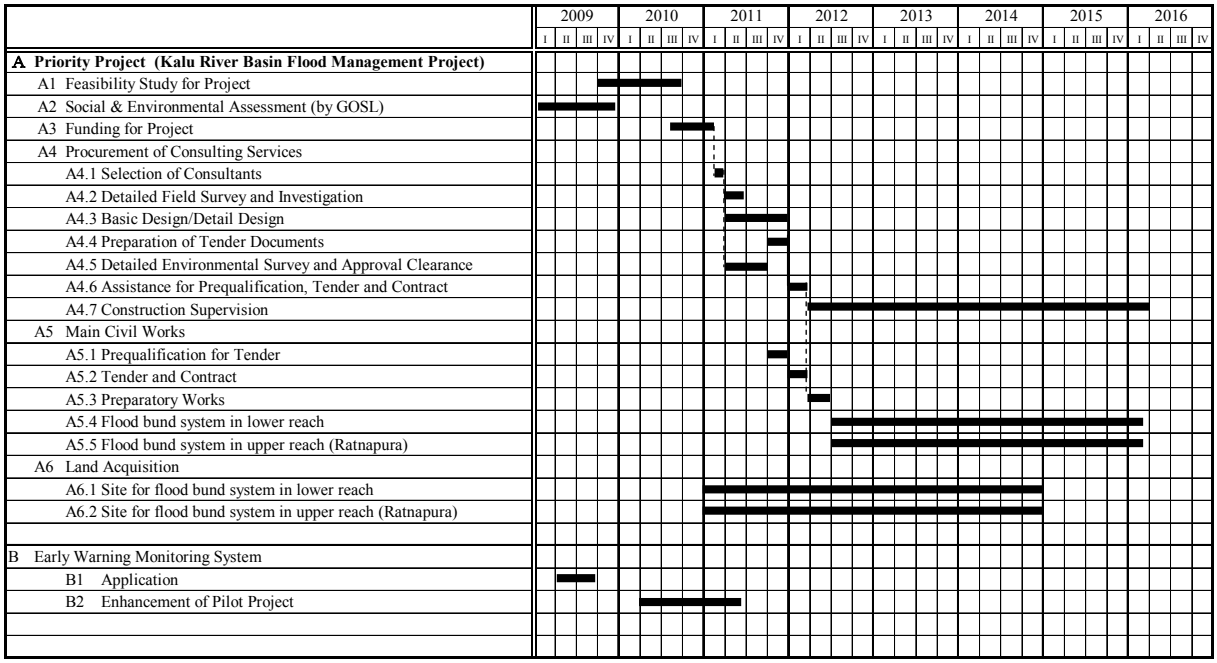
Table 9 Results of Economic Analysis of Priority Project

Index	Priority Project
B-C (Rs. mil.)	7,617
B/C	2.89
EIRR	23.5%

Source: JICA Study Team

Organization for Project Implementation

The executing agency of the project will be DOI taking account the mandate stipulated in the Flood Protection Ordinance, practical experiences of similar works for flood management and project management capability. To implement the project, establishment of a Project Implementation Unit (PIU) that exclusively manages in both technical and logistic aspects of the project" is the most suitable.



Source: JICA Study Team

Figure 1 Implementation Schedule

Required Environmental and Social Considerations

Under the Amended National Environmental Act No.56 of 1988, the activities of the Priority Projects are required to obtain environmental clearance through Environmental Impact Assessment (EIA). This must be conducted prior to the approval of the individual development projects. Initial Environmental Examination (IEE) for the structural measures has been completed in this study, and it concludes that further examination is required.

Recommendations for Flood Management

Common

- Implementation of integrated of water resources management; integration of water resources development and flood management
- Strengthening of capability development for project management
- Enhancement of technical capability (e.g. hydrological simulation, design of facility) for flood management
- Improvement of accuracy in hydrological and hydraulic analyses including consolidating basic data such as topographic data and observed hydrological data, etc.
- Improvement of data Management system of DOI
- Updating the hydrological models established in the Study
- Key Issues on Environmental and Social Consideration
- Institutional Strengthening of Irrigation Department (setting-up of Flood Management Sections)
- Setting-up of River Basin Forum
- Strengthening of Engagement in Climate Change

Kelani River Basin

- Early implementation of urgent works

- Hydrological and topographical analysis for available volume of the proposed flood retention retarding basin and institutional strengthening for protection of low-lying areas
- Early implementation of Non-structural measures
- Urgent rehabilitation works of existing structures
- Study on New Pumping Station

Kalu River Basin

- Early implementation of the Priority Project
- Forming Organization of Implementing Agency and Setting-up of River Basin Forum
- Further consideration for possibility of Malwala Multipurpose Dam scheme for integrated water resources management
- Incorporating the flood management concept to Ratnapura Urban Development Project
- Dredging for prevention of river mouth closure in Kalutara
- Monitoring of adverse affect on drainage system caused by the South Expressway Project

Gin River Basin

- Early implementation of urgent works
- Further consideration on hydrological/hydraulic and social aspects to address the people who are living in unprotected area
- Modernization/Rehabilitation of existing pumping stations
- Monitoring of adverse affect on drainage system caused by the South Expressway Project

Nilwala River Basin

- Early implementation of urgent works
- Study on gaps that is existing in the downstream reaches
- Detailed study on technical, environmental and social aspects for theTrans-basin Project at upstream area

3. Early Warning and Evacuation System Planning

Procedure of Planning

Procedure for Multi-Hazard EWE System planning is shown below.

Conceptual Planning

Information flow, methods of dissemination and role allocation of related organization from monitoring to warning issuance and to people's evacuation were shown in the concept design and table after discussion with GOSL. This conceptual plan was the basis of following activities.

Implementation of Pilot Project

Based on the conceptual plan of EWE system, Flood EWE system for Kelani and Kalu was established as a pilot project. The pilot project consists of following activities:

- Establishment of Hydrological Information System to automate hydrological monitoring
- Establishment of Intra-Governmental Network to share information among related organizations
- Recommendation of information dissemination method to people
- System development from monitoring to warning issuance, information dissemination and sharing,

evacuation instruction issuance and peoples evacuation, and implementation of disaster management exercise to trial the developed system

Review of Actual Events

Actual "Tsunami warning" was issued due to earthquake at Indonesia and flood disaster occurred due to heavy rainfall during this Study. These actual events were reviewed from the point of EWE system and issues and lessons were raised for system development.

Multi- Hazard EWE System Planning

Present conditions and issues of existing system were studied using the results of the above activities. Also, Multi-Hazard EWE System was planned with recommendation for implementation of the plan.

Multi-Hazard EWE System Plan

EWE System Plan is shown in the table below. Plan is divided into Short Term and Mid/Long Term Plan. Short Term Plan shall be conducted in 2 years, Mid Term Plan in 5 years, and Long Term Plan in 10 years.

Table 10 Short Term Plan

Category		Plan
Role Allocation		- Launching of Working Group for "Role Allocation" and signing agreement by related organizations
Risk knowledge	Flood	- Identification of risky area and interview survey to people - Comparison of interview result and water level data of nearby gauging station
	Landslide	- Identification of risky area - Community hazard mapping
	Tsunami	- community hazard mapping
	Common	- Launching of Working Group for "Hazard Mapping" and signing agreement by related organizations
Monitoring & Warning Service	Rainfall	- Preparation of action plan for accuracy improvement of rainfall forecasting with schedule of facility improvement
	Flood (slow)	- New construction and automation of monitoring stations at Gin and Nilwala river - Preparation of target water level for all stations of Kelani, Kalu, Gin and Nilwala - Setting warning criteria for stations which has enough data, by correlation analysis of water level at upstream and water level at downstream
	Flood (fast)	- Listing up of target areas and selection of priority area as model area - Installation of rain gauge and water level gauge at model area as pilot project and start monitoring - Accumulation of data at model area - Setting warning criteria by correlation analysis of rainfall amount at upstream and water level at downstream
	Landslide	- Start manual monitoring of daily rainfall at all risky DS and GN offices - Installation of automatic rain gauge with telemeter system at priority DS and GN offices - Collection of daily rainfall at nearby stations at the time of landslide - Upgrading warning criteria by correlation analysis of landslide occurrence and daily rainfall - Start same analysis using hourly rainfall data according to installation condition of rain gauge
	Community EWE System	- Identification of target areas for Community level EWE system - Monitoring of community activities where system is installed during JICA Study and expansion to other target areas
	Common	- Launching of Working Group for "Monitoring Station and Equipments" and singing agreement by related organizations

Category		Plan
		- Launching of Working Group for "Information Disclosure", and signing agreement by related organizations
		- Launching of Working Group for "Warning Service" and signing agreement by related organizations
Dissemination & Communication		- Discussion on Information flow, equipments, and rule of O&M etc. in the Working Group for "Role Allocation". And signing agreement by related organizations
Response Capability	Proper O&M	- Launching of following Working Groups and signing agreement by related organizations ・ Role Allocation ・ Hazard Mapping ・ Monitoring Station and Equipments ・ Information Disclosure ・ Warning Service ・ Disaster Management Exercise - Preparation of Emergency Response Manual - Periodical Implementation of Disaster Management Exercise
	CD of Officers	- Participation to meeting of Working Groups, preparation work of Emergency Operation Manual, Disaster Management Exercises, and Training Programs
	CD of People	- Continuous Community Activities - Implementation of Evacuation Drill and other exercise
	CD of DMC	- Implementation of EWE system plan by initiative of DMC

Source: JICA Study Team

Table 11 Mid Term Plan

Category		Plan
Risk knowledge	Flood	- Identification of risky area and interview to people - Comparison with water level data of nearby gauging station
	Landslide	- Identification of risky area - Community hazard mapping
	Tsunami	- community hazard mapping
Monitoring & Warning Service	Flood (slow)	- Expansion of new construction and automation of monitoring stations to other rivers - Preparation of target water level for all stations of Kelani, Kalu, Gin and Nilwala - Setting warning criteria for stations which has enough data, by correlation analysis of water level at upstream and water level at downstream
	Flood (fast)	- Expansion of installation of rain gauge and water level gauge to other target areas - Expansion to other target areas according to the condition of installation of rain gauge and water level gauge, and condition of accumulation of data
	Landslide	- Expansion of installation of automatic rain gauge with telemeter system to other DS and GN offices - Collection of daily rainfall at nearby stations at the time of landslide - Upgrading warning criteria by correlation analysis of landslide occurrence and daily rainfall - Start same analysis using hourly rainfall data according to installation condition of rain gauge
	Community EWE System	- Identification of target areas for Community level EWE system - Monitoring of community activities where system is installed during JICA Study and expansion to other target areas

Source: JICA Study Team

Table 12 Long Term Plan

Category		Plan
Risk knowledge	Flood	- Flood simulation by using detailed topographical map and hydrological data
	Landslide	- Upgrading community level hazard map by using detailed topographical map

Category		Plan
	Tsunami	- Tsunami simulation
Monitoring & Warning Service	Flood (slow)	- Expansion of new construction and automation of monitoring stations to other rivers - Accumulation of data and expansion to other stations and other rivers
	Flood (fast)	- Expansion of installation of rain gauge and water level gauge to other target areas - Expansion to other target areas according to the condition of installation of rain gauge and water level gauge, and condition of accumulation of data
	Landslide	- Expansion of installation of automatic rain gauge with telemeter system to other DS and GN offices - Upgrading warning criteria by correlation analysis of landslide occurrence, short term rainfall and cumulative rainfall

Source: JICA Study Team

Conclusion and recommendation on Early Warning and Evacuation System

Multi-Hazard EWE System was planned by five categories: "Role Allocation", "Risk Knowledge", "Monitoring & Warning Service", "Dissemination & Communication" and "Response Capability". Plans were divided into Short Term, Mid Term and Long Term. Concrete methods were described as much as possible for the short term plan and early implementation is expected.

For implementing Multi-Hazard EWE System Plan, implementation of the following activities is strongly recommended to address the above issues.

- Signing Agreement on Role Allocation
- Information Disclosure and Proper Warning Issuance
- Periodical Implementation of Disaster Management Exercise
- Establishment of Early Warning and Monitoring System for the Southern Western Four River Basins

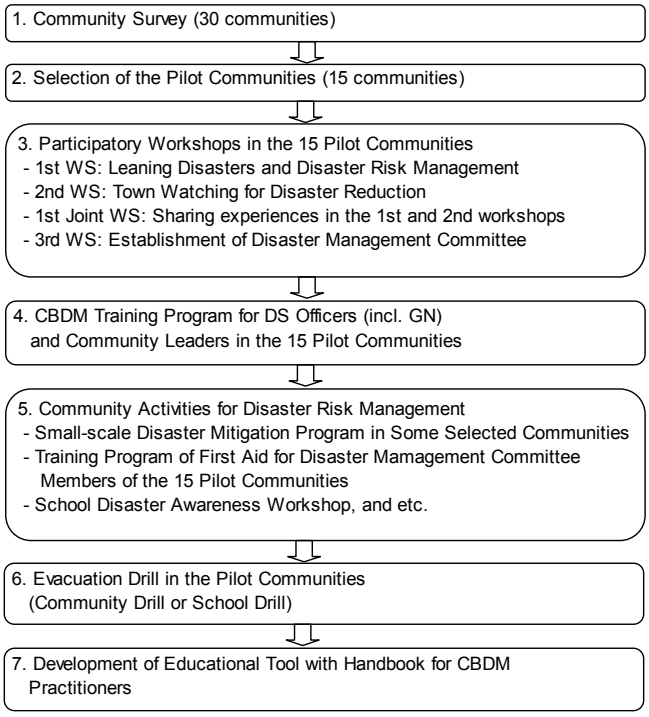
4. Community-Based Disaster Management Activity

Flow of CBDM Activity

Community-Based Disaster Management (CBDM) Activity of this Study has been conducted in accordance with the flow described in Figure in close cooperation with the DMC, as well as the technical counterpart organizations such as DOI and NBRO.

Community Activities

The 15 pilot communities were selected based on the result of a preliminary survey on social condition, disaster situation, disaster risk management system in community and recommendation from DMC, DOI, and NBRO



Source: JICA Study Team

Figure 2 Flow of the Activities of Community-Based Disaster Management

Table 13 Selected 15 Pilot Communities for Community Activities

Type of Disasters	Target Areas	Target Communities	G.N..	Division	District
Flood	Kelani River basin	Kittampahuwa	Kittampahuwa	Kolonnawa	Colombo
		Malwana Town*	Malwana Town	Biyagama	Gampaha
	Kalu River basin	Angammana	Angammana	Ratnapura	Ratnapura
		Mudduwa	Mudduwa	Ratnapura	Ratnapura
		Ukwatta	Ukwatta	Dodangoda	Kalutara
	Gin River basin	Baddegama	Baddegama	Baddegama	Galle
	Nilwala River basin	Kadduwa	Kadduwa	Malimbada	Matara
Sediment Disasters	Ratnapura District	Kiribathgala	Wanniyawatta	Nivithigala	Ratnapura
		Helauda	Mahawala	Ratnapura	Ratnapura
	Kalutara District	Niggaha	Niggaha	Bulathsinhala	Kalutara
		Nagalakanda	Kananvila-south	Horana	Kalutara
Tsunami	Matara District	Gandara South	Gandara	Devinuwara	Matara
		Kottegoda	Suduwella	Dickwella	Matara
	Ampara District	Sinna Ullai	Sinna Ullai	Pothuvil	Ampara
		3rd Section	Vinayagapuram	Thirukkovil	Ampara

Source: JICA Study Team

Community Participatory Workshops and Joint Seminars

Total of five community activities including community participatory workshops and evacuation drill were conducted in each pilot community, and joint seminars that representatives of the pilot communities and local government officers were invited were conducted as the CBDM activities of this Study.

Activities Conducted for Supporting the Community's Efforts

Besides of the above mentioned series of activities, the activities to support community's efforts for proceeding CBDRM activities such as "Small-scale Mitigation Program for the Pilot Communities Vulnerable to Sediment Disaster" in Ratnapura District and "River Water Level Monitoring Activity in Flood Prone Community" in Colombo and Gampaha District, "Consultative Meeting on Flood Bund Gate in Matara District, "One day First Aid Training for G.N. Level DM Committee Members at each District", and "Activities Approaching from School Children" were conducted.

Development of Educational Tool for CBDRM Activities

An educational tool for the CBDM named "Fliptation (a combination word of flip chart and presentation)" was developed based on the experience in the JICA Study program. Main objectives of the development are to make CBDRM practitioners' efforts easier and to ensure dissemination of appropriate knowledge about disaster mechanism by the standardized and easy-understandable educational tool. Further, Fliptation is suit for the on-site community activities because they are not require electricity or advanced presentation equipment. The composition and main contents of the "Fliptation" is as describes in Table 14.

Table 14 Composition and Main Contents of "Fliptation"

Theme	Main Contents	Specification
CBDRM Activities	- Outline of CBDRM Activities - Importance of Knowing Risks - Community-based Hazard Mapping - Formation of Disaster Management Committee	Total 19 pages on A1 durable material

Theme	Main Contents	Specification
	- Disaster Management Drill - Disaster Risk Management Plan	
Mechanism of Disasters and Disaster Reduction - Volume 1: Flood - Volume 2: Sediment Disasters - Volume 3: Tsunami	- Mechanism of Disasters - Major Historical Disasters in Sri Lanka - Structural Measures to Mitigate Disaster Damages - Non-structural Measures to Mitigate Adverse Impact of Disasters	10 pages for each volume on A1 durable material

Source: JICA Study Team

Conclusions and Recommendations on CBDM Activities

All the planned community activities in the Study were completed without any big issues and problems in close cooperation with the counterpart organizations and concluded with tangible achievement. Persons involved in the activities could develop their capacities to deal with CBDRM activities at each of levels of their responsibilities. In the meanwhile, the following points could be reviewed and recommended for further improvement of CBDRM activities in Sri Lanka.

- Enhancing Capacities of Local Authorities and Local Bureaucracies for Sustainable CBDRM Activities
- Promotion of Activities which Needs Continuous Actions of Community Members for Ensuring Sustainability
- Encouraging More Active Involvement of Officers of Technical Organizations in CBDRM Activities
- More Implementation of Community Evacuation Drill combined with Government-level Information Transfer Exercise
- Promotion of Public Awareness through School Activities for Disaster Reduction
- Effective Utilization of Developed Educational Tool "Fliptation" for CBDRM
- Formulation of Program to Make Effective Implementation of CBDRM Activities

5. Capacity Development

Capacity development plan that targets the counterparts and their organizations and selected communities in Component 3, was formulated with the CD goal of 1) At the end of the Study, an end-to-end early warning system established by the pilot project of this Study will be operating well, and 2) At the end of the Study, a flood management plan and flood warning plan is to be prepared/revised based on the resources from Sri Lanka.

Table 15 Capacity Development Plan for Selected Organizations

	Individual Goals/Outputs	Mode of Activity
DMC	・ Enhance capability as leading agency of disaster management ・ Enhance capacity on Coordination, decision-making and information transfer	a), b), c), f) Overseas training Trainers Training for DDMCU
DOI	・ Enhance technical capabilities ・ Develop capability to revise the plan by conducting engineering analysis ・ Complete flood monitoring network and set up of flood warning criteria ・ Develop capability to issue warning without delay ・ Provide technical information on flood to community-based activity	a), b), c), f) Overseas training

	Individual Goals/Outputs	Mode of Activity
NBRO	・ Enhance technical capabilities ・ Set warning criteria for landslide ・ Establish early warning system for landslide ・ Provide technical information on landslide to community-based activity ・ Obtain capacity to predict disaster event	a), b), c), f) Overseas training
DOM	・ Enhance technical capabilities ・ Develop capability to forecast hazardous weather based on past experience ・ Develop ability to provide real-time based weather information to relevant organizations including media in an understandable manner	a), b), c), f) Overseas training
DDMCU	・ Enhance DM capacity in total ・ Develop proper knowledge on hazard which happens in their place ・ Acquire proper knowledge on disaster management in mitigation, preparedness and response ・ Timely transfer of proper disaster information in an understandable manner	b), c), d), e), f) Overseas training Trainers Training for Sub-National Gov. Organization
Sub-National Level Gov. Organization	・ Enhance DM capacity in total ・ Develop proper knowledge on hazard which happens in their place ・ Acquire proper knowledge on disaster management in mitigation, preparedness and response ・ Transfer disaster information properly	c), d), e), f) Overseas training
Community	・ Enhance DM capacity in total ・ Acquire proper knowledge on disaster and their role in disaster management ・ Ability to follow proper procedure in case of warning receive ・ Get ready in case of emergency ・ Formulate community-based disaster management organization ・ Coordinate community-based DM activity by themselves	c), d), e)
Media/ Society	・ Increasing involvement in disaster management ・ Allocate and achieve certain roles in disaster management ・ Transfer proper disaster information or forecast through the media in time ・ Allocate space for synoptic weather chart on newspaper or broadcast synoptic weather chart regularly	b), c), e), f) MOU preparation

Note: a) Day-to- day working with Study Team, b) Counterpart meetings, c) Drills, d) Seminars, e) Workshops, f) Others
Source: JICA Study Team

Capacity Development Activities

Seminars and Counterpart Meetings

Three seminars and 18 counterpart meetings were taken place during the course of the Study.

Capacity Development Activity for Early Warning and Evacuation System

Ensuring the effectiveness and sustainability of the proposed early warning and evacuation (EWE) system plan, the capacity development activities focusing on the enhancement of the planning capacity as well as the operational capacities, were conducted during the EWE system planning process by adapting a combined approach of "participatory planning process" and "exercise implementation".

Overseas Training in Japan

Seven counterpart members, 4 in 2007 and 3 in 2008, took the overseas training program in Japan during the Study period.

Evaluation of the Capacity Development

As for the first objective, the flood early warning system established in the Pilot Project is currently functioning well as a whole even though some shortcomings have been observed. Regarding the planning capacity (second objective), the understanding of flood management planning in general have been deepened, however, the capacity enhancement on technical elements, e.g. simulation techniques, has not

been fully achieved. It is considered that the necessary capacity for the EWE planning has already been obtained because the DMC centered coordinating mechanism has been established and the organizations concerned with the early warning system understood their role and responsibility.

Table 16 summarizes the results of the evaluation and future CD requirements for each organization.

Recommendations

- Recruiting of Talented Personnel and Human Resources Development in DMC and DDMCU
- Capacity Enhancement of Local Level Government Organizations
- Preparation and Consolidation of the Information related to Disaster Management Activities and its Sharing
- Focus on Disaster Forecast and Adaptation of Climate Change
- Implementation of Continuous and Repeated Disaster Management Activity
- Stronger Cooperation with Concerned Organizations
- Establishment of Flood Management Division

Table 16 Capacity Development Planning for Selected Organizations

	Evaluation	Further Requirements on CD
DMC	As far as the EWE system planning and CBDM activities in this Study, DMC lead the meeting and activities, and has been recognized as leading organization of DM. Implemented DM exercise 3 times. Dissemination capacity of disaster information has been increased however appropriateness on information dissemination still needs to be improved.	・ Repeated exercise ・ Further discussion on early warning ・ Prepare basic information for precise early warning
DOI	Most of the staffs of the Hydrology division become familiar to the hydrological information system. Increment of staffs that can operate the application for simulation is limited. Warning criteria and time for early warning issue is not sufficiently improved.	・ Expanding early warning system to other river basins ・ Continuous monitoring and analysis on flood data ・ Further discussion on the flood early warning criteria with other organizations ・ Training on staff to acquire proper knowledge for early warning ・ Training on the hydrological information system and simulation software
NBRO	The warning criteria have not decided in the Study and the early warning system for landslides has not completed yet but the community level warning system has been progressed. Warning can be issued relatively in time and frequency of warning is increased.	・ Continuous monitoring and analysis on landslide data for enhancing a capacity to issue landslide warning ・ Continue hazard/risk assessment ・ Training on staff to acquire proper knowledge for early warning
DOM	Real-time basis weather observation will be completed by the end of Feb. 2009. Capacity enhancement for forecasting weather based on the past experience is still not enough	・ Enhancing realtime observation capacity and forecasting capacity based on the realtime data ・ Analysis on the relationship between past disaster event and weather condition

	Evaluation	Further Requirements on CD
DDMCU	Capacity of DDMCU, especially target areas for the Pilot Project has been enhanced in general. Increased awareness on community- based activities and an early warning system can be seen from their attitude. However, in view of appropriateness, information dissemination capacity is still not insufficient level.	・ Continue and expand the activities that have been done in the Study ・ Training to DM coordinators and his staffs to acquire proper knowledge on DM ・ Expand the Intra-Gov. Network to other DDMCU offices
Sub-National Level Gov. Organization	Capacity of officers who participated workshops / seminars and exercises considered to be remarkably enhanced, and they showed that have sufficient capacity to deal with a part of DM activity. However, due to small number of target organizations, capacity in general not so much enhanced in the Study.	・ Continue and expand the activities that have been done in the Study ・ Training to sub-national government officers to acquire proper knowledge on DM
Community	Knowledge and ability to cope with disaster in target communities are considered to be increased. Two landslide prone communities and two flood prone communities are started disaster mitigation activities by themselves. However, due to small number of target communities, capacity in general not so much enhanced in the Study.	・ Continue and expand the activities that have been done in the Study ・ Training to community leaders to acquire proper knowledge on DM
Media/ Society	Media people who attended the planning process and exercise of the Early Warning have got increased awareness on it, and appointed the focal point for disaster information dissemination. They have enough capacity to disseminate the information, if they have information in time. Discussion on the involvement of society other than media has not been taken place sufficiently. Community people show the different evacuation behavior based on their disaster experience.	・ Continue discussion on role of media/society in disaster management and how they can contribute ・ Continue disaster education

Source: JICA Study Team

6. Conclusions and Recommendation

Conclusion

In the wake of the recent large-scale disasters especially the Tsunami disaster in December 2004, the disaster management system in Sri Lanka has changed meaningfully. While four years have passed since the devastating tsunami disaster and the memories of this catastrophe are fading with time, the Government of Sri Lanka is strengthening disaster management administration, particularly the strengthening of DMC. The Study also has greatly contributed for the development of the capacity of disaster management in Sri Lanka.

Recommendations

- Authorizing the plans presented in this Report and their early implementation
- Establishment of DMC's core areas and implementing focused activities in them
- Preparation, consolidation and sharing of the information related to the disaster management
- Implementation of the structural measures
- Definition and designation of the disaster areas, conservation areas and public water body in written format
- Incorporating disaster management into development and enforcement of Disaster Impact Assessment (DIA)
- Promotion of cooperation among concerned organizations

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ABBREVIATIONS

ADB	Asian Development Bank
CBDM	Community-based Disaster Management
CBDRM	Community-based Disaster Risk Management
CD	Capacity Development
CIDA	Canadian International Development Agency
DANIDA	Danish International Development Agency
DDMCU	District Disaster Management Coordinating Unit
DHI	Danish Hydraulic Institute
DIG	Disaster Imagination Game
DMC	Disaster Management Centre
DOI	Department of Irrigation
DOM	Department of Meteorology
DM	Disaster Management
DM Coordinators	District Disaster Management Coordinators
DRM	Disaster Risk Management
DS	Divisional Secretary
EOC	Emergency Operation Centre
ESCAP	United Nations Economic and Social Development in Asia and the Pacific
EWC	Early Warning Committee
EWE	Early Warning and Evacuation
GA	Government Agency
GN	Grama Niladhari
GOJ	Government of Japan
GOSL	Government of Sri Lanka
GTZ	German Technical Cooperation
GWh	Giga Watt hour
JICA	Japan International Cooperation Agency
LHI	Lanka Hydraulic Institute
LSSD	Landslide Studies & Service Division of NBRO
M/DM&HR	Ministry of Disaster Management and Human Rights
MCM	Million Cubic Meters
MSL	Mean Sea Level
MW	Mega Watt
NBRO	National Building Research Organization
NCDM	National Council for Disaster Management
NIE	National Institute of Education
RDA	Road Development Authority
the Study	Comprehensive Study on Disaster Management in Sri Lanka
UDA	Urban Development Authority
UNDP	United Nations Development Programme
UN/ISDR	United Nations International Strategy for Disaster Reduction
WB	The World Bank
WS	Workshop

Part I: Introduction

PART I INTRODUCTION

CHAPTER 1 GENERAL

In recent years, several large-scale disasters have devastated Sri Lanka (e.g. floods and landslides in 2003 and the Indian Ocean Tsunami on December 2004). In the wake of these disasters, the Government of Sri Lanka (GOSL) announced a policy to reinforce the national level disaster management system and Sri Lanka. Disaster Management Act No. 13 of 2005 set up the comprehensive framework from prevention/mitigation, preparedness, emergency response and rehabilitation covering not only natural disasters but also all kinds of disasters.

Based on the Act, the National Council for Disaster Management (NCDM), a decision making body for disaster management, was established. This Council is headed by the President and its members are composed of Ministers of relevant agencies and the Disaster Management Centre (DMC), the national level planning and coordinating body for disaster management. DMC carries out disaster management planning and coordinates with related organizations that provide disaster management services at both national and sub-national level.

However, in the result of the project formulation study "Program on Strengthening the Disaster Management Administration" conducted by Japan International Cooperation Agency (JICA) from September 2005 to March 2006, the following problems were identified regarding disaster management against natural disasters.

- Insufficient measures for water-related disasters such as flood and sediment disaster
- Insufficient efforts for non-structural measures such as early warning and evacuation planning and community-based disaster management (CBDM)
- Inadequate capacity of and cooperation among the DMC and related organizations

Under these circumstances, GOSL requested the Government of Japan (GOJ) to implement a study that will develop plans to solve the abovementioned problems, with particular focus on how to mitigate the damages. GOJ decided to implement the Comprehensive Study on Disaster Management in Sri Lanka (the Study), and GOSL and GOJ agreed on the Scope of the Study on 22 June 2006.

In accordance with the Scope of Work, JICA dispatched the Study Team on October 2006. The Study Team submitted and explained the Inception Report (IC/R) of the Study to the Sri Lankan side at the Steering Committee Meeting on 18 October 2006, after which the Study officially started.

In February 2009, the Study Team completed all field activities in Sri Lanka and this Final Report was prepared to summarize the Study.

CHAPTER 2 OBJECTIVES OF THE STUDY

The overall goal of the Study is to develop plans to mitigate the damages caused by natural disasters in Sri Lanka such as flooding, sediment disasters and Tsunami, by strengthening the capacity of concerned organizations and communities. As a part of the activities towards achieving the overall goal, the following activities will be implemented in this Study.

- To formulate integrated flood management plans for selected river basins in the south-western region of Sri Lanka
- To support the establishment of early warning and evacuation (EWE) systems
- To support community-based disaster management (CBDM) activities
- To strengthen capacity of concerned organizations

CHAPTER 3 STUDY AREA

The Study Area covers the entire country of Sri Lanka, with particular focus on the disaster-prone areas of the country in the southeast and southwest which are coded in the map below.

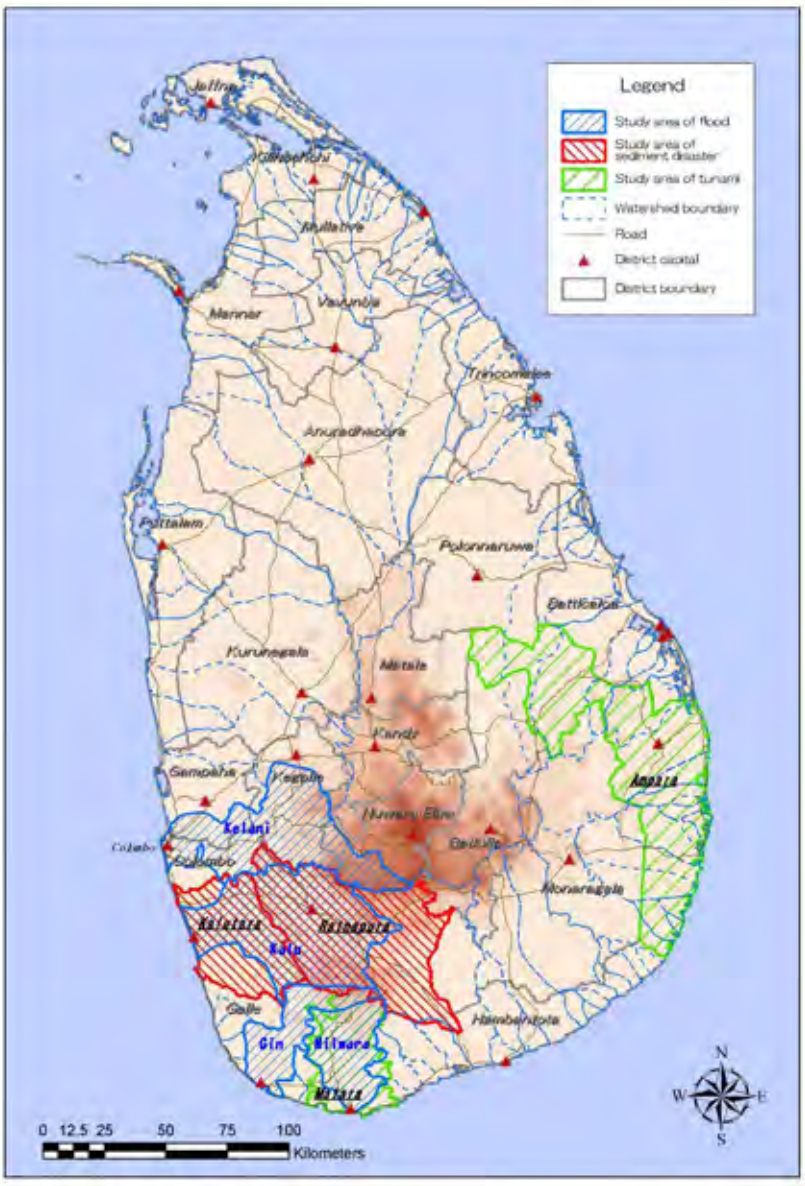


Figure I-1 Study Area

CHAPTER 4 SCOPE OF THE STUDY

The Study is composed of four components, namely: 1) Integrated flood management planning in Kelani, Kalu, Gin, and Nilwala Rivers, 2) EWE systems, 3) CBDM, and 4) Capacity building of organizations concerned. Table I-1 lists the specific items that will be covered by the Study.

Table I-1 Scope of the Study

Component	Scope of Work
Component 1: Integrated Flood Management Planning in Kelani, Kalu, Gin, and Nilwala Rivers	1. Collection, review and analysis of data and information
	2. Examination on characteristic of vulnerability and hazard
	3. Evaluation of current disaster mitigation measures
	4. Flood Risk assessment
	5. Flood Management planning through a review of existing master plans and integration of structural as well as non-structural measures
	6. Selection of priority areas and projects
	7. Formulation of action plan
	8. Initial environmental evaluation
Component 2: EWE System	1. Collection, review and analysis of data and information
	2. Institution, law and regulation survey
	3. Designing concept of EWE system
	4. Pilot project planning in Kelani River basin
	5. Pilot project implementation in Kelani River basin
	6. Support to establishment of flood EWE system in Kalu, Gin, Nilwala Rivers
	7. Support CBDM activities and evacuation drills
Component 3: CBDM	1. Collection, review, survey, and analysis of related data and information
	2. Selection of pilot communities in tsunami, flood and sediment disasters
	3. Support to CBDM activities in prioritized communities
	4. Evaluation
	5. Preparation and dissemination of CBDM manual to concerned organizations
Component 4: Capacity Building of Organizations Concerned	1. Needs Assessment on capacity building
	2. Recommendation on institutional strengthening
	3. Preparation of materials for operation and maintenance
	4. Formulation of capacity building plans
	5. Implementation of training programs and workshops for concerned organizations' staff
	6. Provision of technical advice on ongoing projects on a day-to-day basis

CHAPTER 5 TIME SCHEDULE OF THE STUDY

The Study started in September 2006 and completed in March 2009. During the two and a half year study period, a lot of activities are being conducted in accordance with the Scope of work of the Study. The Study schedule with milestone activities is summarized in the following figure.

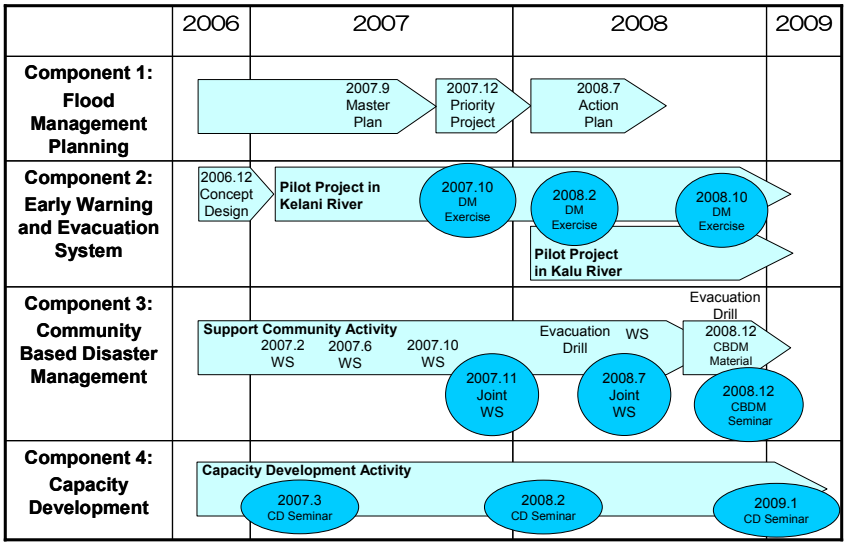


Figure I-2 Schedule of the Study

CHAPTER 6 ORGANIZATIONAL STRUCTURE OF THE STUDY

6.1. Organizational Structure of the Study

The Study Team has been working closely with the counterpart organizations of DMC, Department of Irrigation (DOI), National Building Research Organization (NBRO) and Department of Meteorology (DOM) to achieve the abovementioned objectives. JICA also dispatched monitoring missions to Sri Lanka in October 2006, October 2008 and January 2009. The monitoring mission team discussed with the counterparts as well as visited sites, and gave technical advice to JICA for effective implementation of the Study. The Study has following organizational Structure.

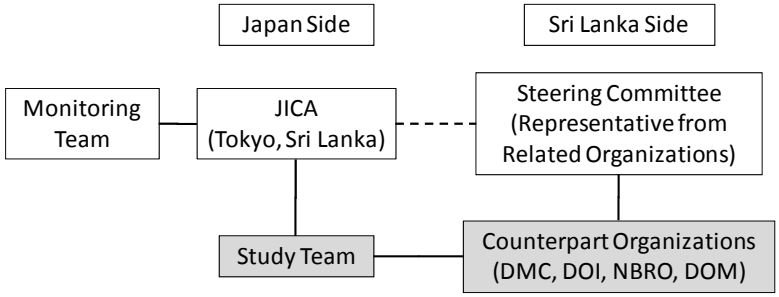


Figure I-3 Organizational Structure of the Study

6.2. Members of the Study

6.2.1 Steering Committee and Counterparts

In order to take smooth implementation of the Study as well as technology transfer to GOSL officials, GOSL formed a steering committee and assign counterpart personnel for the Study:

Steering Committee:

(1) Secretary, Ministry of Disaster Management and Human Rights (Chair)
(2) Director General, DMC
(3) Director General, DOM

(4) Director General, DOI
(5) Director General, NBRO
(6) Director General, External Resources Department, Ministry of Finance and Planning
(7) Director General, National Planning Department, Ministry of Finance and Planning
(8) Representative of Ministry of Irrigation and Water Management
(9) Representative of Ministry of Environment
(10) Other organizations concerned, if necessary

Counterparts :

(1) DMC: Disaster management planning, community based disaster management, and early warning system
(2) DOI: Flood early warning system, and flood mitigation
(3) NBRO: Sediment Disasters
(3) DOM: Meteorological observation

6.2.2 Monitoring Team Members

(1) Mr. Satoru NISHIKAWA, Ministry of Land Infrastructure, Transport and Tourism (MLITT)
(2) Mr. Junichi YOSHITANI, Public Works Research Institute
(3) Mr. Junichi KURIHARA, Nagano Prefectural Government

6.2.3 Study Team Members

The Study Team consists of 22 experts covering all aspects of the study as follows:

Table I-2 Members of the Study

Responsibility	Name
1. Team Leader	Toshiaki KUDO (Sep. 2008 - Mar. 2009)
	Kimio TAKEYA (Sep. 2006 -Aug. 2008)
2. Disaster Management Administration 1	Ryo MATSUMARU (Deputy Leader: Disaster Management Planning)
3. Disaster Management Administration 2	Koji SUZUKI
4. Flood Management Planning	Yoshihiro MOTOKI (Deputy Leader: Flood Management Planning)
5. Hydrology/Hydraulics	Borala Liyanage JAYARATNE
6. Flood Vulnerability Evaluation/Project Evaluation	Kenji MORITA
7. River Structures	Hikaru SUGIMOTO
8. Cost Estimation/Project Management	Tadahiro FUKUDA
9. Land Use Planning	Yuko SAKAI
10. Environment	Naohito WATANABE
11. Early Warning and Evacuation (EWE) Planning	Yoshihiko UCHIKURA (Deputy Leader：EWE)
12. Early Warning and Evacuation System Planning 1	Hiroaki KURITA
13. Early Warning and Evacuation System Planning 2	Hirotsugu KATO
14. Disaster Management Exercise	Shinya TANAKA
15. Disaster Management Exercise 2	Chiho OCHIAI
16. Meteorological Observation	Chuji YAMAMOTO
	Masahiro SATO

Responsibility	Name
17. Community Disaster Management 1 (Disaster Management Activities)	Miki KODAMA
18. Community Disaster Management 2 (Disaster Management Education)	Akiko NAKAMURA
19. Sediment Disaster	Satoru TSUKAMOTO
20. Social Consideration/Coordination	Chiho OCHIAI
	Natsuko SEKIGUCHI
21. Enlightenment / Publicity	Chiho Ochiai

CHAPTER 7 STRUCTURE OF THIS REPORT

This Final Report presents the overall output of the Study. It is composed of four separate volumes: namely Summary, Main Report, Supporting Report and Data Book.

The contents of each volume are summarized in the table below:

Table I-3 Composition and Contents of the Report

Volume	Contents
Summary	Summary
Main Report	Part I: Introduction
	Part II: Flood Management Planning for Kelani, Kalu, Gin and Nilwara Rivers
	Part III: Early Warning and Evacuation System Planning
	Part IV: Community Based Disaster Management
	Part V: Capacity Development
	Part VI: Conclusion and Recommendations
Supporting Report	A: Current Condition and Master Plan Formulation
	B: Hydrological and Hydraulic Model Studies
	C: Flood Damage and Inundation Survey Results
	D: Land Use Planning
	E: Preliminary Structural Drawings for Structural Measure Options
	F: Preliminary Cost Estimate
	G: Environmental and Social Consideration
	H: Economic Evaluation
	I: Established Systems in Pilot Project
	J: Warning Criteria and Content of Warning Message
	K: Result of Interview Survey
	L: Meteorological Consideration for Disaster Management
	M: Community-based Disaster Management
	N: Study on Sediment Disaster
Data Book	1. River Cross Section Survey
	2. Disaster Management Exercise Manual
	3. Questionnaire of Interview Survey
	4. Questionnaire and Result of Community Survey
	5. Handbook and “Fliptation” (Flip Chart & Presentation) Materials
	6. Community Hazard Maps (15 pilot communities)
	7. Newsletters
	8. Screenshot of Web pages

Part II:

Flood Management Planning for Kelani, Kalu, Gin and Nilwara Rivers

PART II FLOOD MANAGEMENT PLANNING FOR KELANI, KALU, GIN AND NILWARA RIVERS

CHAPTER 1 INTRODUCTION

1.1 Rationale

Sri Lanka is a natural disaster prone country due to its geographical position and geological features. Past disasters have included Tunami, floods, sediment disaster, drought and lightening ignited fires, etc. In particular, habitual flooding causes serious havoc for development of the country due to its strong impact to large numbers of the people. Activities to harmonize economic development and natural conservation for flood management including storm water drainage have been one of the main disaster management issues. Therefore, implementation of appropriate flood management plans is indispensable to reduce vulnerability of natural disasters in Sri Lanka.

It should be noted that devastating floods hit the Kelani River basin in 1989 and another three river basins in 2003. In addition, recent large-scale floods have damaged the Study Area twice between April to June 2008 during the current Study. Taking account of the experiences and observations during the flood events, the Master Plans prepared in past in the four river basins were reviewed and formulated in the current Study and the major output is presented in this Report.

1.2 Objective

The overall goal of the Study is plan to mitigate the damage caused by natural disasters such as flooding, sediment disasters and Tunami, by strengthening the capacity of related organizations and communities. As a part of the activity for achieving the goal, Component 1 aims to formulate flood management plans in the selected four river basins (i.e. the Kelani, Kalu, Gin and Nilwala) and Action Plans of selected priority projects.

1.3 Study Area

The target four river basins consisting of the Kelani, Kalu, Gin and Nilwala are located in southwest wet zone in Sri Lanka. The two major rainy seasons (the southwest monsoon period from May to September and inter-monsoon period from October to November) bring high intensity downpours. Therefore, these river basins have experienced some of the highest annual rainfall depths received anywhere in the island. Some areas in the central highlands receive in excess of 4,000 mm as an annual rainfall. Principal features of the four river basins are summarized in Table II-1.

Table II-1 Principal Features of Target Four River Basins

Item	Kelani	Kalu	Gin	Nilwara
Catchment Area (km^2)	2,292	2,719	932	971
River Length (km)	150	101	113	78
Annual Rainfall (mm)	3,800	4,040	3,290	2,890
Discharge Volume at River Mouth (MCM)	3,417	4,032	1,268	1,152
Major Tributaries	Maskeliya Oya, Keheigamu Oya,	Kuda Ganga, Maguru Ganga,	Kepuela, Holuwagoda Ela,	Kirama Ela, Kaddaweduwa Ela,

Item	Kelani	Kalu	Gin	Nilwara
	We Oya, Ritigana Oya, Gurugoda Ganga, Seetawaka Ganga, Wak Oya	Kukule Ganga, Way Ganga	Kimbiya Ela, Galagoda Ela, Divitura Ela, Maben Ela	Badulla Oya, Digili Ela
Principal Water Level Gauging Station	Kitulgala, Deraniyagala, Glencourse Holombuwa, Hanwella	Ratnapura, Dela, Ellagawa, Kukulegama, Kalawellawa, Millakanda, Putupaula	Agaliya, Tawalama	Pitabeddara, Bopagoda
Districts	Gampaha, Colombo, Kegalle, Ratnapura, Nuwala Eliya	Kalutara, Ratnapura	Galle, Ratnapura	Matara, Galle
Population	2,773,000	1,127,000	490,000	459,000
Population in Flood Prone Area (% in Total Population)	150,000 (5.4%)	132,000 (11.8%)	32,000 (6.5%)	100,000 (21.8%)

Source: Prepared by the Study Team based on the information from DOI and other agencies concerned

1.4 Scope of Work for Component 1

Component 1 covers the main objectives for revision of the flood management master plan and preparation of action plans for priority projects with following work items:

(1) Collection, review and analysis of data and information related

(2) Examination on characteristics of vulnerability and hazard

(3) Evaluation of current disaster mitigation measures

(4) Flood risk assessment

(5) Flood management planning through a review of existing master plans and integration of structural as well as non-structural measures

(6) Selection of priority areas and projects

(7) Formulation of action plan

(8) Initial environmental examination (IEE)

The screening of structural measures was conducted by focusing disaster management rather than water resources development. Therefore, multipurpose dam scheme was assessed for its viability at a preliminary level. Based on the current study results, further viability of flood management with water resources development options will require other studies.

CHAPTER 2 CURRENT FLOOD MANAGEMENT SITUATION AND PLANNING PRINCIPLES

2.1 Current Situation of Flooding and Countermeasures

The Study Area situated in the southwest quarter of the island, receives heavy rainfall in the two monsoon periods: the southwest monsoon period from May to September and inter-monsoon period from October to November. The annual rainfall in the area varies from 2,500 mm to over 5,000 mm. According to the historical records of floods in the Study Area, the largest flood in the past three decades occurred in May to June during the southwest monsoon.

Recently, large scale flooding with 10 to 30-year return period hit the Study Area twice at the end of April and the end of May 2008. A newspaper reported that some 400,000 people in seven districts (Kalutara, Gampaha, Colombo, Galle, Matara, Ratnapura and Kegalle) were displaced and death toll was 20 (as of June 5, 2008). Kalutara District was the worst area hit by the flood.

Flooding habitually affects and devastates people's daily life and economic activities almost every year in the country. However, the realization of flood management plan is significantly delayed behind the original schedule recommended in the study report in the past except for some minor river training. One of major reasons of the delay is lack of a Master Plan for flood management, which consists of step-wise development.

Therefore, formulation/updating of the Master Plan integrated with structural and non-structural measures at the earliest time in the four vulnerable river basins (i.e. Kelani, Kalu, Gin and Nilwala) is a prerequisite to mitigate the perennial flood damage.

2.2 Data/Information Collected and Field Survey Works

Various data and information for master plan formulation of Component 1 were collected in the course of the Study. The data can be categorized into raw records (rainfall, discharge, water level, flood damage, etc.), analyzed results, maps/drawings and study reports, etc. These were mainly collected from DOI central/regional offices, DOM, UDA, LHI, and other related governmental agencies including the local governmental offices.

In connection with Component 1, flood damage and inundation survey was carried out by means of interviews (517 households and 30 local governmental offices) to furnish information on flood damage and hydrological characteristics of inundation for hydrological analysis and master planning for the current Study.

In addition, river cross section survey was carried out at 18 sections (4 in Kelani, 6 in Kalu, 4 in Gin and 4 in Nilwala) to supplement information on river cross sections at key locations.

2.3 Planning Principles of Flood Management in Sri Lanka

Based on an overview of the current flood management situation in Sri Lanka, this Study applied the following six principles to review and formulate the flood management master plan:

(1) Minor floods should be prevented by structural measures and it should be done in short term projects. In order to accrue flood management benefit earlier with limited budget, certain downscaling from full target protection level should be considered by structural measures such as small scale river improvement with channel excavation and flood bund system, etc. in the short term.

(2) Further to item (1), existing facilities should be utilized as much as possible to bring immediate benefit to the project and to minimize the cost for implementation. However, through verification of current conditions of the existing structures (flood bund, sluices, pumping stations, etc.) in the four river basins, some of them were found to be out of operation due to lack of proper maintenance and/or over-aged facilities. Therefore, repair and renewal of the existing facilities needs to be prioritized.

(3) Wetlands, which naturally serve as flood retention areas, should be utilized as retarding basins for major floods or severe floods. The function of such wetlands and marshes needs to be carefully verified and conserved with clear demarcation through flood zoning. In this connection, institutional and organizational strengthening of concerned governmental agencies needs to be incorporated.

(4) Environmental and social impacts should be minimized when target planning level for structural measures are determined. Even considering affordability for implementation among stakeholders, environmental considerations and mitigation measures are essentially required. In Sri Lanka, securing concurrence on EIA (Environmental Impact Assessment) is required to implement the project. Its detailed procedure is shown in Section 9.8.

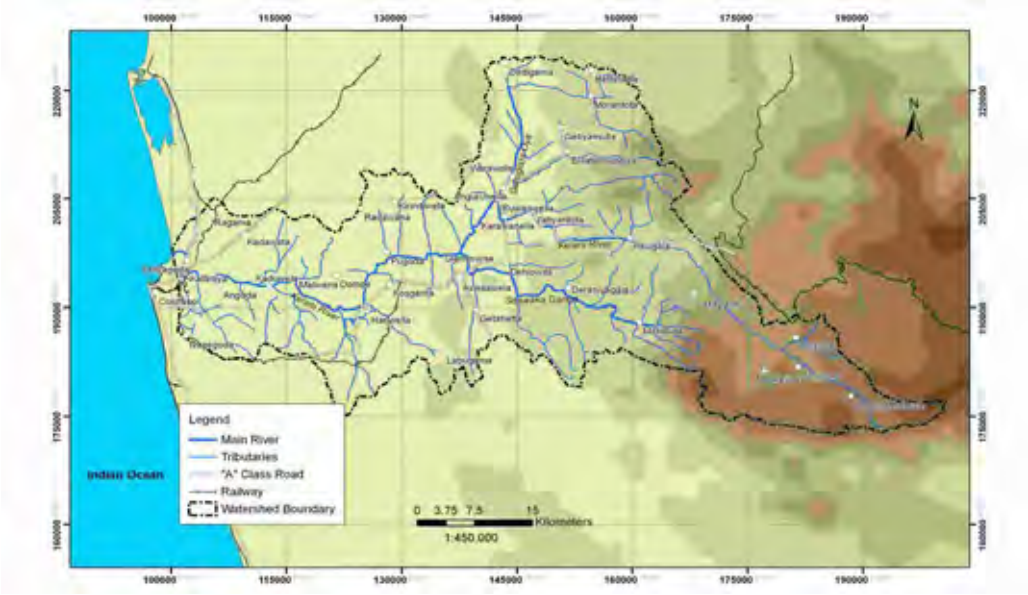
(5) Optimal combination of structural and non-structural measures should be considered. It needs to be recognized that the role of non-structural measures in the current study is to support and enhance the benefit expected by structural measures. In this respect, appropriate menu of both measures needs to be examined based on particular conditions in the four river basins.

(6) Future climate changes need to be considered by means of enhancement of meteorological and hydrological monitoring networks. In addition, management of flood risk from severe floods mainly by non-structural measures will be inevitable to secure livelihood and human life of inhabitants in the flood prone area.

CHAPTER 3 KELANI RIVER BASIN

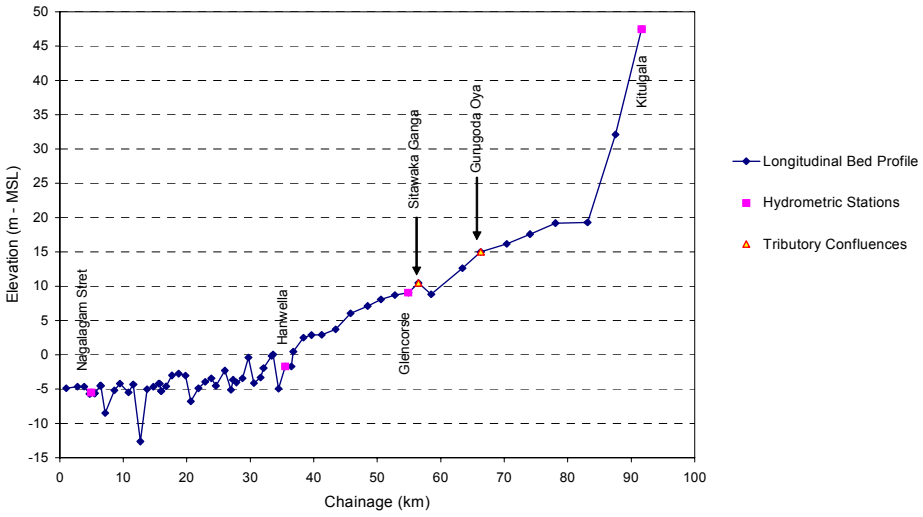
3.1 Basin Overview

The Kelani River is the second largest river in the country. It originates in the central hill country of the island, and flows mainly to the west until it reaches the sea at the northern boundary of the city of Colombo. The river basin, which is located entirely in the wet zone of the country, has an area of 2,292 km^2 and an annual runoff of 3,417 million m^3. A location map of the Kelani River is shown in Figure II-1. A longitudinal profile of the Kelani River (Kitulgala - river mouth) is shown in Figure II-2.



Source: JICA Study Team

Figure II-1 Location Map of Kelani River Basins



Source: Hydrology Division of DOI and LHI

Figure II-2 Longitudinal Profile of Kelani River

In order to control inundation of the downstream stretches during minor floods, several minor flood protection schemes (MFPs) have been constructed by DOI. The city of Colombo and its suburbs adjacent to the north and south banks of the Kelani River are protected by flood bunds acting as major flood

protection schemes. Recently DOI has begun proceeding with bank protection works at the existing North Bund (Gampaha side) to stabilize the river banks and the Bund against erosion.

3.2 Past Significant Floods

The most severe flood occurred in June 1947 with gauge post recording of 12.85 feet at Nagalagam Street station, which is located at approximately 5 km upstream from the Kelani river mouth. In the last 20 years, June 1989 flood is the most significant and reached to "Dangerous" water level with gauge post recording of 9.20 feet at Nagalagam Street station. The extent of inundated agricultural land was estimated at about 50,000 acres (approx. 202 km^2).

During the current study, torrential rainfall hit the Kelani River basin twice during about one month from the end of April to the beginning of June 2008. The second flood that occurred on May 30 to June 1 was a little larger than the previous one occurring in April 28. In fact, the water level of the Kelani rose up to GL 5.90 ft at Nagaragam G/S on May 31, which was the 3rd highest within the last three decades. A very wide area from Hanwella to Kelanimulla (Colombo side) and from Pugoda to Maluwana (Gampaha side) was inundated during both floods. Based on site reconnaissance and interviews to the affected people by the Study Team, the average inundation depth in the areas seems to be between 0.5 to 1.0 m in the basin during the two flood events.

Flood in Biyagama
(opposite side of Kaduwela, June 01, 2008)

Flood in Kolonnawa
(near Gotatuwa Bund, June 01, 2008)

3.3 Review of Previous Flood Management Studies

Several flood control studies in the Kelani River have been carried out since 1940's as listed below.

(1) "Flood Control of the Kelani Ganaga, International Engineering Company, San Francisco, 1948"

(2) "Kelani Flood Protection Scheme, Dr. Mylvaganam, Irrigation Department, 1948"

(3) "Diversion Canal, Irrigation Department, 1950"

(4) "Kelani Ganga Basin Scheme, Technopromexport, USSR,1961"

(5) "Wetland Site Report and Conservation Management Plan, Colombo Flood Detention Areas, Central Environmental Authority/Euroconsult, Ministry of Transport, Environmental and Women's Affairs, January 1995"

(6) "Western River Basin Sector Project, TA3030-SRI, DHI, July 1999"

Out of them, the Study by USSR (1961) proposed an ambitious scheme for the multi-purpose development

of the Kelani River basin. However, none of recommendations have been implemented due mainly to the high cost involved and the social impacts. The Study by DHI (1992) and the Study by Central Environmental Authority (1995) assessed utilization of retarding basins in low-lying lands in the downstream basin.

3.4 Hydrological and Hydraulic Model Studies

Hydrological and hydraulic analyses for the target rivers were carried out to assess the inundation conditions (area, depth, intensity and duration etc.), river channel capacity and consequently to evaluate the possible countermeasures for flood management.

The river basin model of the Kelani River contains the river basin of the Kelani River between Kitulgala and Colombo together with its two main tributaries Sitawaka Ganga from Algoda Bridge and Gurugoda Oya from Imbulana. They were divided into 6 sub-catchments, and 22 rainfall station data were adopted to estimate the mean areal rainfall in the basin. Probable daily rainfall of major stations are presented in table below:

Table II-2 Daily Annual Maximum Rainfall

River	Name	Elevation (m)	Data Available Period	Annual Daily Maximum Rainfall (mm/day)				
				10 year	25 year	50 year	100 year	Obs.Max
Klani	Avissawella	30.5	1950-2006	202.5	237.8	263.9	289.9	264.2
	Colombo	7.3	1950-2006	236.7	286.2	323.0	359.5	493.7

Source: JICA Study Team

Probable flood discharge at major stations in the Kelani River were estimated as shown in Table II-3 with assumption that the runoff from all sub-catchments were directed to main river without having any flood storage outside the main river, aiming to estimate maximum water level and discharge at the main river.

Table II-3 Probable Flood Discharge of Kelani River

Return Period (Year)	Peak Discharge (m^3/s)			
	Glencourse	Hanwella	Kaduwela	Nagalagam
2	1,438	1,566	1,613	1,665
5	2,292	2,569	2,673	2,788
10	2,860	3,247	3,415	3,601
20	3,401	3,886	4,104	4,346
30	3,714	4,263	4,513	4,790
50	4,105	4,735	5,026	5,349

Note: Analysis was based on no river overflow and also no storage in flood basin

Source: JICA Study Team

3.5 Land Use Planning in associated with Flood Management Plan

The characteristics of existing land use in the Kealni River are summarized as follows:

(1) Built-up area occupies 1.0% of the river basin area which is the largest area in four river basins.

(2) Crop fields spread over almost half (49.7%) of the river basin area, with rubber fields accounting for the largest area (67.4%).

(3) The second largest utilization of the land is cultivated area (34.0%), with homesteads/ garden area accounting for the largest area (74.1%), followed by the paddy area (22.4%).

In the past 20 years, the land uses which exhibited the most remarkable changes were homestead with 17% decrease and forestland with 19% decrease.

Colombo Core Area is the most populated and population dense area in the country, where many new economic and development activities and also redevelopment works are taking place. In addition, Avissawella will become another residential center with industrial uses according to the Regional Structure Plan of the Western Region Megapolis. With regards to disaster management along the Kelani River, the development activities should be controlled by strict regulations and the leadership of the responsible agency.

3.6 Basic Concept for Flood Management Planning

3.6.1 Planning Scale

The planning target to formulate a Master Plan was set at 20 years taking into consideration the following: (i) current channel capacity, (ii) experienced maximum flood peak discharge and (iii) future land use conditions. Considering the required period of implementation of the proposed Master Plan, the target period was set for 15 years starting 2010 and ending 2024. This planning scale for the Kelani River basin as well as those for other three river basins was mutually agreed by the Sri Lankan side through discussions in counterpart meetings.

Table II-4 Planning Scale of Kelani River Basin

Present Safety Level (Flow Capacity)	Experienced Max. Peak Flood	Future Land Use	Planning Scale
- South Bund 100-year probability (Colombo side) - North Bund 30-year probability (Gampaha side) - Non-flood bund section 2 to 3-year probability	Aprrox.60~70-year (June 1989 flood)	Sprawl of Metropolitan Colombo area will proceed and urbanization will be further progressed. Low lying wetland located along the Kelani will be encroached and decreased if effective land use regulation/ ordinance is not introduced.	20-year (3,400 m^3/s at river mouth) (in case excluding natural retarding basins)

Source: JICA Study Team

3.6.2 Key Issues for Formulation of Master Plan

(1) Current conditions of flood damage:

- Habitual flooding in the unprotected area at downstream area having no flood bund (currently inundated by 2 to 3-year probable flood)
- Inundation by intensive rainfall in land side at downstream area having flood bund
- Bank erosion at meandering section that threatens collapse of the North Bund (existing from Talwatta to Peliyagoda at Gampaha (left bank) side

(2) Unprotected area

The areas, not protected from overtopping of flood discharge by flood bund or other structures within the stretches, are called the "Unprotected areas". Actually, such areas are situated at the downstream of the Kelani, Gin and Nilwala. Most of the areas are threatened by habitual flooding since flow capacity of low water channels is relatively small.

(3) Early warning and monitoring system (EWMS)

In the Kelani River basin, pilot project of installation of automatic water level and rain gauges was conducted in association with community-based disaster management component of the current study. It was verified and recognized through the Pilot Projects that the system could be effectively applied as one of non-structural measures in the Study area.

(4) Dam and reservoir schemes

To create flood control and reservoirs are effective options for reducing flood peak discharge in the basin. In fact, some potential dam schemes have been identified and proposed since the 1960's. However, not even a single project has been realized yet in the Study Area except for the hydropower project in the Kukule Ganga, Kalu River, by CEB due mainly to financial and environmental issues.

(5) Non-flood bund stretches (Retarding Basin)

Natural retarding basins are located in the lowly undulated area between river mouth to approximately 50 km upstream. They are classified into three categories: (i) wetland (most of area is under water throughout year), (ii) abandoned land (mainly grassland) and (iii) cultivated land (mainly paddy). By means of the rereading function of the basins, flood peak discharge in Colombo Metropolitan area has naturally decreased, thus playing vital function of protection against flooding. If the disorderly development seen in some areas recently is accelerated, the safety level of the core center of Colombo city will be remarkably deteriorated.

(6) Inland drainage

In the Colombo Metropolitan area, inundation due to insufficient drainage of rainwater occurs almost every year. As for the inland drainage improvement, construction of new pumping station is ongoing by SLLRDC and UDA. DOI is in charge of management of existing flood bund and Minor Flood Protection schemes (MFPs). Since some of existing structures such as sluice gate, appurtenant facilities at MFPs and flood bund are already obsolete and/or heavily damaged, repair and rehabilitation of them is urgently required.

3.6.3 Basic strategy

Basic strategy of flood management plan in the Kelani River was set up as follows:

(1) Target area: From Hanwella to river mouth

(Unprotected area, area without flood bund at downstream and meandering section threatened by serious erosion at left bank)

(2) Scale of countermeasures:

Short-term target	Long-term target
1/5 (Q_{peak}=2,300 m^3/s)	1/20 (Q_{peak}=3,400 m^3/s)

(3) Basic strategy of flood protection:

- To raise flood protection level at habitual flooding area from 2~3-year probability to 5-year probability of flow capacity of low water channel.

- To strengthen safety of the existing flood bund and extension/improvement of Minor Flood Protection schemes (MFPs).
- To promote and proceed non-structural measures in the unprotected area.
- Since dam schemes at upstream area include many issues such as large scale of relocation of main road, involuntary resettlement and complex rule of allocation of multi-purpose benefit, etc., it is not considered as a short-term measure. As a long-term measure, single purpose flood control dam is assumed and compared with other alternatives in this Study.
- To strengthen retarding function of flood peak at low lying wet land in the stretches with non-flood bund along the Kelani River (by allowing overtopping excess flood discharge over 5-year return period into the retarding basin).

3.7 Alternative Structural Measures

Based on the basic strategy of structural measures, three alternative plans of structural measures were set as follows:

Table II-5 Structural Measure Element of Alternative Plans (Kelani River)

Alternative	Short term (common for all 3 Alternatives)	Long term
I	・ Repair of MFPs and existing flood bund ・ Flood bund system ・ Early warning and monitoring system	Heightening of flood bund
II		Dam (Nawata Dam)
III		Retarding basins

Source: JICA Study Team

Design standard and guideline in Sri Lanka as well as the international standards were applied for the structures proposed in this Study. Short term structural measures were preliminarily designed as follows:

Table II-6 Principal Dimensions of Structural Measures (Short term)

Alternative	Structural measures	Principal dimensions and numbers of structure
I, II and III	Repair of MFPs and existing flood bund	Improvement : 9 sluices Reconstruction: 8 sluices New construction: 1 sluice
		Bank protection: L=670 m (between Talwatta and Peliyagoda on North bund)
	Flood bund system	For 5-year flood protection (in u/s of existing flood bund) -15,060 m (Ave. H=3.4m) for left bank -19,640 m (Ave. H=3.8m) for right bank
	Early warning and monitoring system	9 rain gauges and 3 hydrometric gauges

Source: JICA Study Team

On the other hand, principal feature of long term structural measures were designed as shown below.

Table II-7 Alternative Structural Measures (Long term)

Alternative	Structural measures	Principal dimensions and numbers of structure
I	Heightening of flood bund	For 20-year flood protection (u/s of existing flood bund) -15,060 m for left bank, -19,640 m for right bank
II	Dam (Nawata Dam)	Nawata Dam (H=86.9 m, V=1,060 MCM)
III	Retarding basins	7 locations (A=46.5km^2)

Source: JICA Study Team

3.8 Promising Non-Structural Measures

The non-structural measures can be introduced with less cost and time for planning. To reduce the risk of flood disaster in the target river basins, it is essential to introduce effective non-structure measures at the earliest time possible. In particular, the unprotected area in between the North Bund and railway Embankment, which is about 2,100 ha exposed to habitual flooding in Wellampitya, Wennawatta, Kotuwila and Kelanimulla needs to prioritize non-structural measures as follows:

(1) Enhancement of flood forecasting and early warning system

(2) Management of flood retarding basins (flood zoning)

(3) Installation of rainwater on-site storage and rainfall infiltration facility

(4) Promotion of water-resistant architecture promotion of flood fighting activities

(5) Promotion of flood fighting activities

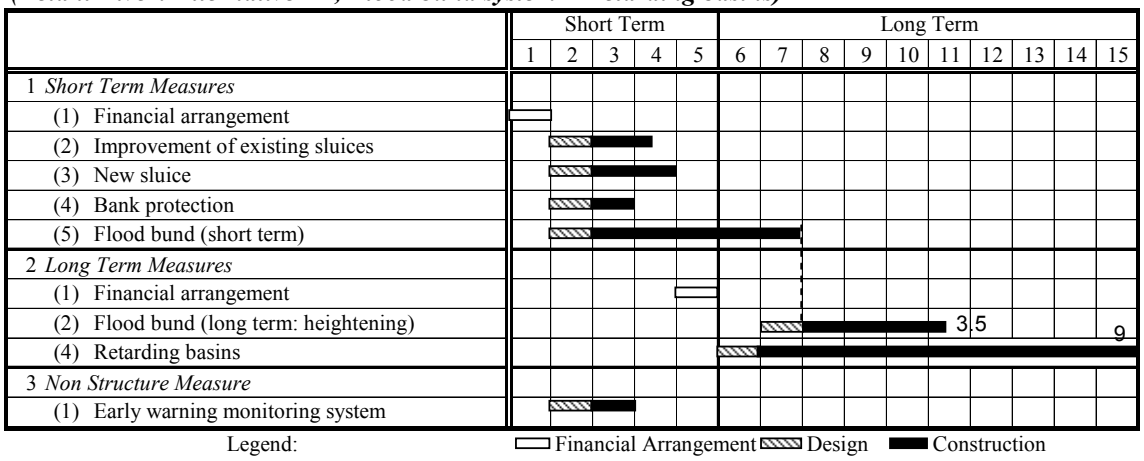
3.9 Construction Plan and Cost Estimation

Construction periods of each project proposed in the master plan are assumed to be 5 to 7 years for short term countermeasures and 3 to 10 years for long term countermeasures talking into account work volumes of proposed structural measures and construction periods of similar past projects.

The construction works will be executed by contractors capable of executing the works properly. The contractors will be selected through international competitive bidding (ICB) complying with the regulations of the Government of Sri Lanka and the guidelines of international financing agencies. Further to utilize local contractors will be encouraged in order to reduce the construction cost and to develop the capacity of local contractors in the country.

Implementation schedule of selected plan (Alternative III) among three alternatives is shown below.

(Kelani River: Alternative III, Flood bund system + Retarding basins)



Source: JICA Study Team

Figure II-3 Implementation Schedule of Alternatives in Kelani River
(Alternative III was selected as the Master Plan after evaluation)

The project costs are estimated based on the preliminary design, current prices of construction resources and the construction plan. The financial project cost consists of the cost items shown in Table II-8.

All costs are estimated at the price level of January, 2007. The exchange rate is estimated as average of the exchange rate between January and July 2007 and set as follows:

US$1.0 = Rs. 111.11 = ¥119.64

Table II-8 Conditions of Cost Estimate

Item	Conditions of cost estimate
A) Construction cost	Unit price x Quantity, or lump sum basis referring to the actual cost of similar projects considering the price escalation
B) Land acquisition and compensation cost	Unit price x Quantity The compensation cost is assumed to be 20% of the land acquisition cost for the master plan study.
C) Engineering service cost	15% of the construction cost
D) Administration cost	2% of A), B) and C)
E) Price escalation	10%
F) Physical contingency	10% of A), B), C) and D)
G) Tax	15% of A) and C).

Source: JICA Study Team

The project costs of the alternative cases are summarized below.

Table II-9 Project Costs of Alternatives in Kelani River

(unit: US$, thousand)

Item			Alternative I Flood bund system +Heightening of flood bund	Alternative II Flood bund system +Dam (Nawata Dam)	Alternative III Flood bund system +Retarding basins
I.	Construction cost				
		short term measures	16,467	16,467	16,467
		long-term measures	8,875	79,975	84,573
II.	Land acquisition cost		78,774	81,718	43,954
III.	Engineering service cost		3,801	14,466	15,156
IV.	Administrative expenses		2,158	3,853	3,203
V.	Price escalation		70,550	202,130	182,873
VI.	Physical contingencies		11,008	19,648	16,335
VII.	Tax and duty		4,371	16,636	17,429
Grand Total			**196,000**	**434,900**	**380,000**

Source: JICA Study Team

Annual O&M cost is assumed to be 2.5% for the pumping stations cost and 1% for the other civil structures cost. O&M costs for alternatives are presented below.

Table II-10 Annual O&M Costs (Kelani River)

(unit: US$, thousand)

O&M costs	Alternative I	Alternative II	Alternative III
Total	**253**	**964**	**1,010**

Source: JICA Study Team

3.10 Project Benefit

3.10.1 Project Benefits of Alternatives

Project benefit is generally defined as an economic difference between "with-project" and "without-project" situation. As for the Study, "With-project" means the condition that structural measures and non-structural measures are developed completely or gradually, and "Without-project" means the condition without any such measures.

Two types of project benefits are estimated: (1) flood damage reduction benefit and (2) the benefit of multiple uses of dam as shown in Table II-11. The project benefits for each alternative plan are presented in Table II-12.

Table II-11 Types of Project Benefits

(1) Flood damage reduction benefit	(Direct damage) ・ House damage ・ Household property damage ・ Agricultural damage (paddy) ・ Public infrastructure damage (Indirect damage) ・ Interruption to business operations
(2) Benefit of multiple uses of dam	・ Construction cost of alternative thermal power generation ・ O&M cost of alternative thermal power generation

Source: JICA Study Team

Table II-12 Annual Average Benefit of Alternative Plans

(Unit: Million Rs./year)

Alternatives		short	long
Alternative I	Flood bund system	2,077.7	3,216.7
Alternative II	Dam	2,077.7	6,721.0
Alternative III	Retarding basins	2,077.7	3,585.9

Source: JICA Study Team

In addition to the quantitative benefits, it should be noted that the proposed project will produce a lot of intangible benefits that cannot be measured quantitatively. The following intangible benefits can be expected through the implementation of the project:

(1) Promotion of land use development and economic development

(2) Hygienic improvement of the environment

(3) Alleviation of disturbance to peoples lives

(4) Elimination of the menace of flooding

3.10.2 Economic Evaluation for the Proposed Project

On the basis of the estimated construction cost, operation and maintenance cost (O&M cost) and estimated economic benefits, the Economic Internal Rate of Return (EIRR), B-C and B/C of proposed selected projects are calculated based on the following assumptions:

(1) Evaluation period of Project: 50 years after completion of the project

(2) Discount rate of 10%

(3) Project cost of short term is disbursed according to the construction schedule

(4) Project cost of medium and long term is disbursed according to the construction schedule.

(5) The O&M cost is assumed to disbursed for the entire project lifetime from the year following completion of the project works in each term of short term and medium and long term.

(6) Benefit is produced over the entire project life from the year following completion of the project works in each term of short term and medium and long term.

(7) The benefit is expected not to increase.

The results of the evaluations of selected projects in each basin are summarized in the table below for all alternatives:

Table II-13 Results of Economic Analysis of All Alternative Plans

Index		Flood bund		Dam		Retarding basin	
		Alterntive I		Alternative II		Alternative III	
		Overall	Short	Overall	Short	Overall	Short
B-C	(Rs. mil.)	8,287	9,139	14,616	9,039	9,611	8,811
B/C	(%)	2.1	3.5	2.3	3.4	2.4	3.2
EIRR	(%)	19.2%	25.8%	19.7%	25.6%	20.7%	24.4%

Source: JICA Study Team

3.11 Environmental and Social Consideration

Initial Environmental Examination was done for the structural measures planned in the Flood Management Plan in the four rivers, based on sight reconnaissance and examination of existing materials. Alternatives for structural measures including a "no implementation alternative" were examined from environmental and social points of view.

The major negative impacts that may occur in relevance to the implementation of the structural measures studied for the Kelani River Basin, and proposed mitigation measures are indicated in the following.

(1) Improvement of existing sluices (Magnitude of Impact: Minor)

The improvement of existing sluices may have temporary impact to the water quality of the river by through increased turbulence, etc. However, taking into regard the small scale of construction works and that the number of sluices is limited to only 9 locations, the negative impact caused by this measure is expected to be minor.

(2) New sluice (Magnitude of Impact: Minor)

The construction of new sluices may have temporary impact to the water quality of the river by through increased turbulence, etc. However, taking into regard the small scale of construction works and that the number of sluices is limited to only 9 locations, the negative impact caused by this measure is expected to be minor. The surrounding environment including the position of near by housings should be taken into regard when deciding the location of the new sluices.

(3) Bank protection (Magnitude of Impact: Minor)

Depending on the type of protection works, the access of local residents to riverine resources may be obstructed. However, the impact may be reduced to a minor level by taking countermeasures such as installation of access routes and staircases.

(4) Flood bund (short term) (Magnitude of Impact: Moderate)

There is considerable possibility of involuntary resettlement occurring due to the extension of flood bunds. The magnitude of resettlement is expected to be limited due to the low density of housings along the river. However, detailed surveys for clarifying the number and location of residents should be conducted at the design stage, in order to examine the linear of the bund with minimum resettlement, as well as identifying necessary compensation for those of which resettlement is inevitable. Furthermore, extended flood bunds may obstruct access of local residents to riverine resources. This should be mitigated by taking countermeasures such as installation of access routes and staircases.

(5) Flood bund (long term) (Magnitude of Impact: Minor)

Heightening of flood bunds in the long term plans may obstruct access of local residents to riverine resources. However, the impact may be reduced to a minor level by taking countermeasures such as installation of access routes and staircases.

(6) Dam and reservoir (Nawata) (Magnitude of Impact: Significant)

Depending on its location, dam construction in the upper streams of Kelani River has considerably high possibility of causing involuntary resettlement for several hundreds of households, as well as eliminating the base of economic activities in the area such as farmlands.

Furthermore, other factors that are expected to receive negative impact include; existing social infrastructure and services, land use and use of local resources, cultural / religious heritage, hydrology, flora/fauna and bio-diversity, landscape, and other factors relevant to construction works. Some of the impact may be decreased to a certain level through mitigation measures, but the overall negative impact of dam construction is expected to be significant. In order to minimize the impact of the dam and reservoir, a resettlement action plan with not only measures for land compensation, but also with clear measures to compensate for factors such as livelihood and economic activities must be prepared and implemented. Such action plan should be prepared based on detailed socio-economic surveys, disclosure of information / participation of local residents. Moreover, consensus on the resettlement action plan must be built with the local residents from the stage of preparation.

(7) Retarding basin (Magnitude of Impact: Minor)

The seven retarding basins planned in the lower stretches of Kelani River will have a total area of 46.7km^2. However, the planned retarding basins are lowlands which are conventionally functioning as natural retarding basins, and the main aim of this measure is to secure the area as retarding basins through legislative measures. In this regard, physical impact due the retarding basin is expected to be minor. However, the restriction for land use of such areas may have impact on the economic activities of the land owner, since it may restrict economic development. Necessary compensation should be examined in this regard.

The implementation of Alternative I and III have moderate impact on the environment and the society, while Alternative II is expected to have significant impact. The "no implementation" alternative will have the minimum negative impact, but will leave the area without any flood protection, viz., the people in the area will have to constantly face the risk of flood damage. Taking this into account, and also since the involuntary resettlement for the flood bund (short term) is expected to be at a limited number, it may be said that Alternatives I and III are desirable from environmental and social points of view.

Table II-14 Results of IEE for Four Alternatives in Kelani River Basin

		Alternative I	Alternative II	Alternative III	No Implementation
Structural Measures	Improvement of existing sluices	C	C	C	D
	New sluice	C	C	C	D
	Bank protection	C	C	C	D
	Flood bund (short term)	B	B	B	D
	Flood bund (long term)	C	D	C	D
	Dam and reservoir (Nawata)	D	A	D	D
	Retarding basin	D	D	C	D
Effect on Flood Protection		○	○	○	×
Evaluation from the viewpoint of ESC (negative impact of the alternative)		B	A	B	D

ESC: Environmental and Social Considerations

A: Significant Impact, B: Moderate Impact, C: Minor / unknown impact, D: No impact

○: Effective, ×: Not effective

Source: JICA Study Team

3.12 Flood Management Master Plan

Based on the results of economic analysis, Alternative III (retarding basin) shows most favorable indicators for both short-term and overall evaluations. IEE result of this Alternative indicates considerably less

negative impact than Alternative II, but a slightly higher possibility compared to Alternative I. However, since the planned retarding basins are conventionally flooded areas with no resettlements expected, the differences are expected to be minor compared to the expected effect on flood protection. On the other hand, technical viabilities of the proposed works are almost equivalent among the three alternatives, because DOI has experienced implementation of similar structure measures. However, with particular regard to retarding basin, due care for area zoning with declaration as flood retarding area is indispensable by the implementing agency through substantial consultation to the stakeholders. Under such provisions, Alternative III was selected for the flood management master plan in the Kelani River basin.

The proposed component of the short-term and long-term plans consisting of the Master Plan is summarized as follows:

Table II-15 Proposed Major Components in Master Plan

(1) Structural Measures

Short-term plan

Kind of structure	Major dimensions
1. Improvement of existing sluices	Improvement of existing sluice gates (9 nos.), canal lining (L=200 m), bank protection (L=200 m)
2. New sluices	Reconstruction (8 nos.), new construction (1 no.)
3. Bank protection	L=670 m
4. Flood bund (5-yr)	Left bank (L=15,060 m, H=3.4m) Right bank (L=19,640m, H=3.8m)

Long-term plan

Kind of structure	Major dimensions
5. Flood bund heightening (20-yr)	Left bank (L=15,060m, H=4.6m) Right bank (L=19,640m, H=5.1m)
6. Retarding basin	7 nos. (A=46.5 km^2)

Source: JICA Study Team

(2) Non-structural Measures (to proceed in parallel with the short-term plan)

Table II-16 Non-Structural Measures to be Promoted

1. Early warning and monitoring system	9 rain gauge stations 3 hydrometric stations
2. Management of flood retarding basins	・ Delineation and legal designation of the retarding area for flood management ・ Restriction of land use in retarding basin by law ・ Strengthening of penalization against illegal activities in retarding basin
3. Restriction of further development in urban area	・ Management and monitoring of land use ・ Prohibiting housing development in flood prone area ・ Flood zoning with hazard mapping,
4. Promotion of water-resistant architecture	・ Heightening of building foundation ・ Construction of column-supported ・ Housing, change to multi-storied housing ・ Water proofing of wall/housing materials, etc.
5. Promotion of flood fighting activities	・ Information dissemination in the communities, ・ Evacuation to safer area ・ Removal of properties in house/building, etc.
6. Institutional strengthening of implementing agency	・ Consensus building for project implementation ・ Integration with urban development and land use development plans

Source: JICA Study Team

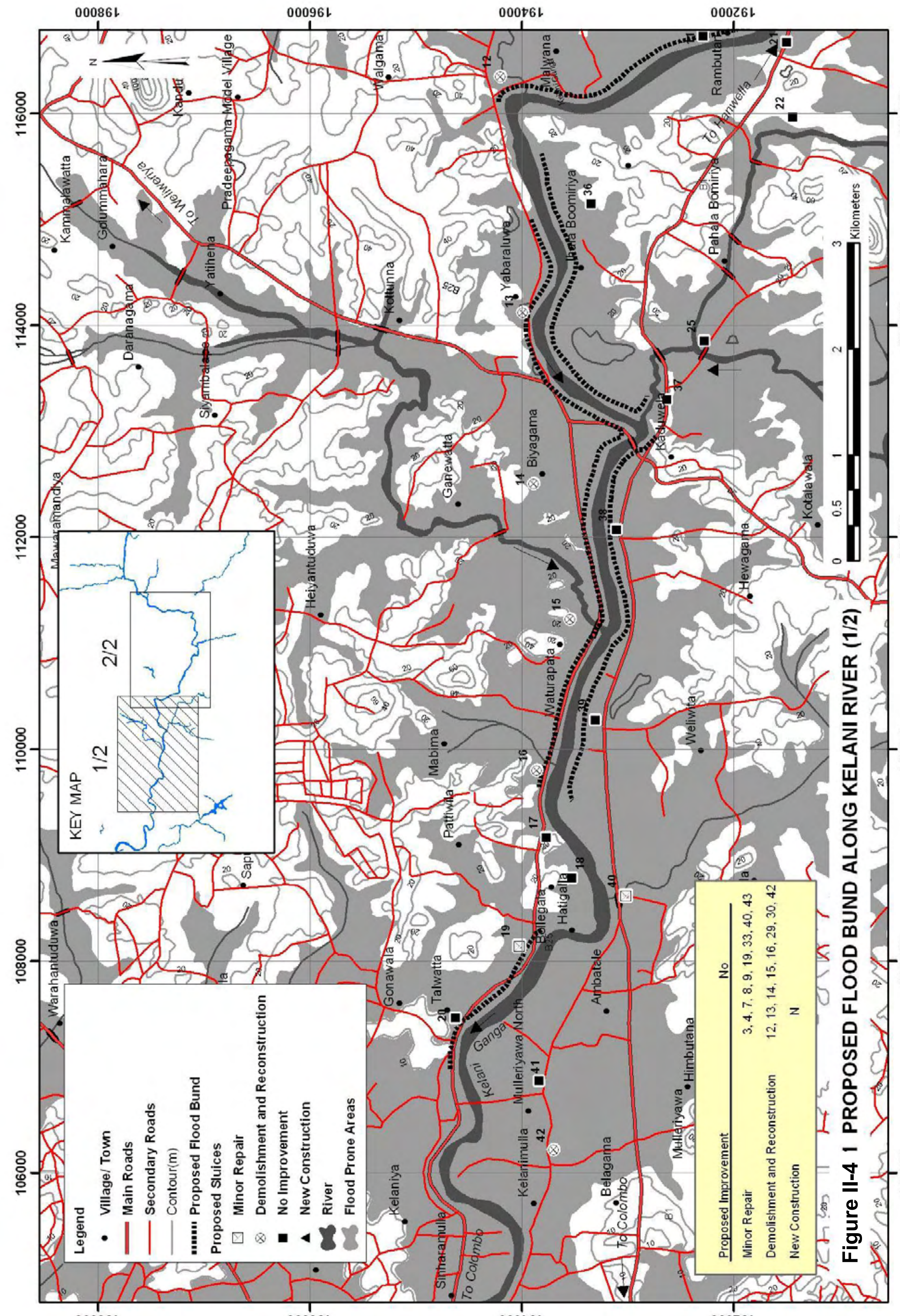


Figure II-4 PROPOSED FLOOD BUND ALONG KELANI RIVER (1/2)

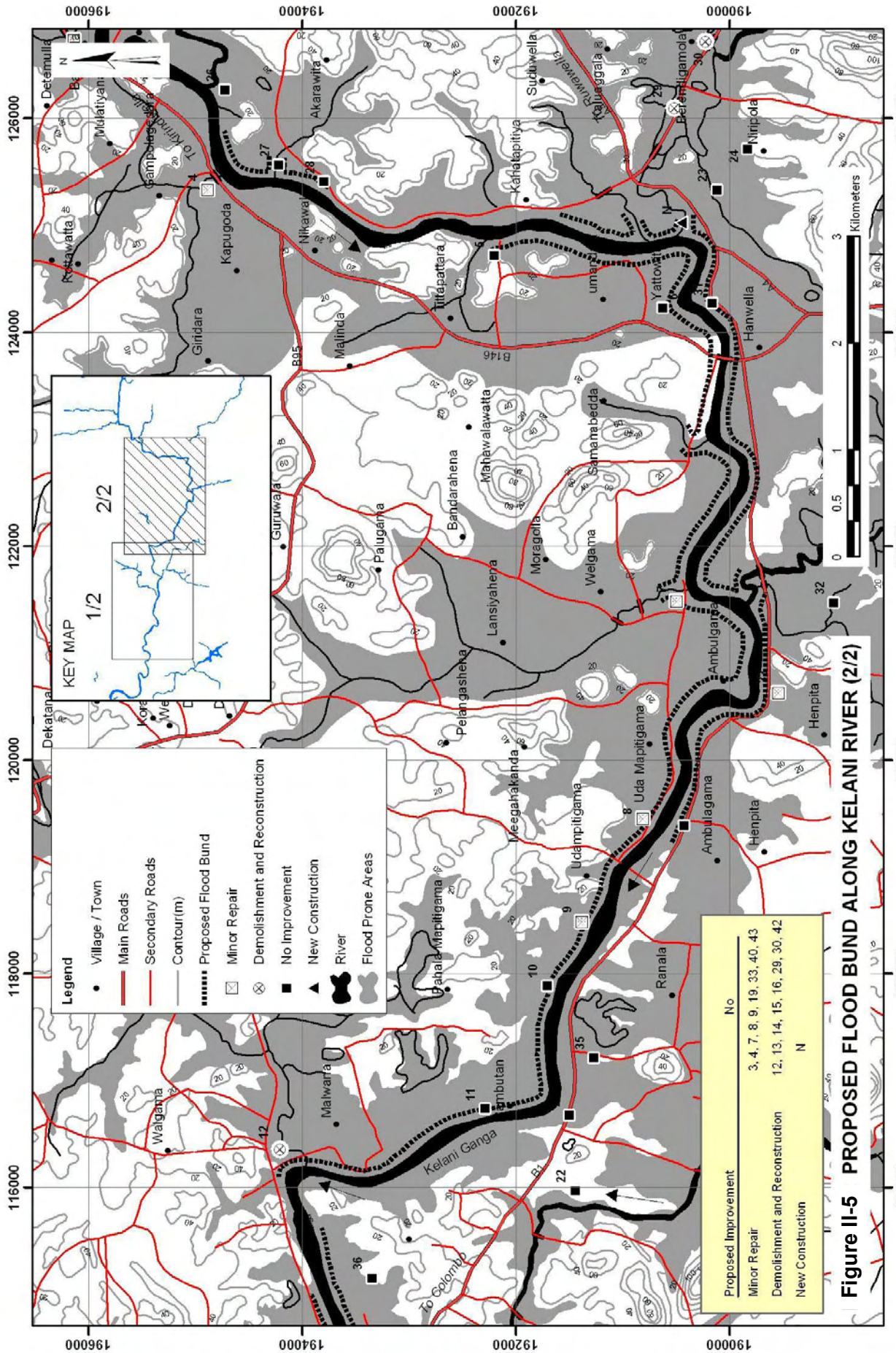


Figure II-5 PROPOSED FLOOD BUND ALONG KELANI RIVER (2/2)

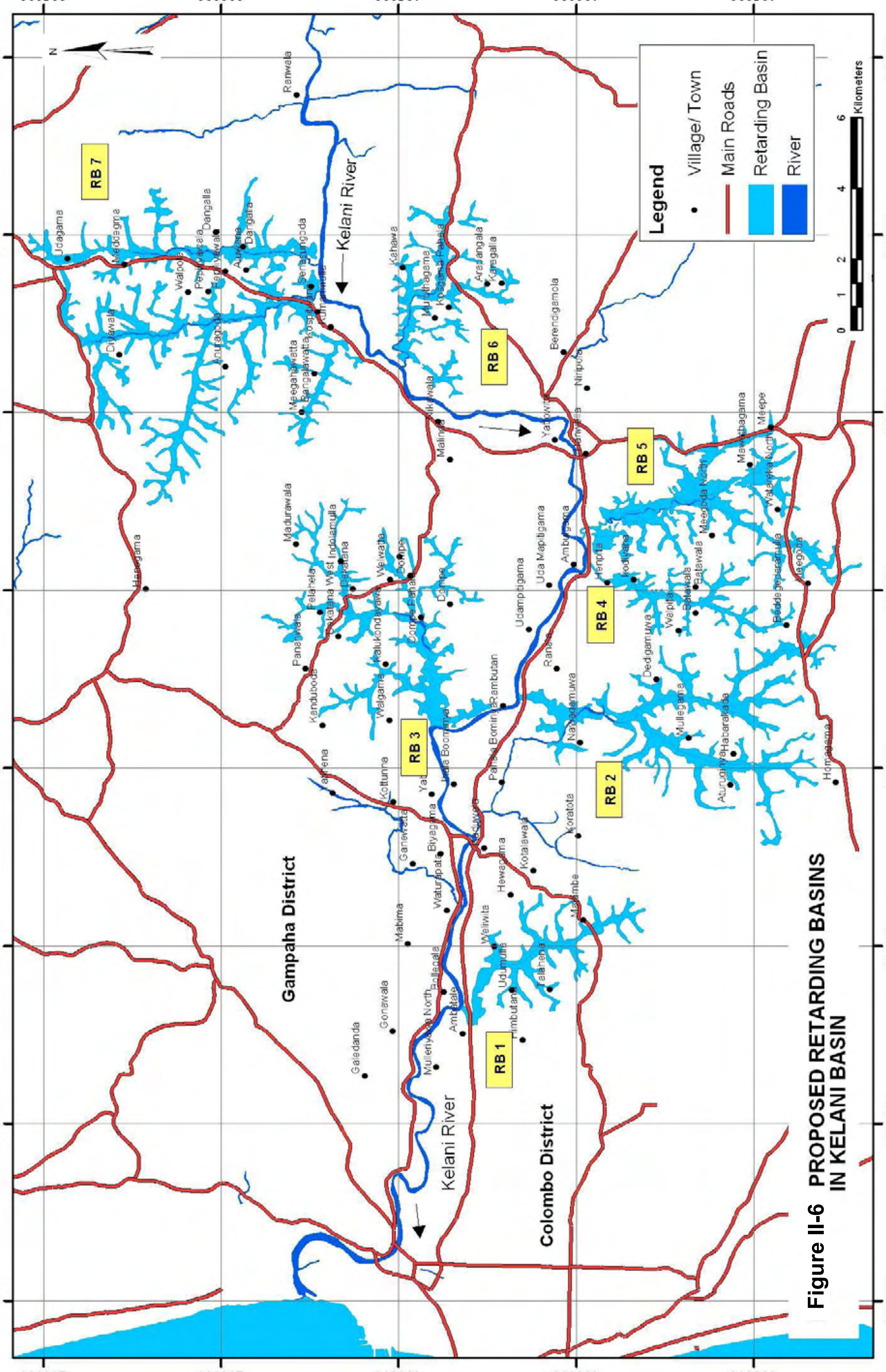


Figure II-6 PROPOSED RETARDING BASINS IN KELANI BASIN