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

(SUMMARY)

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

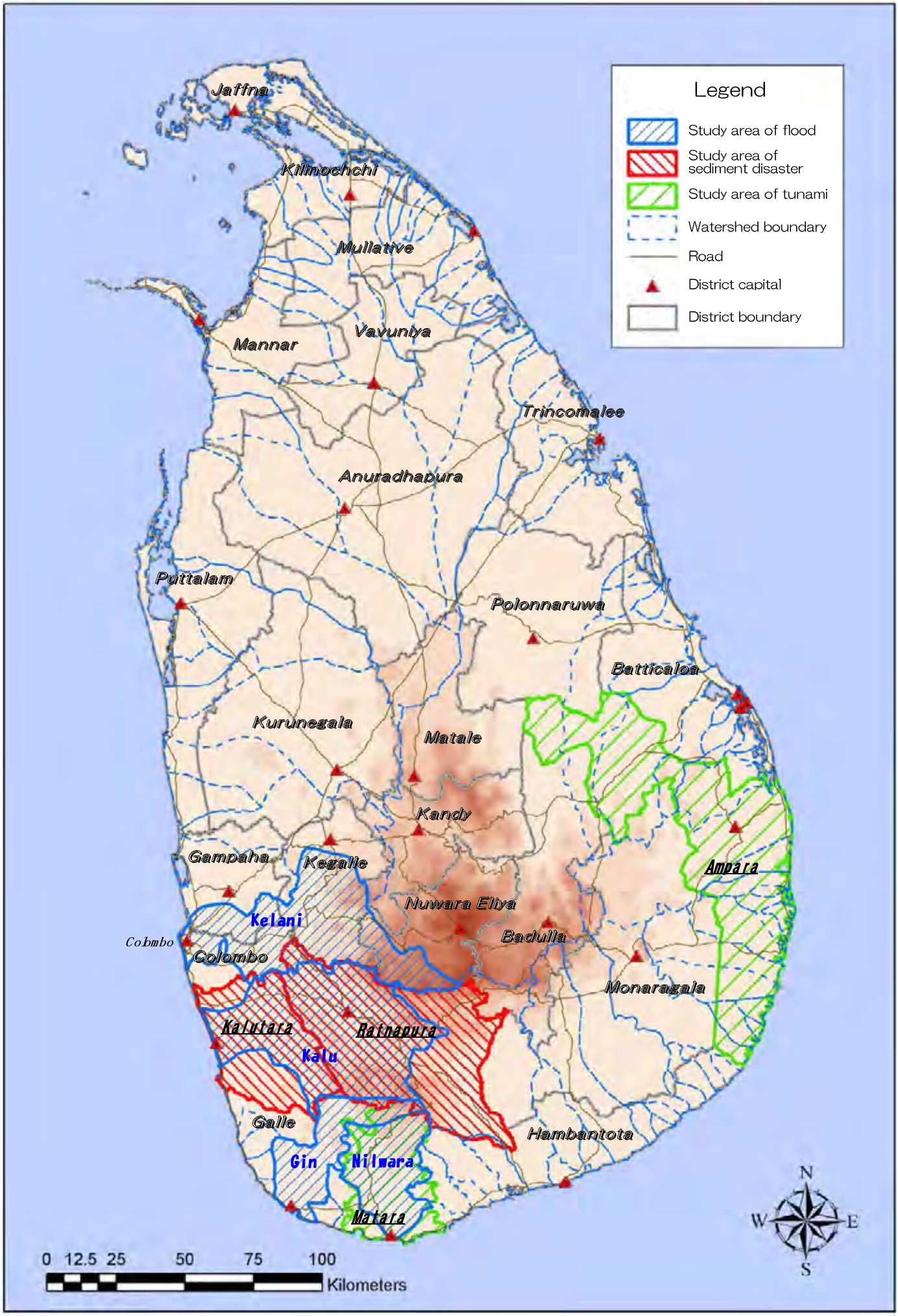


Figure 1 Location Map of Study Area

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

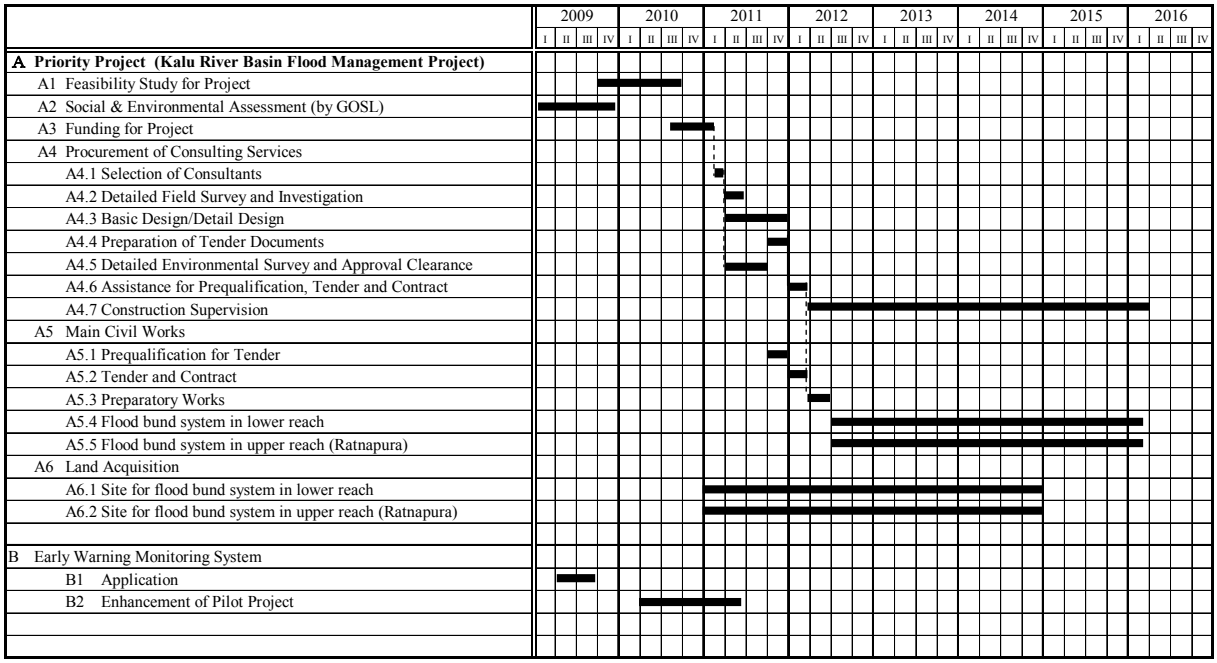
Table 9 Results of Economic Analysis of Priority Project

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

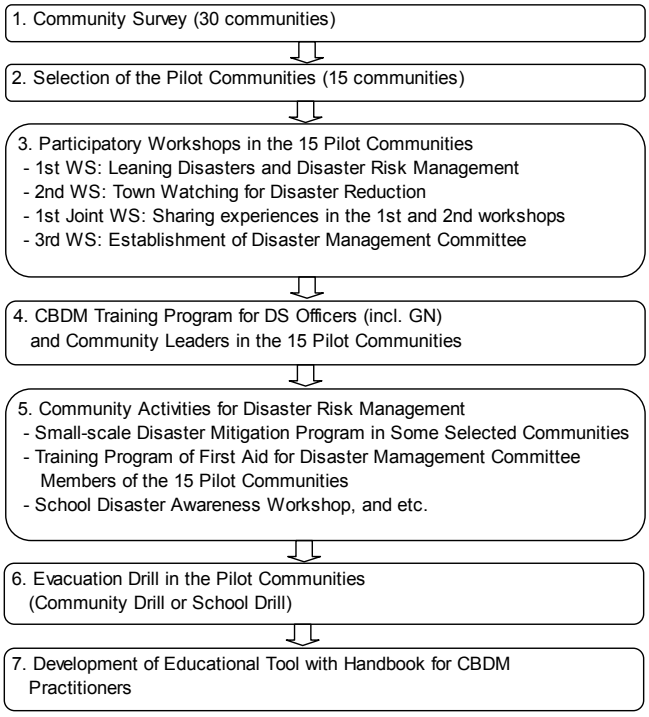
4. Community-Based Disaster Management Activity

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

CHAPTER 1 INTRODUCTION

1.1 General

In the wake of the recent large-scale disasters, the Government of Sri Lanka (GOSL) has started to make efforts for reinforcing the national level disaster management system and Sri Lanka. Disaster Management Act No. 13 of 2005 was enacted in May 2005 to set up the comprehensive framework of disaster management. Based on the Act, the National Council for Disaster Management (NCDM), highest decision making body for disaster management, and the Disaster Management Centre (DMC), national level planning and coordinating body for disaster management, were established.

On the other hand, the project formulation study "Program on Strengthening the Disaster Management Administration" conducted by Japan International Cooperation Agency (JICA), that was conducted from September 2005, identified the following problems on disaster management.

- 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, and GOJ decided to implement the Comprehensive Study on Disaster Management in Sri Lanka (the Study).

In accordance with the Scope of Work agreed in June 2006, JICA dispatched the Study Team on October 2006 to Sri Lanka and the Study officially started. In December 2008, the Study Team completed all field activities in Sri Lanka and this Final Report was prepared to summarize the Study.

1.2 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

1.3 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.

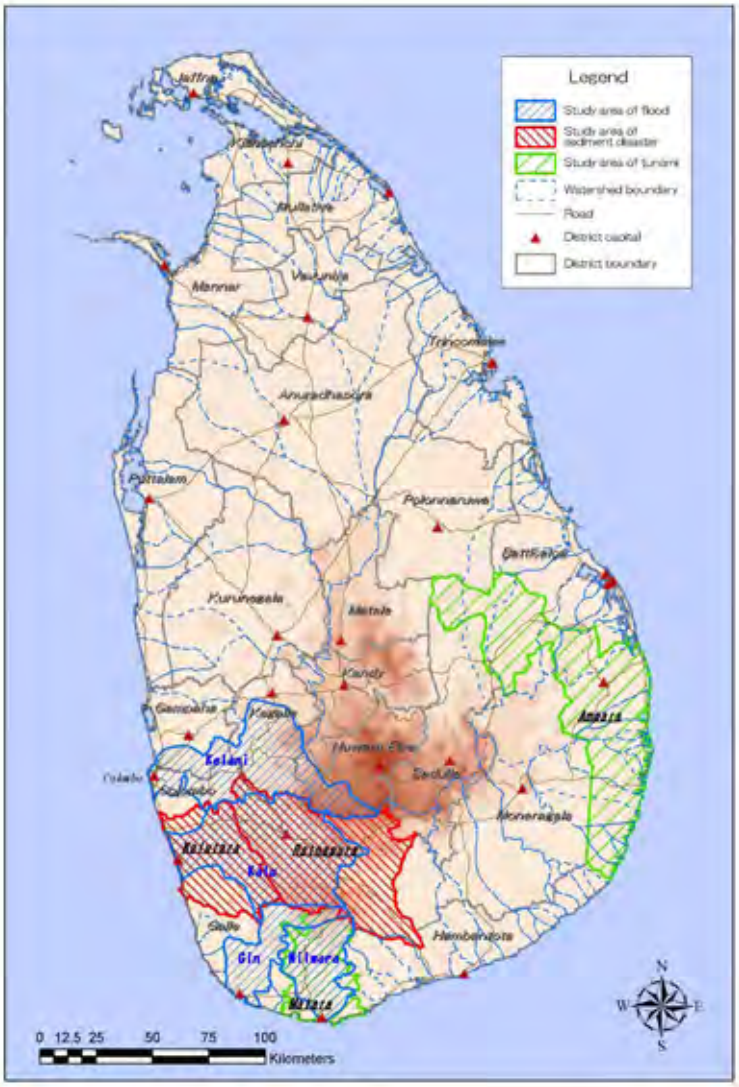


Figure 1 Study Area

1.4 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 1 lists the specific items that will be covered by the Study.

Table 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. Environmental and Social Consideration

Component	Scope of Work
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

1.5 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.

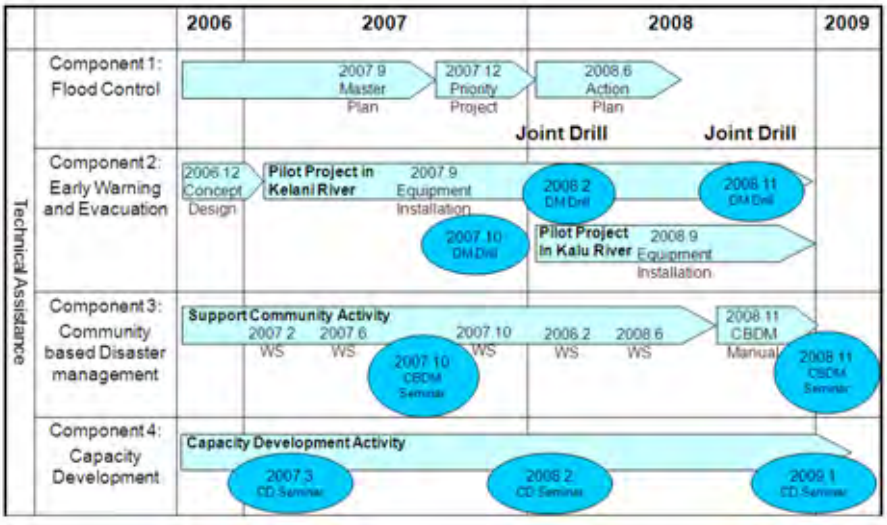


Figure 2 Schedule of the Study

1.6 Organizational Structure of the Study

1.6.1 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.

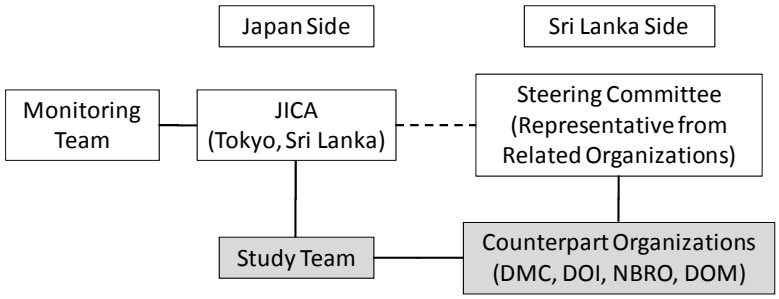


Figure 3 Organizational Structure of the Study

1.6.2 Steering Committee and Counterparts

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

1.7 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 2　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

CHAPTER 2 FLOOD MANAGEMENT PLANNING FOR KELANI, KALU, GIN AND NILWARA RIVERS

2.1 Introduction

The target four river basins consisting of the Kelani, Kalu, Gin and Nilwala are located in southwest wet zone in Sri Lanka. Since there is much rainfall during the southwest monsoon period from May to September and inter-monsoon period from October to November in this region, these river basins have frequently experienced severe floods during this period. Flood in 1989 in the Kelani River basin and flood and landslides in 2003 in other three river basins are remarkable disasters in recent years. Principal features of the four river basins are summarized in Table 3.

Table 3 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

For revision of the flood management master plan for four river basins and preparation of action plans for priority projects, the following works were carried out in this Study:

- Collection, review and analysis of data and information related
- Examination on characteristics of vulnerability and hazard
- Evaluation of current disaster mitigation measures
- Flood risk assessment
- Flood management planning through a review of existing master plans and integration of structural as well as non-structural measures
- Selection of priority areas and projects
- Formulation of action plan
- Initial environmental examination (IEE)

2.2 Planning Principles

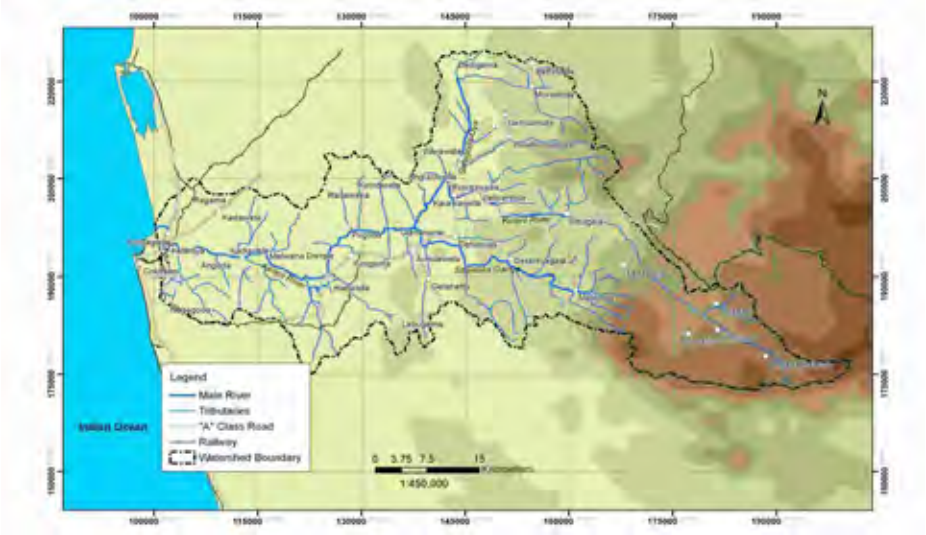
Based on an overview of the current flood management situation in Sri Lanka, this Study applied the following six principles to review and formulate the flood management master plan:

- 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 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.
- 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. Its detailed procedure is shown in Section 9.8..
- 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.

2.3 Flood Management Master Plan for Kelani river basin

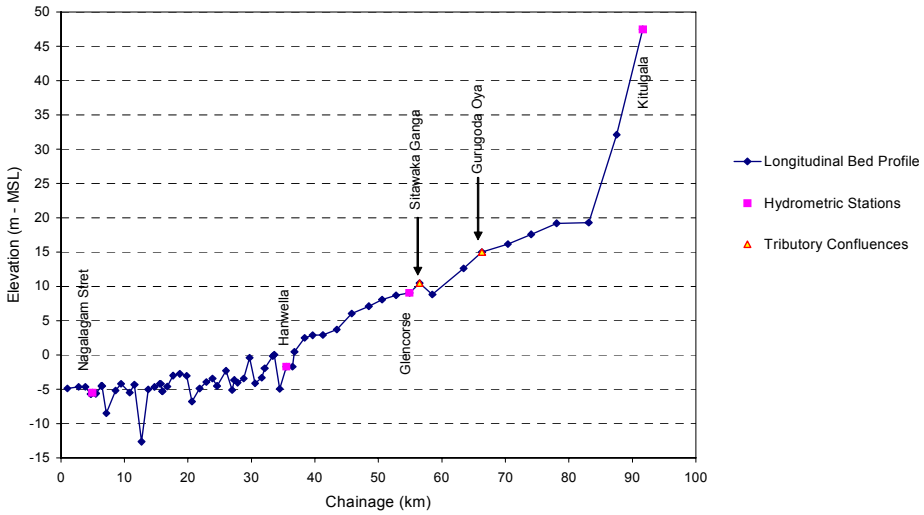
2.3.1 Basin Overview

The Kelani River is the second largest river in the country. 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 (Figure 4, Figure 5).



Source: JICA Study Team

Figure 4 Location Map of Kelani River Basins



Source: Hydrology Division of DOI and LHI

Figure 5 Longitudinal Profile of Kelani River

2.3.2 Flood Management Master Plan for Kelani River Basin

Structural Measures

Table 4 Proposed Major Components in Master Plan (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)

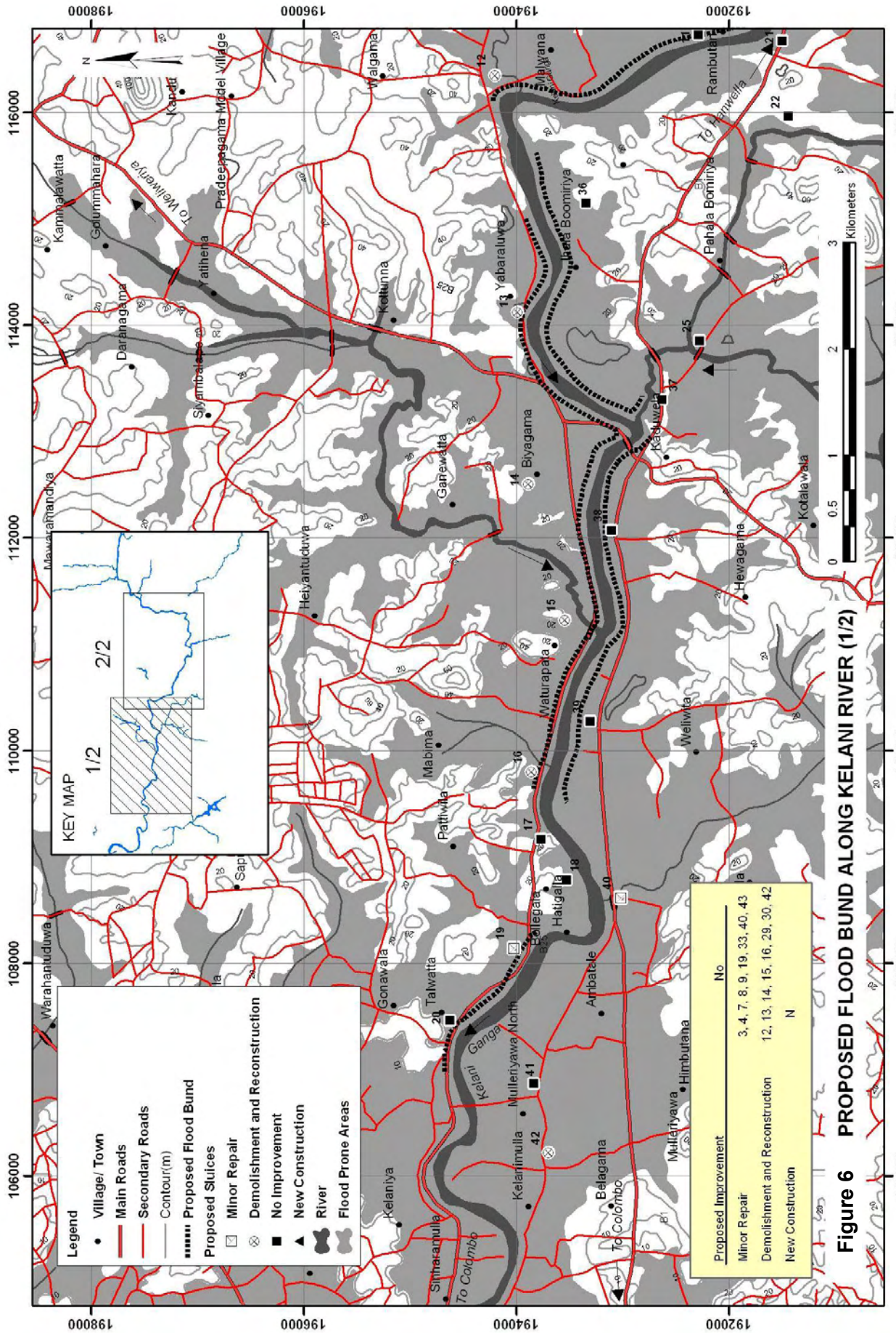
Source: JICA Study Team

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

Table 5 Non-Structural Measures to be Promoted (Kelani River)

Measures	Major Items
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


PROPOSED FLOOD BUND ALONG KELANI RIVER (1/2)
KEY MAP
1/2
2/2
Legend
Village/ Town
Main Roads
Secondary Roads
Contour(m)
Proposed Flood Bund
Proposed Sluices
Minor Repair
Demolishment and Reconstruction
No Improvement
New Construction
River
Flood Prone Areas
Proposed Improvement
No
Minor Repair
3, 4, 7, 8, 9, 19, 33, 40, 43
Demolishment and Reconstruction
12, 13, 14, 15, 16, 29, 30, 42
New Construction
N
Kilometers
Kelani Ganga
To Colombo
To Colombo
To Wellawatta
To Ratmalana
To Hanwella
Kandy
Pradeepagama Model Village
Kaduwela
Kotalawala
Hewagama
Biyagama
Ganewatta
Kottunna
Yatiheta
Darbagama
Skyrambalagama
Kammalawatta
Gotumbara
Mawaramandiya
Heiyantuduwa
Mabima
Pathwila
Waturapata
Talwatta
Gonawala
Warahanduduwa
Hatigalla
Arbatale
Weliwita
Himbutana
Mullariyawa
Mullariyawa North
Kelaniya
Kelanimulla
Siththamulla
Belagama
Yaharaluwa
Rambutana
Pahala Boomiriya
Hena Boomiriya
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116000
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Figure 6

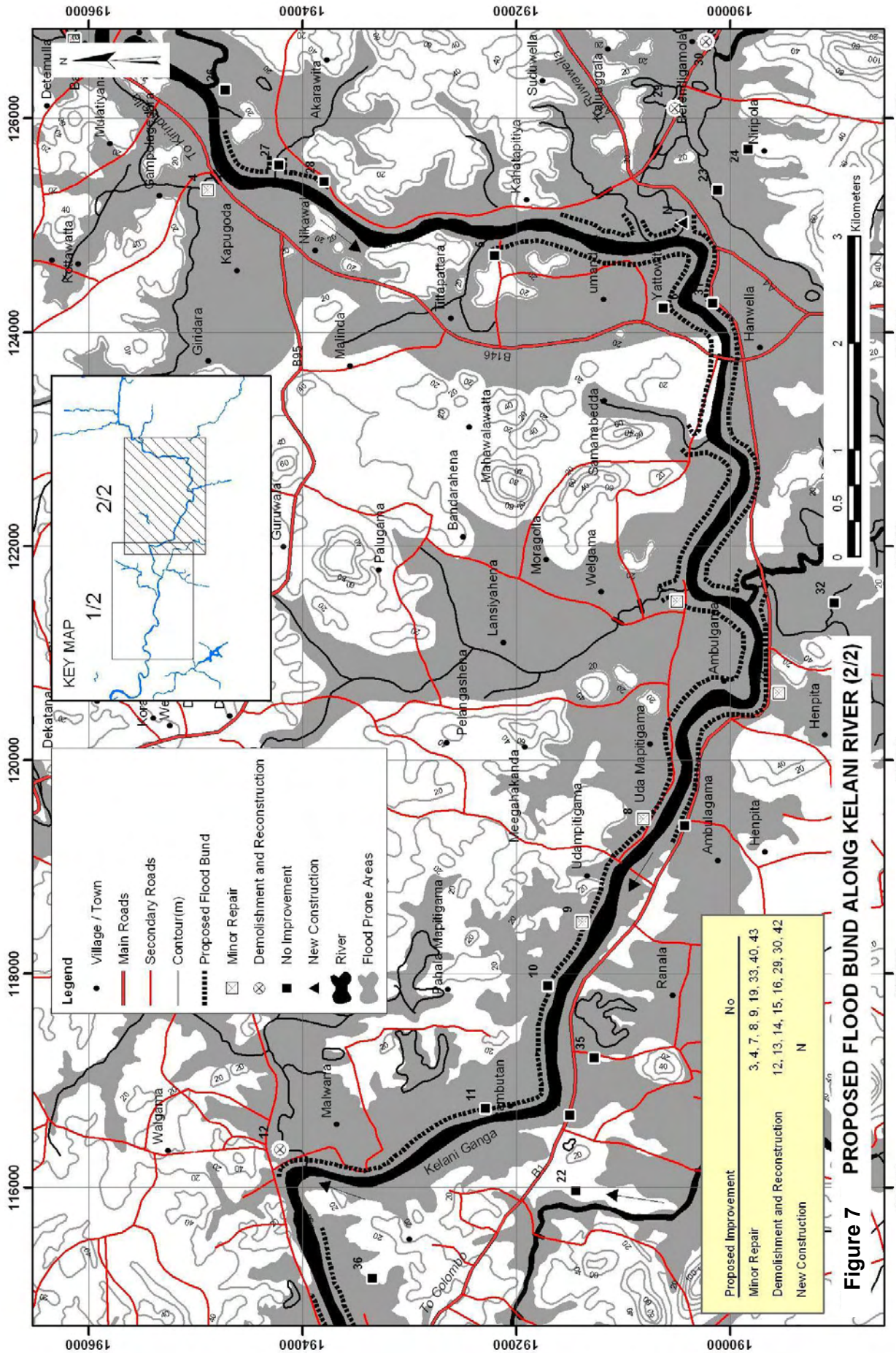

Figure 7 PROPOSED FLOOD BUND ALONG KELANI RIVER (2/2)

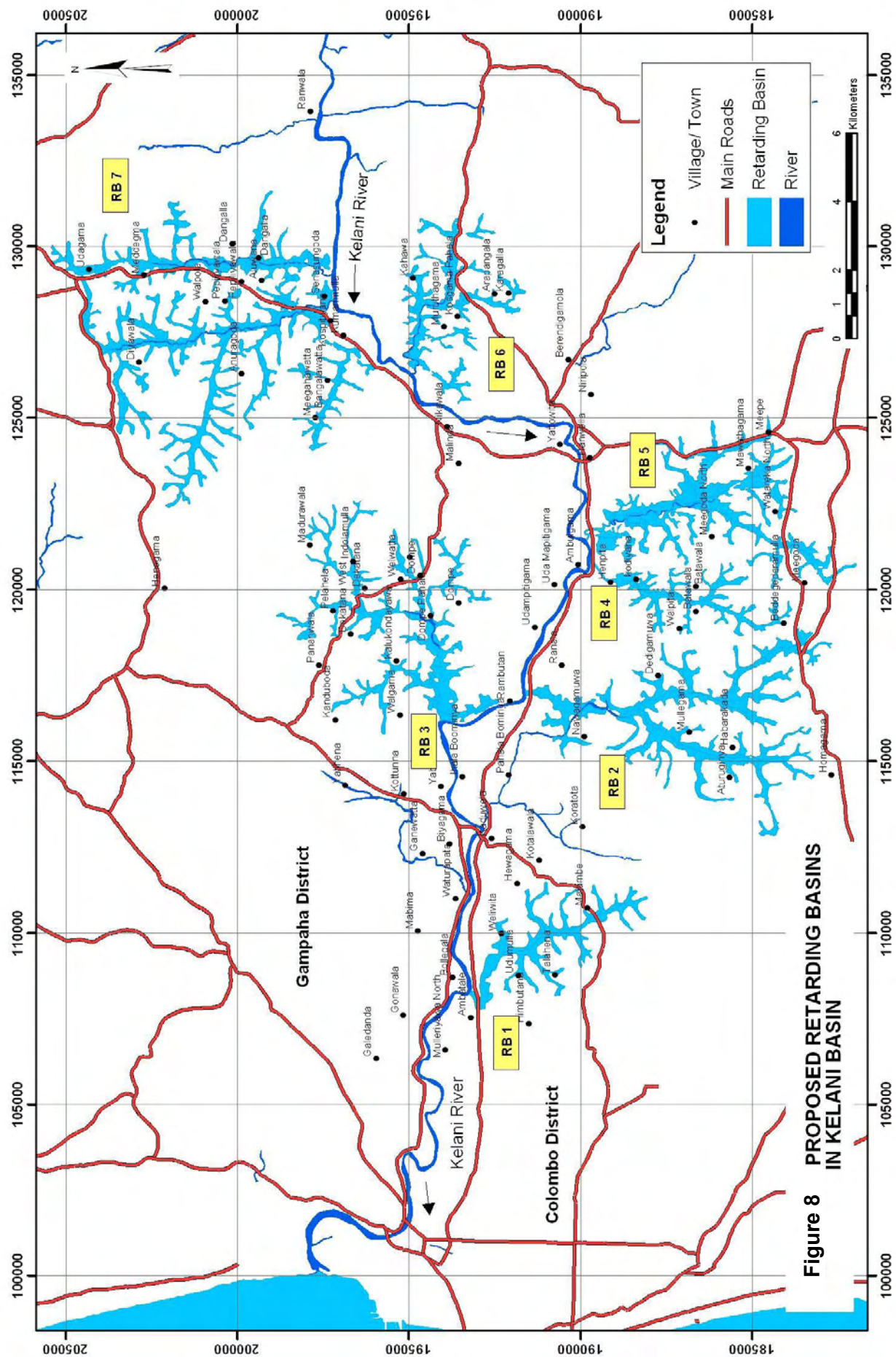

Figure 8 PROPOSED RETARDING BASINS IN KELANI BASIN