

## CHAPTER 5 GIN RIVER BASIN

### 5.1 Basin Overview

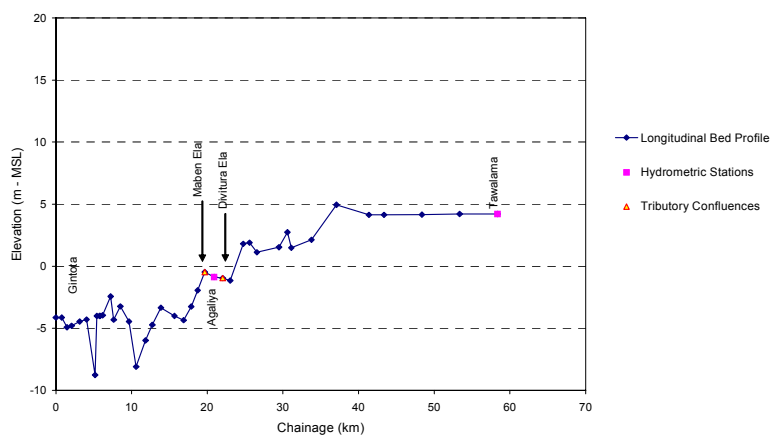
Gin River originates from the mountainous region in southern side of Sinharaja forest and runs through Tawalama, Neluwa and Agaliya and falls into sea at Gintota, Galle. The basin area of the river is 932 km<sup>2</sup> with an average annual runoff of 1,268 MCM. The catchment, which covers with a variety of types of vegetation, has an estimated average annual rainfall of around 3,290 mm.

A flood protection scheme which included a levee system and some pumping stations was implemented in 1970s in lower reaches of the river. In addition, the bypass canal Kapu Ela connected to main stream at Holuagoda also discharges water flow into Indian Ocean at Galle. A location map of the Gin River is shown in Figure II-15. Longitudinal profile is illustrated in Figure II-16.



Source: JICA Study Team

Figure II-15 Location map of Gin River Basin Inundation Area (May, 2003)



Source: LHI

Figure II-16 Longitudinal Profile of Gin River

### 5.2 Past Significant Floods

According to the annual maximum water levels after 1979 at Tawalama and Agaliya available, May 2003

flood was the worst one. Significant floods occurred in the basin in 1979, 1993, 1999 and 2003.

Until early morning on 17th of May 2003, mainly upstream area of the Gin River have received heavy rainfall over 350 mm in Sinharaja Forest. Flood water overtopped the flood bund at Nelwa around 20 km upstream from the river mouth and stagnated in three to four days. The inundation area due to May 2003 flood is shown in Figure II-15.

### 5.3 Review of Previous Flood Management Studies

The Study by ECI (1968) (see paragraph 58) recommended the flood control project for Gin River basin comprising of 54 individual flood bunds with a total length of 29.6 km and 22 pumping stations. After the Study, in fact, some of the recommendations were realized under the technical and financial assistance of Chinese Government in 1970's.

### 5.4 Hydrological and Hydraulic Model Studies

The river basin model of the Gin River contained the river basin from Tawalama to sea out falling at Galle together with Terun Ela, Kepu Ela and Holuagoda Ela. They were divided into 11 sub catchments, and 9 rainfall station data were adopted to estimate the mean areal rainfall in the basin. Probable daily rainfalls of major stations are presented as below:

Table II-30 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
Gin	Deniyaya (Anningkanda)	533.5	1950-2006	195.2	228.2	252.7	277.0	230.8
	Galle	12.5	1950-2006	186.5	218.6	242.4	266.1	282.6
	Hiniduma	-	1994-2006	212.1	243.9	267.6	291.0	224.2

Source: JICA Study Team

The model simulations were conducted under steady flow condition applying the same manner as the other river basins. The probable flood discharge and flood water level at major station in the Gin River is presented in Table II-31:

Table II-31 Probable Flood Discharge of Gin River

Return Period (Year)	Peak Discharge (m <sup>3</sup> /s)				
	Tawalama	Agaliya	Gin-Kepu Confluence	River Mouth (Gintota)	Kepu Ela Mouth(Galle)
2	542	633	687	497	190
5	863	1,024	1,119	787	333
10	1,076	1,289	1,415	983	434
20	1,279	1,546	1,703	1,160	545
30	1,397	1,691	1,864	1,257	610
50	1,543	1,887	2,089	1,390	701

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

Source: JICA Study Team

### 5.5 Land Use Planning in associated with Flood Management Plan

In Gin River basin, cultivated area accounts for the largest area (38.5%) with homesteads/garden area accounting for more than half (51.5%) followed by the paddy area (31.7%). The second largest utilization of the land is for crop field (24.4 %), with tea field occupying the largest area (52.0%), followed by rubber

field (38.5%). Forest area occupies almost the same ratio with the second largest (23.1%).

The development of the South-West Expressway and stimulated development in the area along the expressway will bring a drastic change of the land use and economic activity in this region. Although, those areas are away from main stream of the Gin River, any influence due to construction of huge embankment to current drainage system should be carefully examined.

## 5.6 Basic Concept for Flood Management Planning

The planning scale as target to formulate Master Plan in the Gin River was set at 30 years. Considering the required period of implementation of the proposed Master Plan, the target period was set for 15 years starting from 2010 and ending 2024.

Table II-32 Planning Scale of GIn River Basin

Safety Level (Flow Capacity)	Experienced Max. Peak Flood	Future Land Use	Planning Scale
- Flood bund section 20-year - Non-flood bund section: 2~5-year (Pumping facilities is designed to cope with 10-year flood in landside)	Approx.20-year (May 2003 Flood)	As regional development center, urbanization of Galle will be continued. However, no drastic change of land use is presumed from current situation (mainly agriculture- driven land use)	30-year (1,900 m <sup>3</sup> /s at river mouth)

*Source: Study Team*

### 5.6.1 Key Issues for Formulation of Master Plan

Current conditions of flood damages in the Gin River basin are characterized as below:

- Habitual flood damage in middle stream where flood bund dose not exist (by 2- to 5-year probable flood)
- Inundation at downstream floodway area (river area outside of existing flood bund, inundation occurs by 2-year probable flood)
- Insufficient drainage of land side at downstream stretches with flood bund
- Aging pumping facilities at downstream area, insufficient budget for proper operation and maintenance.
- Running cost for operation and maintenance of existing pumping facilities

#### (1) Unprotected area

The same issues for unprotected area in Kelani River basin are predicted.

#### (2) Dam and reservoir schemes

In the Study by ECI (1968), several dam schemes in the Gin River basin were studied. At present, DOI is conducting a study of development plan which aims to transfer surface water from Mediripitiya Dam to the southeast dry zone (Hanbantota District) via reservoir group in the Nilwala upstream. Although the dam schemes in the Gin River basin will be effective in the aspect of flood retarding function, many social environmental issues need to be addressed prior to implementation to

mitigate impact. Due to limitation of appropriate dam site and low level of economic viability, realization of the dam scheme in short-term seems not feasible.

(3) Non-Flood Bund in Middle Reaches

The middle reaches, which do not have existing flood bund at present, are habitual flooding zone by only 2- to 5-year probable flood. On the other hand, flood bund exists at the downstream reaches between the river mouth to Agaliya with almost 1/20 safety level. Flood risk at downstream reaches is relatively low. Under such current situation, disparity between the area with and without flood bund is remarkable. Needs of the residents for extension of the flood bund are increasing and were confirmed through a series of community development workshop. Although Phase 3 development scheme of flood bund construction for extension has been contemplated by China assisted project, its implementation has not been committed until present.

(4) Drainage Improvement in Protected Area

In order to safely drain rain water in land side at downstream reaches having flood bund, ten pumping stations (average design capacity  $Q=7 \text{ m}^3/\text{s}$ ) has been installed through a financial assistance from the Government of China. However, DOI currently encounters many problems: i.e. deterioration of over-aged pumping facilities (electrical system, building, control gate, trash rack, raking devices, etc.), heavy load of operation cost (annual electricity fee of about Rs.15 mil.) and lack of effective communication system between pumping stations.

5.6.2 Basic Strategy

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

- (1) Target area: (i) Non-flood bund area in middle reaches, (ii) Floodway area at downstream flood bund stretches, and (iii) Inundation area at land side (drainage area subject to existing pumping station)
- (2) Scale of countermeasures:

Gin River	Short-term target	Long-term target
	1/10 ( $Q_{\text{peak}}=1,450 \text{ m}^3/\text{s}$ )	1/30 ( $Q_{\text{peak}}=1,900 \text{ m}^3/\text{s}$ )

- (3) Basic strategy of flood protection:
  - Since dam schemes at upstream area (Jasmin dam, etc.) include many social environmental issues, it is not considered as a short-term measure. Thus, as a long-term measure, single purpose flood control dam is assumed and compared with other alternatives in the current Study.
  - To raise flood protection level at habitually flooded area in the middle stretches (non-flood bund section)
  - To upgrade and modernize the existing pumping facilities (total 10 pumping stations)
  - To undertake non-structural measures at non-flood bund stretches at downstream
  - In the Gin River basin, river channel width is relatively small compared with the Kelani River and appropriate site for retarding basin could not be found, which will meet required volume and area of flood control.

### 5.7 Alternative Structural Measures in Target River Basins

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

Table II-33 Structural Measure Element of Alternative Plans (Gin River)

Alternative	Short term		Long term
	Common	Each	
I	<ul style="list-style-type: none"> <li>Rehabilitation of existing pumps</li> <li>Mound dike</li> <li>EWMS</li> </ul>	-	Dam (high) (Jasmin Dam)
II		Flood bund system (long distance)	Dam (low) (Jasmin Dam)
III		Flood bund system (short distance)	Heightening of flood bund Extension of flood bund
IV		Flood bund system (long distance)	Heightening of flood bund

Source: JICA Study Team

#### 5.7.1 Distribution of Design Flood Discharge

Distribution of probable discharges for four alternative plans is shown in Figure II-17.

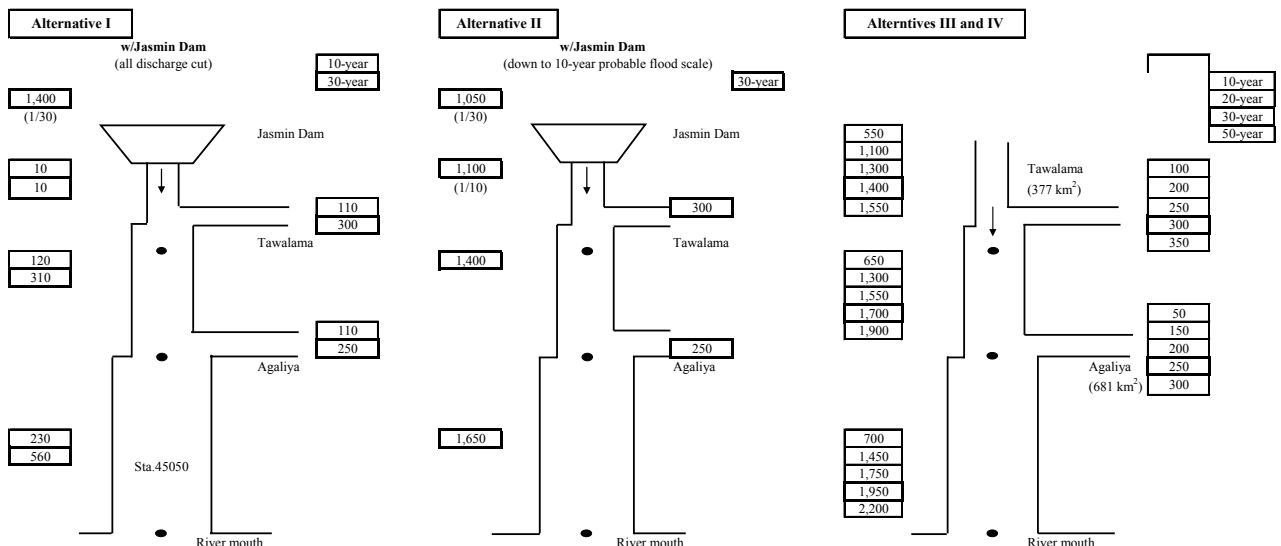


Figure II-17 Distribution of Probable Flood Discharge (Gin River)

#### 5.7.2 Principal Feature of Structural Measures (short term)

Design standards and guidelines in Sri Lanka as well as the international standards were applied for the structures proposed in this Study. Short term structural measures were preliminary designed as shown below.

Table II-34 Alternative Structural Measures (Short term)

Structural measures	Basic dimension
New sluiceways	9 sluiceways
Flood bund in downstream (short term)	For 10-year flood protection (in u/s of existing flood bund) (for Alternative II & IV) -L=8,360 m for left bank, L=7,620 m for right bank (for Alternative III) -L=390 m for left bank, L=1,830 m for right bank
Rehabilitation/ modernization of existing pumping stations	10 existing pumping stations
Mound dike	A=51,000m <sup>2</sup> in total (3 sites)
Early warning and monitoring system	8 rain gauges and 5 hydrometric gauges

Source: JICA Study Team

Principal feature of long term structural measures were designed as shown below.

Table II-35 Alternative Structural Measures (Long term)

Structural measures	Basic dimension
Heightening of flood bund	For 20-year flood protection (u/s of existing flood bund) -L=8,360 m for left bank, L=7,620 m for right bank
New pump house	8 nos.
Dam	Jasmin Dam (H=64.0 m, Earthfill Dam) (ref. 1968 M/P)

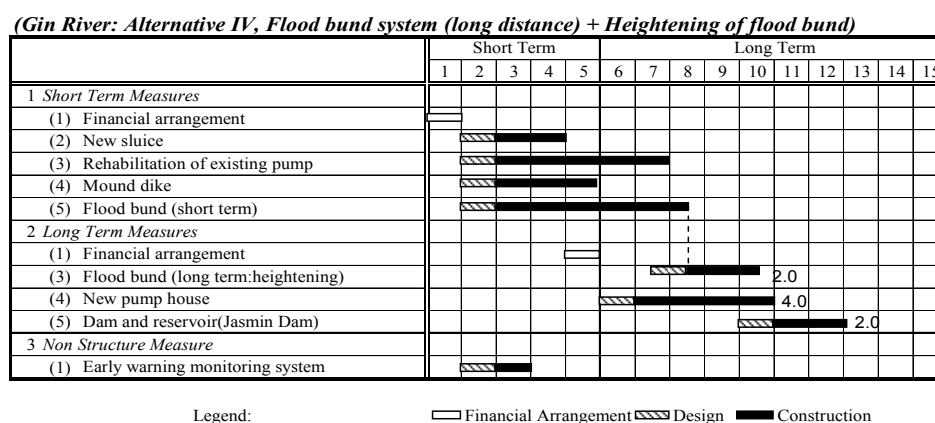
Source: JICA Study Team

### 5.8 Promising Non-Structural Measures

The same concept of the non-structural measures as introduced in the Kelani River basin was also applied in other river basins.

### 5.9 Construction Plan and Cost Estimation

Implementation schedule of selected alternative is shown in Figure II-18.



Source: JICA Study Team

Figure II-18 Implementation Schedule of Alternatives in Gin River (Alternative I selected as the Master Plan after evaluation)

The items and conditions for cost estimates are the same as those for Kelani, Kalu River basins. The project costs of the alternative cases are summarized below.

Table II-36 Project Costs of Alternatives in Gin River

(unit: US\$, thousand)

Item	Alternative I	Alternative II	Alternative III	Alternative IV
	Dam (high) (Jasmin Dam)	Flood bund system (short distance) + Dam (low) (Jasmin Dam)	Flood bund system (short distance) + Heightening of flood bund	Flood bund system (long distance) + Heightening of flood bund
I. Construction cost				
short term measures	57,749	69,645	57,798	68,315
long-term short term measures	82,891	41,792	27,952	16,899
<b>Sub Total</b>	<b>140,640</b>	<b>111,437</b>	<b>85,750</b>	<b>85,214</b>
II. Land acquisition cost	69,504	43,201	3,241	3,241
III. Engineering service cost	21,096	16,716	12,863	12,782
IV. Administrative expenses	4,625	3,427	2,037	2,025
V. Price escalation	207,825	114,615	64,471	54,498
VI. Physical contingencies	23,587	17,478	10,389	10,326
VII. Tax and duty	24,260	19,223	14,792	14,699
<b>Grand Total</b>	<b>491,500</b>	<b>326,100</b>	<b>193,500</b>	<b>182,800</b>

Source: JICA Study Team

Operation and maintenance costs for alternatives are presented below.

Table II-37 Annual O&M Costs (Gin River)  
(unit: US\$, thousand)

O&M costs	Alternative I	Alternative II	Alternative III	Alternative IV
Total	2,214	2,123	1,866	1,861

Source: JICA Study Team

## 5.10 Project Benefit

The items and conditions of estimate for project benefit are the same as other river basins. The project benefit for each alternative case was estimated as shown below.

Table II-38 Annual Average Benefit of Alternative Plans

Alternatives		short	long
Alternative I	Dam (high)	219.5	1,850.6
Alternative II	Dam (low)	1,319.0	1,726.4
Alternative III	Flood bund system (short)	586.5	1,534.4
Alternative IV	Flood bund system (long)	1,319.0	1,534.4

Source: JICA Study Team

Results of the evaluations of selected projects in each basin are summarized in the Table below for all alternatives:

Table II-39 Results of Economic Analysis of All Alternative Plans

Index		High dam		Low dam		Flood bund (short)		Flood bund (long)	
		Alternative I		Alternative II		Alternative III		Alternative IV	
		Overall	Short	Overall	Short	Overall	Short	Overall	Short
B-C	(Rs. mil.)	-6,561	-5,159	-1,512	1,055	-1,857	-2,003	555	1,512
B/C	(%)	0.55	0.21	0.88	1.15	0.76	0.64	1.07	1.23
EIRR	(%)	5.7%	-2.3%	8.6%	11.5%	7.8%	5.8%	10.7%	12.4%

Source: JICA Study Team

## 5.11 Environmental and Social Consideration

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

### (1) 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.

### (2) Rehabilitation of existing pump (Magnitude of Impact: Minor)

Works for pump houses may lead to temporary impact to water quality of the river through turbulence, etc. However, the impact is expected to be minor, taking into regard of that the works consists only of rehabilitation and repair.

### (3) Mound dike (Magnitude of Impact: Minor)

Taking into regard of the scale and location of the mound dike, which is planned within the river section,

impact of involuntary resettlement is not expected. There is a possibility of temporary impact on water quality through turbidity, etc., but the overall impact is expected to be minor.

**(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, heightening) (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) New pump house (Magnitude of Impact: Minor)**

Construction works of new pump houses may lead to temporary impact to water quality of the river through turbulence, etc. However, the impact is expected to be minor, taking into regard of the scale of construction works and that the location of the pump houses will not be dense. In order to minimize the necessity of land acquisition, the pump houses should be located within the river section as much as possible.

**(7) Dam and reservoir (Jasmin) (Magnitude of Impact: Significant)**

The construction of Jasmin dam will formulate a reservoir in the area near Hinduma East Ihala. The area expected to submerge embraces many communities while the slopes of the valley are developed as plantations. Furthermore, the area is recently being developed as a new center of Hinduma Division, and many administrative facilities are being relocated into the area. Therefore, necessary adjustments must be made with the administration of Hinduma Division before the implementation of the plan. A part of a B class national road will also be submerged by the formulation of the reservoir.

Furthermore, other factors that are expected to receive negative impact include; cultural / religious heritage, hydrology, flora/fauna and bio-diversity, landscape, and other factors relevant to construction works, and 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.

The results of initial environmental examination of possible alternatives are summarized below. The implementation of Alternatives III and IV resulted to have moderate impact on the environment and the society, while Alternative I and II is expected to have significant impact. From the environmental and social point of view, it may be said that Alternatives III and IV are desirable.



Table II-40 Results of IEE of All Alternative Plans

		Alternative				No Implementation
		I	II	III	IV	
Structural Measures	New sluice	D	C	C	C	D
	Rehabilitation of existing pump	C	C	C	C	D
	Mound dike	C	C	C	C	D
	Flood bund (short term and extension in long term)	D	B	B	B	D
	Flood bund (long term, heightening)	D	D	C	C	D
	New pump house	D	C	C	C	D
	Dam and reservoir (Jasmin)	A	A	D	D	D
Effect on Flood Protection		○	○	○	○	×
Evaluation from the viewpoint of ESC(negative impact of the alternative)		A	A	B	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

## 5.12 Flood Management Master Plan

The results of economic analysis show that Alternative IV (flood bund in long stretches) is most favorable with 1.07 of B/C ratio for the overall project, which is only one above viable level of the project. The results of IEE show that Alternative IV, along with Alternative III, are expected to have minimum negative impacts among the four Alternatives. Since the plan includes no complex structures and/or facilities and is composed of only conventional river structures, the plan is substantially feasible from technical aspect. Therefore, Alternative IV is recommended to select as the flood management master plan in the Gin River basin.

### (1) Structural Measures

Table II-41 Proposed Major Structures in Master Plan

#### Short-term plan

Kind of structure	Major dimensions
1. New sluices	9 nos.
2. Rehabilitation of existing pumps	10 pump houses
3. Mound dike	A=51,000 m <sup>2</sup> (3 sites)
4. Flood bund	Left bank (L=8,360 m, H=5.4m) Right bank (L=7,620m, H=5.3m)

#### Long-term plan

Kind of structure	Major dimensions
5. Flood bund (heightening)	Left bank (L=8,360 m, H=6.6m), Right bank (L=7,620m, H=6.3m)
6. New pump house	8 nos.

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

Table II-42 Non-Structural Measures to be Promoted

1. Early warning and monitoring system	<ul style="list-style-type: none"> <li>• 8 rain gauge stations</li> <li>• 5 hydrometric stations</li> </ul>
2. Restriction of further development in urban area	<ul style="list-style-type: none"> <li>• Management and monitoring of land use</li> <li>• Prohibiting housing development in flood prone area</li> <li>• Flood zoning with hazard mapping,</li> </ul>
3. Promotion of water-resistant architecture	<ul style="list-style-type: none"> <li>• Heightening of building foundation</li> <li>• Construction of column-supported</li> <li>• Housing, change to multi-storied housing</li> <li>• Water proofing of wall/housing materials, etc.</li> </ul>
4. Promotion of flood fighting activities	<ul style="list-style-type: none"> <li>• Information dissemination in the communities</li> <li>• Evacuation to safer area,</li> <li>• Removal of properties in house/building, etc.</li> </ul>
5. Resettlement	<ul style="list-style-type: none"> <li>• Mound dike</li> </ul>
6. Institutional strengthening of implementing agency	<ul style="list-style-type: none"> <li>• Consensus building for project implementation</li> <li>• Integration with urban development and land use development plans</li> </ul>

*Source: JICA Study Team*

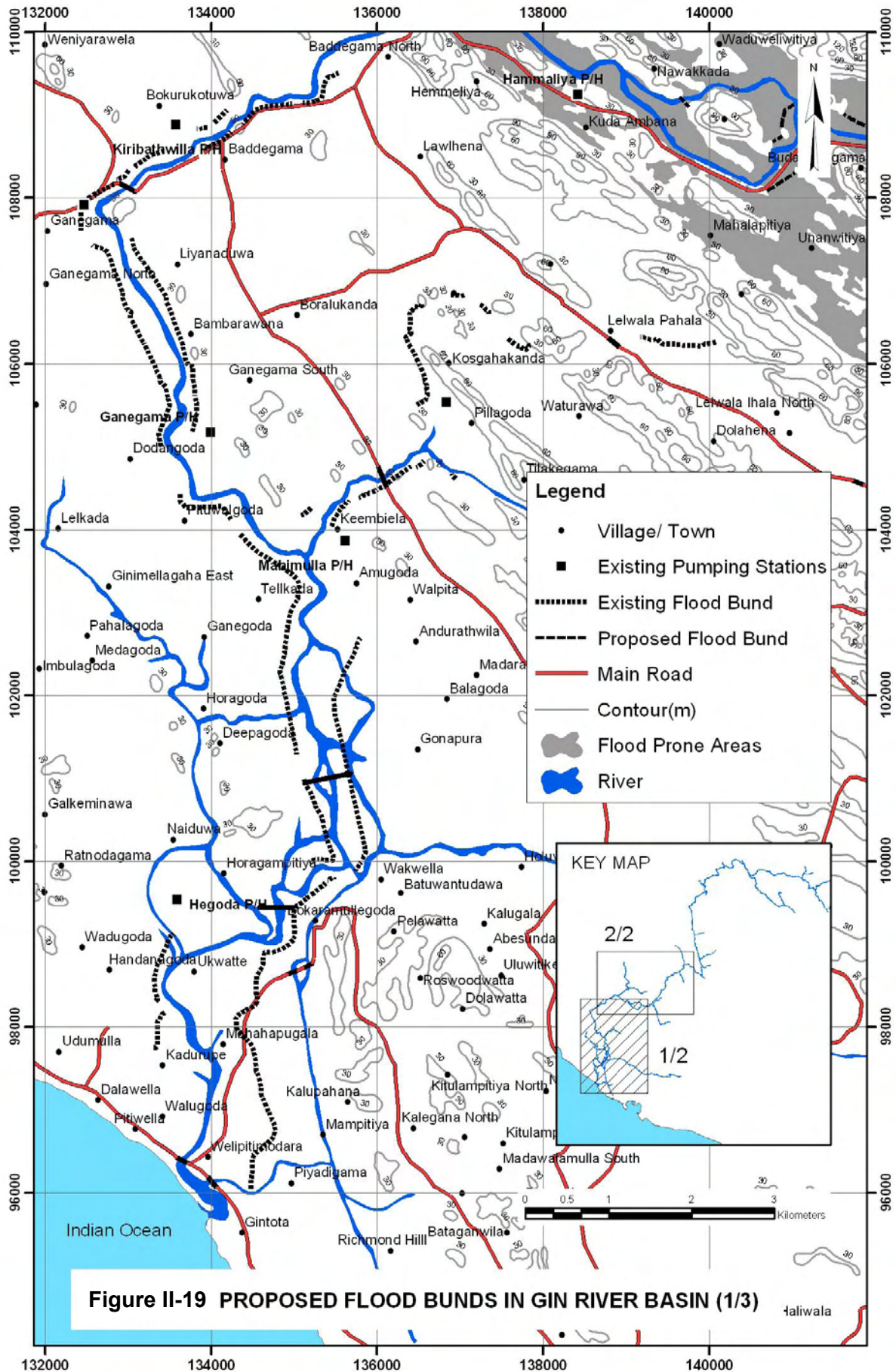


Figure II-19 PROPOSED FLOOD BUNDS IN GIN RIVER BASIN (1/3)



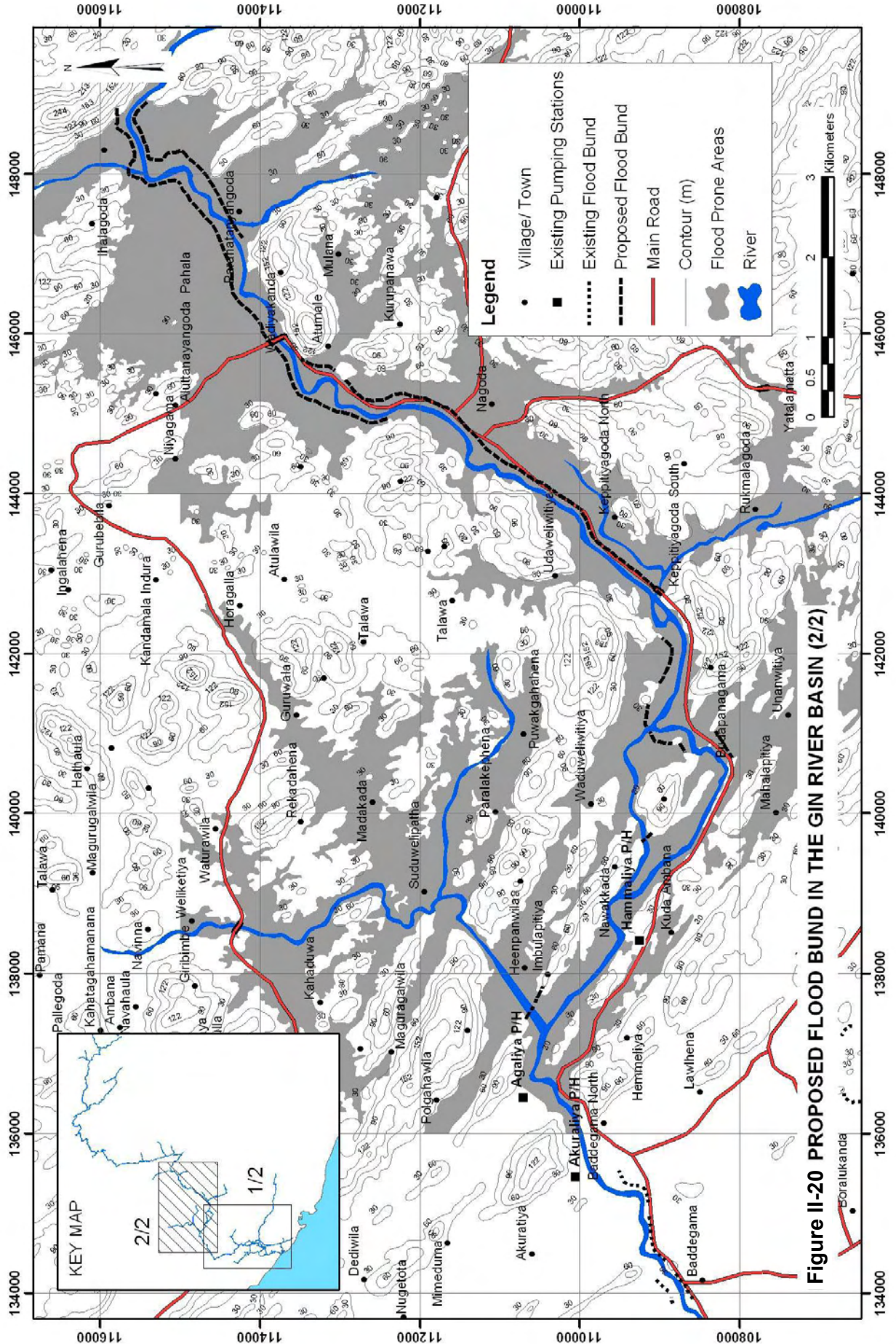
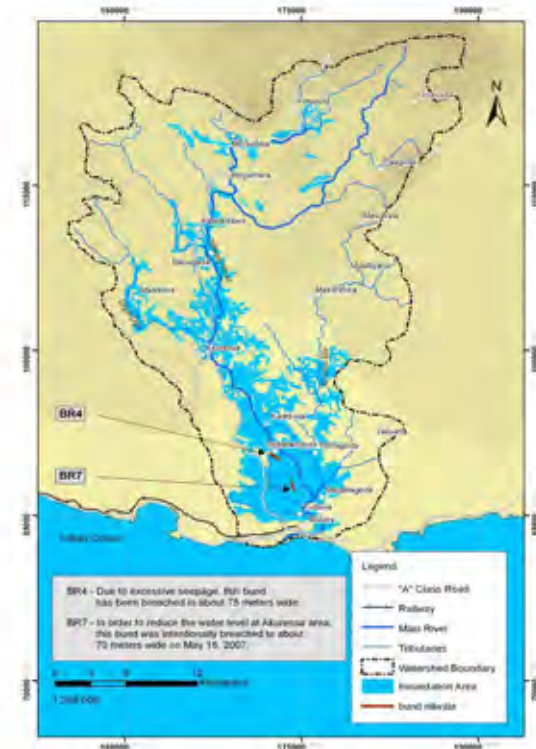


Figure II-20 PROPOSED FLOOD BUND IN THE GIN RIVER BASIN (2/2)

## CHAPTER 6 NILWALA RIVER BASIN

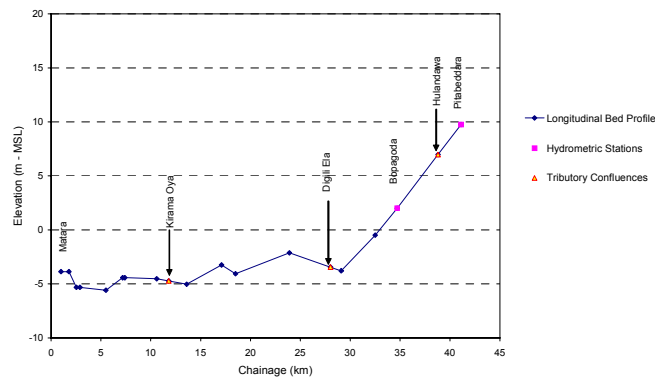
### 6.1 Basin Overview

The Nilwala River has catchment area of 960 km<sup>2</sup> and its length is 78 km. The basin is located adjacent to the Gin River basin at south and is entirely in the wet zone of the country. The annual mean rainfall is approximately 2,890 mm. It varies from 2,000 mm at the coast to 4,500 mm in the upstream mountainous area. The river originates at 1,050 m msl near Deniyaya Hills and drops to 12 m msl within the first 36 km and reaches Pitabeddara. It has a gentle slope down to the sea in the last 42 km downstream reaches from Pitabeddara to Matara. Annual mean discharge to the sea has been estimated as 1,152 MCM. A plan of the Nilwala River is shown in Figure II-21. A longitudinal profile of the Nilwala River is shown in Figure II-22.



Source: JICA Study Team

Figure II-21 Location Map of Nilwala River Basin and Inundation Area (May, 2003)



Source: Galle Regional Office of DOI and LHI

Figure II-22 Longitudinal Profile of Nilwala River

North of Matara city and its suburbs often get flooded during the rainy season. To cope with this problem a flood protection scheme was initiated by DOI in 1979 with the assistance from the Government of France. This flood protection scheme included a levee system and three pumping stations.

## 6.2 Past Significant Floods

According to the annual maximum water levels after 1978 at Pitabeddara and Bopagoda available in DOI, May 2003 flood was the worst one. Significant floods were recorded in 1978, 1993, 1999 and 2003 the same as those occurred in the Given River basin.

The Nilwala River basin was inundated widely in May 2003. It was reported that most of the pumping facilities did not work properly because of malfunction of submerged pumps and/or poor maintenance in routine operation. In Matara, inundation lasted for more than 10 days at maximum. It has been reported that approximately total 8,000 people evacuated. Inundation areas are delineated in Figure II-21.

## 6.3 Review of Previous Flood Management Studies

The Study by ECI (1968) proposed the project consisting of 27 km of flood bunds and 10 pumping stations in the Nilwala River basin. Those recommendations were succeeded and implemented partially by means of technical and financial assistance from the French Government in 1989.

The Study by DOI (2004) recommended that low dam scheme with 40 m height of Bingamara dam having multipurpose functions of hydropower, irrigation and drinking water supply in Matara District.

## 6.4 Hydrological and Hydraulic Model Studies

The river basin model of the Nilwala River contained the main river basin between Pitabeddara and sea outfall at Matara, and linked with three tributaries: namely Hulandawa Ganga, Digili Ella and Kirama Oya. The river basin was divided into 8 sub catchments, and 8 rainfall station data were adopted to estimate the mean areal rainfall in the basin. Probable daily rainfalls of major stations are presented in the Table below.

Table II-43 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
Nilwala	Mawarella	-	1950-1994 &	196.8	235.0	263.3	291.4	354.8
	Thihagoda	-	1950-2002	162.3	198.1	224.6	251.0	203.2

*Source: JICA Study Team*

The model simulations were conducted under steady flow condition applying the same manner as the other river basins. The probable flood discharge at major station in the Nilwala River is presented in Table II-44 below.

Table II-44 Probable Flood Discharge of Nilwala River

Return Period (Year)	Peak Discharge (m <sup>3</sup> /s)				
	Pitabeddara	Bopagoda	Akuressa	Thalgahagoda	River Mouth
2	500	524	558	622	709
5	972	1014	1075	1187	1341
10	1285	1339	1421	1569	1774
20	1584	1652	1753	1939	2193
30	1757	1832	1944	2149	2430
50	1972	2060	2190	2430	2758

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

## 6.5 Land Use Planning in associated with Flood Management Plan

The characteristics of land use are as follows:

- (1) Cultivated area accounts for the largest area (45.6%) of the river basin area, with homesteads/garden occupying the biggest (60.7%) followed by paddy area (31.1%).
- (2) The second largest utilization of the land is for crop field (23.4%), with tea field occupying the largest area of 66.4%.
- (3) Forest area occupies a relatively large area (18.5%).

The future development plan is defined within the Greater Matara Urban Area. The areas along the Nilwala River are planned mostly as environment-ecotourism area and environment- conservation area.

The development of the South-West Expressway is also planned in this region. It will have the most effect on regional drainage system in this area.

## 6.6 Basic Concept for Flood Management Planning

The planning scale target to formulate Master Plan in the Nilwala River was set at 30 years. Considering the required period of implementation of the proposed Master Plan, the target period was set for 15 years starting from 2010 and ending 2024.

Table II-45 Planning Scale of Nilwala River Basin

Safety Level (Flow Capacity)	Experienced Max. Peak Flood	Future Land Use	Planning Scale
- Flood bund section 10~20-year	Approx.20-year (May 2003 Flood)	As regional development center, urbanization of Matara will be continued. However, no drastic change of land use is presumed from current situation (mainly agriculture- driven land use)	30-year (2,200 m <sup>3</sup> /s at river mouth)

*Source: JICA Study Team*

### 6.6.1 Key Issues for Formulation of Master Plan

Current conditions of flood damages in the Gin River basin are characterized below.

- Inundation damage at middle reaches has no flood bund (inundation occurs by 2- to 5-year probable flood)
- Inundation damage at floodway in the downstream flood bund stretches (inundation occurs by 2-year probable flood)
- Damage due to stagnation of rainwater at land side in the downstream flood bund stretches
- Aging pumping facilities at downstream area, insufficient budget for proper operation and maintenance and inefficient operation of pumping facilities due to lack of appropriate communication system between existing pumping stations.

The same issues for unprotected area, dam and reservoir schemes, non-flood bund in middle reaches and drainage improvement in Kelani and Gn River basins are predicted.

### 6.6.2 Basic Strategy

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

(1) Target area: (i), Non-flood bund area in middle reaches, (ii) Floodway area at downstream flood bund stretches, and (iii) Inundation area at land side (drainage area subject to existing pumping station)

(2) Scale of countermeasures:

Downstream Area (Matara)	Short-term target	Long-term target
	1/10 ( $Q_{\text{peak}}=1,900 \text{ m}^3/\text{s}$ )	1/30 ( $Q_{\text{peak}}=2,200 \text{ m}^3/\text{s}$ )

(3) Basic strategy of flood protection:

- Since dam schemes at upstream area include many issues such as large scale of relocation of main road, etc. as seen in the case of the Gin River, it is not considered as a short-term measure. Thus, as a long-term measure, single purpose flood control dam is assumed and compared with other alternatives in the current Study.
- To raise flood protection level at habitual flooding area in the middle stretches non-flood bund section (Akuressa and its vicinity) (to protect against 10-year probability by increasing current scale of 2- to 5-year channel capacity)
- To upgrade and modernize the existing pumping facilities (total of three pumping stations)
- To undertake non-structural measures at non-flood bund stretches at downstream

### 6.7 Alternative Structural Measures

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

Table II-46 Structural Measure Element of Alternative Plans (Nilwala River)

Alternative	Short term	Long term
I	• Flood bund system	Heightening of flood bund
II	• Rehabilitation of existing pumps	Heightening of flood bund, Bypass (in Akuressa)
III	• Mound dike	Dam (high) (Siyambalagoda Dam)
IV	• EWMS	Dam (low) (Siyambalagoda Dam)

Source: JICA Study Team

Distribution of probable discharges for four alternative plans is shown in Figure II-23.



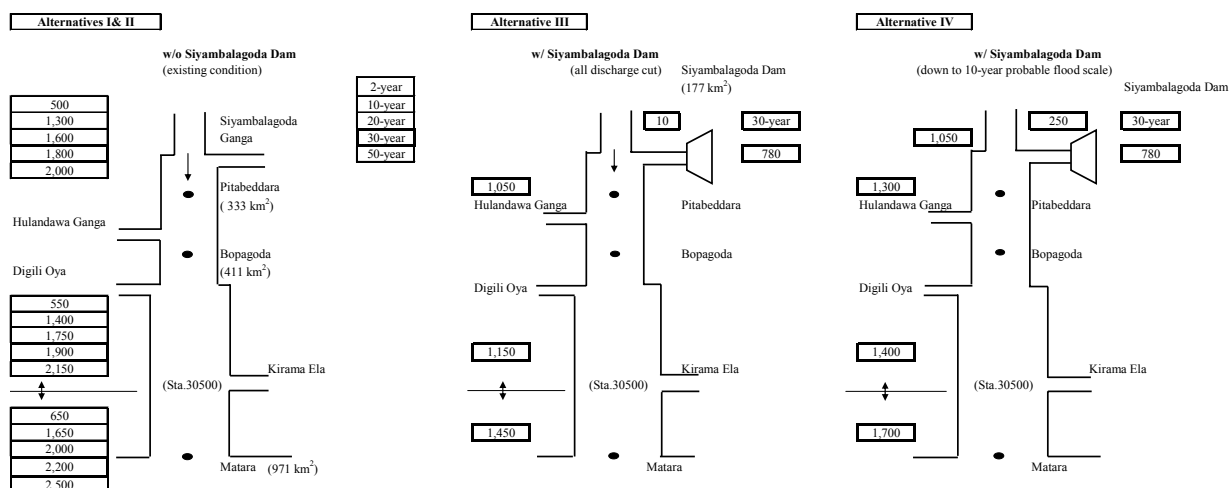


Figure II-23 Distribution of Probable Flood Discharge

Design standards and guidelines in Sri Lanka as well as the international standards were applied for the structures proposed in this Study. Short term structural measures were preliminary designed as shown below.

Table II-47 Alternative Structural Measures (Short term)

Structural measures	Basic dimension
New sluiceways	11 sluiceways
Flood bund in downstream (short term)	For 10-year flood protection (in u/s of existing flood bund) -L=9,570 m for left bank, L=7,460 m for right bank
Rehabilitation/ modernization of existing pumping stations	3 existing pumping stations
Mound dike	A=62,000m <sup>2</sup> in total (3 sites)
Early warning and monitoring system	8 rain gauges and 6 hydrometric gauges

Source: JICA Study Team

Principal feature of long term structural measures were designed as shown below.

Table II-48 Alternative Structural Measures (Long term)

Structural measures	Basic dimension
Heightening of flood bund	For 30-year flood protection (u/s of existing flood bund) -L=9,570 m for left bank, L=7,460 m for right bank
New pump house	8 nos.
Bypass in Akuressa	L=3.2 km, Q=545 m <sup>3</sup> /s, open channel (H=6.5m, W=31.7m, i=1/2,600)
Dam	Siyambalagoda Dam (H=74.0 m, Earthfill Dam) (ref. 2004 F/S)

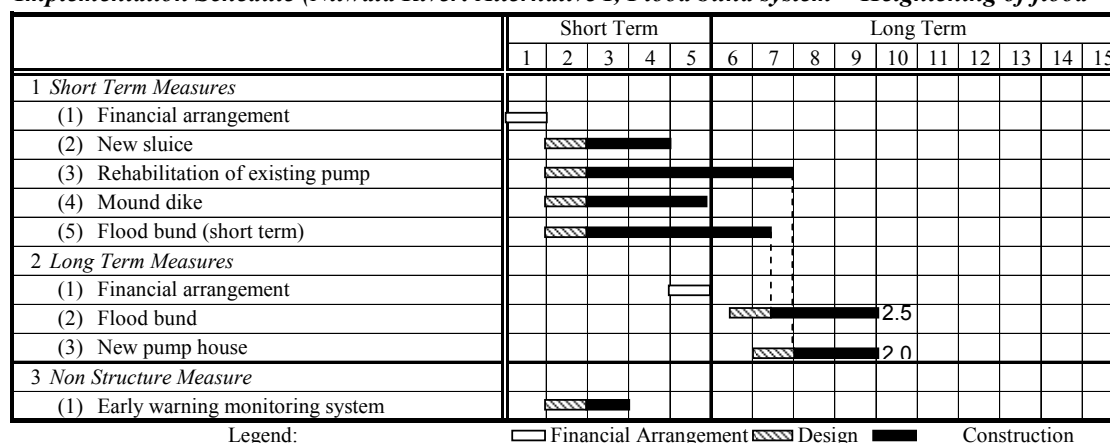
Source: JICA Study Team

## 6.8 Promising Non-Structural Measures

The same concept of the non-structural measures as introduced in the Kelani River basin was also applied in other river basins.

## 6.9 Construction Plan and Cost Estimation

Implementation schedule of alternative is shown in Figure II-24.

**Implementation Schedule (Nilwala River: Alternative I, Flood bund system + Heightening of flood**

Source: JICA Study Team

Figure II-24 Implementation Schedule of Alternatives in Nilwala River  
(Alternative I selected as the Master Plan after evaluation)

The items and conditions for cost estimates are the same as those for Kelani, Kalu river basins. The project costs of the alternative cases are summarized below.

Table II-49 Project Costs of Alternatives in Nilwala River

(unit: US\$, thousand)

Item	Alternative I	Alternative II	Alternative III	Alternative IV
	Flood bund system + Heightening of flood bund	Flood bund system + Bypass (in Akuressa)	Flood bund system + Dam (high) (Siyambalagoda Dam)	Flood bund system + Dam (low) (Siyambalagoda Dam)
I. Construction cost				
short term measures	59,188	59,188	57,441	59,218
long-term short term measures	7,010	18,058	119,537	97,449
II. Land acquisition cost	7,767	9,726	17,912	16,056
III. Engineering service cost	9,930	11,587	26,547	23,500
IV. Administrative expenses	1,678	1,971	4,429	3,924
V. Price escalation	37,844	51,813	228,731	175,022
VI. Physical contingencies	8,557	10,053	22,587	20,015
VII. Tax and duty	11,419	13,325	30,529	27,025
<b>Grand Total</b>	<b>143,400</b>	<b>175,700</b>	<b>507,700</b>	<b>422,200</b>

Source: JICA Study Team

Operation and maintenance costs for alternatives are presented below.

Table II-50 Annual O&amp;M Costs (Nilwala River)

(unit: US\$, thousand)

O&M costs	Alternative I	Alternative II	Alternative III	Alternative IV
Total	1,399	1,510	2,507	2,304

Source: JICA Study Team

**6.10 Project Benefit**

The project benefit for each alternative case was estimated as shown below.

Table II-51 Annual Average Benefit of Alternative Plans

(Unit: Million Rs./year)

Alternatives	short	long
Flood bund system	1,979.5	2,222.9
Flood bund system + Bypass	1,979.5	2,222.9
Dam (high dam)	1,673.0	3,366.0
Dam (low dam)	1,979.5	3,172.9

Source: JICA Study Team

Results of the evaluations of selected projects in each basin are summarized in the Table below for all alternatives:

Table II-52 Results of Economic Analysis of All Alternative Plans

Index	Flood bund		Flood bund + Bypass		High dam		Low dam	
	Alternative I		Alternative II		Alternative III		Alternative IV	
	Overall	Short	Overall	Short	Overall	Short	Overall	Short
B-C (Rs. mil.)	5,890	6,105	5,474	6,021	1,379	3,496	2,851	5,387
B/C (%)	1.85	2.00	1.74	1.98	1.10	1.51	1.22	1.79
EIRR (%)	18.0%	19.2%	17.2%	19.0%	11.0%	14.9%	12.3%	17.3%

Source: JICA Study Team

## 6.11 Environmental and Social Consideration

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

### (1) 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 11 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.

### (2) Rehabilitation of existing pump (Magnitude of Impact: Moderate)

Works for pump houses may lead to temporary impact to water quality of the river through turbulence, etc. However, the impact is expected to be minor, taking into regard of that the works consists only of rehabilitation and repair. On the other hand, appropriate operation plans should be prepared based on detailed survey, taking into regard the wide spread pyrite in the lower stretches of Nilwala River.

### (3) Mound dike (Magnitude of Impact: Minor)

Taking into regard of the scale and location of the mound dike, which is planned within the river section, impact of involuntary resettlement is not expected. There is a possibility of temporary impact on water quality through turbidity, etc., but the overall impact is expected to be minor.

### (4) Flood bund (short term) (Magnitude of Impact: Minor)

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, heightening) (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) New pump house (Magnitude of Impact: Moderate)**

Construction works of new pump houses may lead to temporary impact to water quality of the river through turbulence, etc. However, the impact is expected to be minor, taking into regard of the scale of construction works and that the location of the pump houses will not be dense. In order to minimize the necessity of land acquisition, the pump houses should be located within the river section as much as possible.

On the other hand, appropriate operation plans should be prepared based on detailed survey, taking into regard the wide spread pyrite in the lower stretches of Nilwala River.

**(7) Dam and Reservoir (Siyambalagoda) (Magnitude of Impact: Significant)**

According to the plan of Siyambalagoda dam, a reservoir will be formulated in the eastern valleys of Siyambalagoda. This area is mainly developed as tea plantation, and population density is relatively low compared to the dam sites planned in the other river basins. In this regard, the occurrence of involuntary resettlement is expected to be smaller in number. On the other hand, the impact on economic activities still remains significant. It must also be noted that the area is located adjacent to Mulatiyana forest reserve and the impact to flora/fauna and bio-diversity must also be carefully examined.

Furthermore, other factors that are expected to receive negative impact include; hydrology, landscape, and other factors relevant to construction works. Though involuntary resettlement is expected to be limited to some extent, 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 in order to minimize the impact. 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.

**(8) Bypass canal (Akuressa) (Magnitude of Impact: Moderate)**

Since the bypass canal in Akuressa is planned to mainly go through agricultural lands, direct impact by resettlement is expected to be limited. On the other hand, impact on local economic activities through the acquisition of farmland is expected, and necessary compensation should be examined. The amount of excavation of the canal is expected to be at a considerable level, and thus may have impact on important topographical / geological features, hydrology, and landscape. Though the area has been conventionally developed as agricultural land, the area is expected to be relatively rich in flora ad fauna. In this regard, detailed examination of the impact on flora/fauna and bio-diversity should be made when implementing the plan.

The results of comparison of possible alternatives follow. The implementation of Alternatives I and II resulted to have moderate impact on the environment and the society, while Alternatives III and IV is expected to have significant impact. From the environmental and social points of view, it may be said that Alternatives I and II are desirable.

Table II-53 Results of IEE of All Alternative Plans

Item		Alternative I				No Implementation
		I	II	III	IV	
Structural Measures	New sluice	C	C	C	C	D
	Rehabilitation of existing pump	B	B	B	B	D
	Mound dike	C	C	C	C	D
	Flood bund (short term)	C	C	C	C	D
	Flood bund (long term, heightening)	C	C	D	D	D
	New pump house	B	B	B	B	D
	Dam and Reservoir (Siyambalagoda)	D	D	A	A	D
	Bypass canal (Akuressa)	D	B	D	D	D
Effect on Flood Protection		○	○	○	○	×
Evaluation from the viewpoint of ESC(negative impact of the alternative)		B	B	A	A	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

## 6.12 Flood Management Master Plan

The results of economic analysis show that Alternative I (flood bund system) is most favorable with substantial B/C ratio for the short-term (2.00) and overall projects (1.85) as well. The result of IEE also indicates that Alternative I is expected to have minimum negative impacts among the four Alternatives. Since the plan is composed of only conventional river structures such as flood bund, sluices and installation of pumps, the plan is substantially feasible from technical aspect.

Therefore, Alternative I is recommended for the flood management master plan in the Nilwala River basin.

### (1) Structural Measures

Table II-54 Proposed Major Structures in Master Plan

#### Short-term plan

Kind of structure	Major dimensions
1. New sluices	11 nos.
2. Rehabilitation of existing pumps	3 pump houses
3. Mound dike	A=62,000 m <sup>3</sup> (3 nos.)
4. Flood bund	Left bank (L=9,570 m, H=4.7m) Right bank (L=7,460m, H=4.4m)

#### Long-term plan

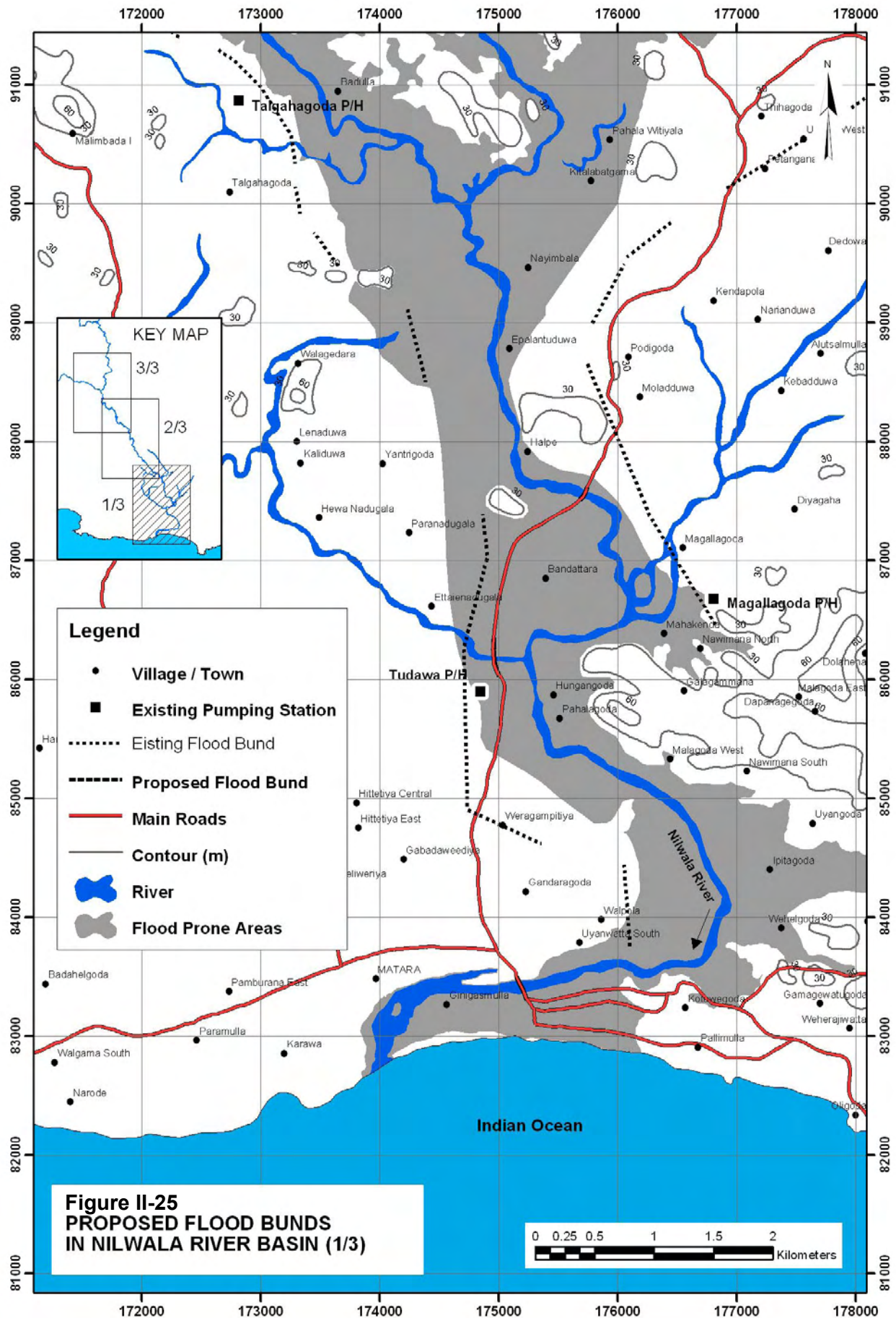
Kind of structure	Major dimensions
5. Flood bund	Left bank (L=9,570 m, H=5.9m) Right bank (L=7,460m, H=5.5 m)
6. New pump house	2 nos. (Q=3.0 m <sup>3</sup> /s, H=5.0 m)

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

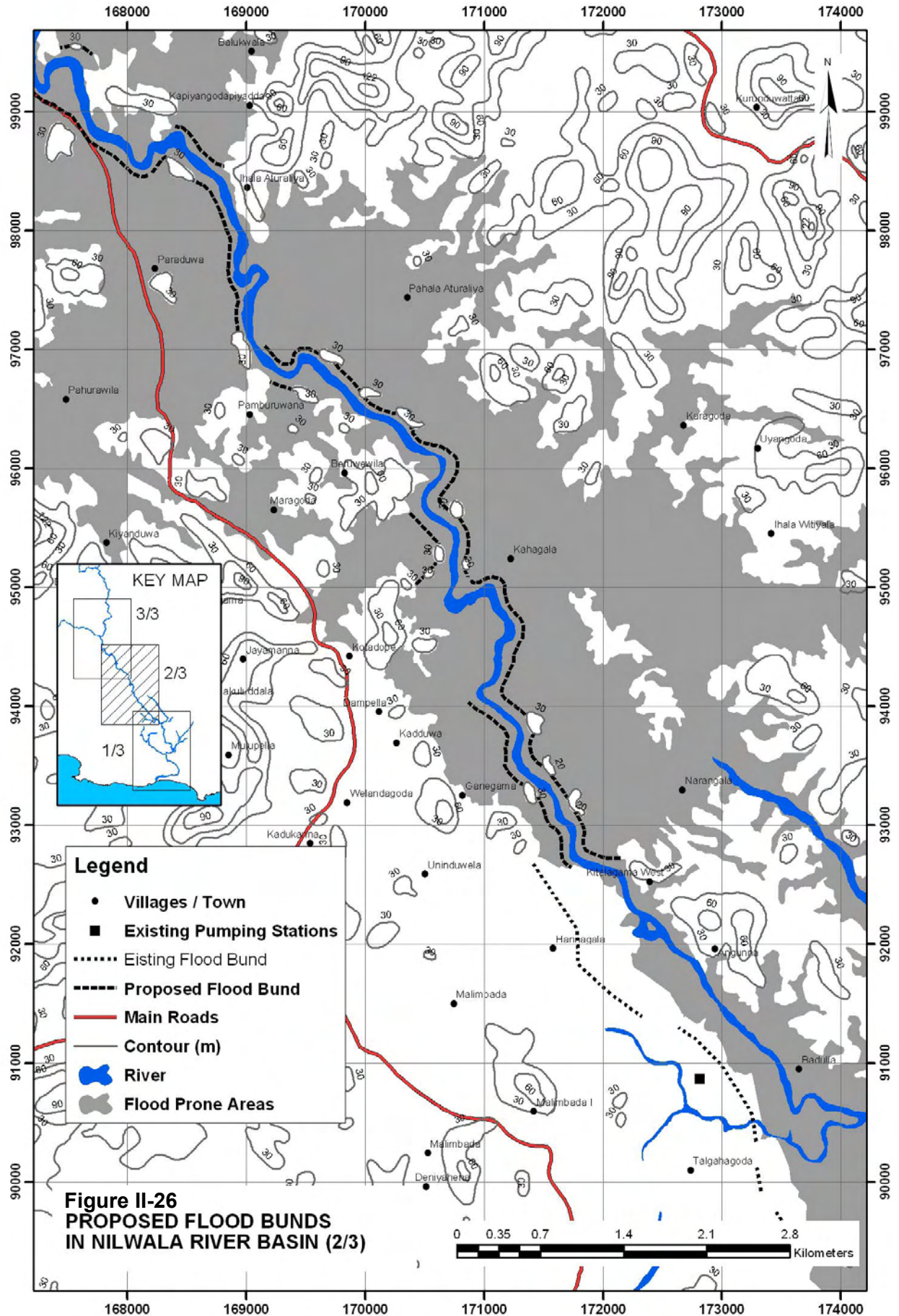
Table II-55 Non-Structural Measures to be Promoted

1. Early warning and monitoring system	<ul style="list-style-type: none"> <li>• 8 rain gauge stations</li> <li>• 6 hydrometric stations</li> </ul>
2. Restriction of further development in urban area	<ul style="list-style-type: none"> <li>• Management and monitoring of land use</li> <li>• Prohibiting housing development in flood prone area</li> <li>• Flood zoning with hazard mapping,</li> </ul>
3. Promotion of water-resistant architecture	<ul style="list-style-type: none"> <li>• Heightening of building foundation</li> <li>• Construction of column-supported</li> <li>• Housing, change to multi-storied housing</li> <li>• Water proofing of wall/housing materials, etc.</li> </ul>
4. Promotion of flood fighting activities	<ul style="list-style-type: none"> <li>• Information dissemination in the communities</li> <li>• Evacuation to safer area (during flood)</li> <li>• Removal of properties in house/building, etc.</li> </ul>
5. Resettlement	<ul style="list-style-type: none"> <li>• Mound dike</li> </ul>
6. Institutional strengthening of implementing agency	<ul style="list-style-type: none"> <li>• Consensus building for project implementation</li> <li>• Integration with urban development and land use development plans</li> </ul>

*Source: JICA Study Team*







**Figure II-26**  
**PROPOSED FLOOD BUNDS**  
**IN NILWALA RIVER BASIN (2/3)**



