CHAPTER 4 STUDY ON FLOOD MITIGATION MASTER PLAN

4.1 Planning Basis

4.1.1 Diagnosis of Flood and Sediment Problems

(1) Flood and Sediment Disasters

Suffering Areas: In the Study Area, major suffering areas of flood and sediment disasters are located in the southern part of Gorontalo City, middle reaches of the Bolango River, Limboto and Isimu-Pohu areas, and western area of Lake Limboto. Among these, problems are more serious in the southern part of Gorontalo City near the confluence of the Bolango and Bone rivers.

Types of Disasters: Types of flood and sediment disasters observed in the Study Area are summarized as follows:

1) Flooding: The flooding is due to floodwater overtopping river and canal banks which are often seen along the river courses in the Study Area after heavy storm.
2) Inundation: The inundation is caused by stagnant flood water in low-lying lands and the areas where gravity drainage is difficult because of natural and artificial obstacles. This type of flood disasters is seen near the confluence of the Bolango-Bone-Tamalate junction, left bank areas of the lower Bolango River, western lands of Lake Limboto, and Isimu-Pohu areas.
3) Bank erosion: Bank erosions are found in most rivers of the Study Area. River stretches with bank protection works are very limited.
4) Silting-up of river: Floodwater with high sediment concentration silts up river and canal beds in the lower reaches where sediment transport capacity becomes low.
5) Sedimentation of Lake Limboto: Lake Limboto is functioning as a natural stilling basin for the sediment carried by the Biyonga, Alo-Pohu and other numerous rivers flowing into the lake.

(2) Causes of Disasters

Causes of Flood and Sediment Disasters: Flood and sediment disasters in the Study

Area are induced basically by the following problems of the basin associated with financial constraint, shortage of engineers and lack of comprehensive flood mitigation master plan to guide all the relevant activities:

1) Concentration of properties on narrow plain
2) Insufficient flood mitigation facilities
3) Devastation of watershed
4) Inappropriate land use in flood plain

Concentration of Properties on Flood Plain: Since the LBB basin is mountainous and the flat lands are only 20% or less, most of the arable lands and settlement are located in the flood plain formed by repeated river flooding for a long period. The flood prone areas of the LBB basin are located in such flood plains.

Insufficient Flood Mitigation Facilities: Flood mitigation facilities such as channel normalization, dikes and bank protection works are seen in the Bolango, Tamalate and Alo-Pohu rivers. However, the works are of small scale and for local measure. Other rivers and drainage channels are not improved yet and the drainage capacity remains low, which causes frequent flooding and elongates the period of flood inundation.

Devastation of Watershed Management: Deforestation and land development for agriculture and settlement take place in the watershed areas, especially in the Lake Limboto and the Bolango River basins. According to our study, 54 km^2 of bush lands and 21 km^2 of forest lands were converted to farm land during past 10 years. These activities reduce natural retention capacity of water and sediment and cause the increase of floodwater and sediment runoffs.

Inappropriate Land Use in Flood Plain: Inappropriate land use in flood plain is another cause to aggravate the flood and sediment disasters. The flood plain is the land originally formed by floods and flooding is apt to take place often there. The inappropriate land use and development regardless this matter may cause the increase of damages in vain.

(3) Mechanism of Flood and Sediment Disasters

Damages (Df) due to the flood disaster generally depend on the devastation of basin's physical conditions (Bd), peoples' concentration of damageable properties (Pd) in flood

plain, and progress of flood mitigation activities (Fm) in the Study Area. Relationship of these factors is conceptually expressed as:

$$D_f = f\,(Bd, Pd, - Fm)$$

In order to secure the stability of peoples' livelihood and development of the region, appropriate watershed management to prevent from devastation and flood plain management to reduce damageable properties are therefore substantial as well as structural flood mitigation measures. Major causes and mechanism of flood and sediment disasters in the main flood prone areas are briefed below:

Southern Part of Gorontalo City:

1) Southern part of Gorontalo City is located in the low land at the confluence of the Bolango and Bone rivers, affected by floods of both rivers.
2) Channel capacity of the lower Bolango River downstream of Tapodu junction is low with only 88% of 2-year flood.
3) Water level of the lower Bolango is raised high for long period due to:
   (1) Long lasting outflow from Lake Limboto which retains huge amount of water,
   (2) Back water effects of the Bone River of which flood duration is longer because of long shaped basin and better vegetation cover, and
4) Under the long lasting water level of the Bolango River, flush flood from the upper Bolango River easily overtops the bank and causes frequent flooding of the city.
5) Floodwater from the north eastern mountainous basin is brought in Gorontalo City by the Tamalate River.

Lake Limboto and Western Area of Lake:

1) Lake Limboto receives flood runoff and sediment from devastated drainage basins of a total area of 890 km^2 consisting of the Alo-Pohu, Biyonga, and other numerous rivers.
2) During the flood of the Bolango River, floodwater stored in the lake cannot be drained due to high water level of the Bolango at the outlet.
3) Even after the flood of the Bolango, it takes time to drain the stored water because of low channel capacities of the Tapodu and the lower Bolango rivers.
4) This situation brings about the long period inundation in the western part of the lake and other lakeside lands. Sedimentation of the lake aggravates the inundation in the lakeside areas.

4.1.2 Administrative and Socio-Economic Background

(1) Administrative Innovation

Establishment of Gorontalo Province: The establishment of Gorontalo Province was agreed by Central Government with the Law No.38/2000 and the organization and working order of the Dinas in Gorontalo Province have been established, among which Dinas of Public Works/Settlement and Regional Infrastructure was included. Though the organizational and institutional setup of new Gorontalo Province is progressing, it would take much more time to attain full function.

Decentralization Policy: Government administration changed to decentralization system, mainly by the Law No.22/1999 pertaining regional governance and the Law No. 25/1999 pertaining fiscal balance between central and regional governments. Under the decentralization system, all the authorities regarding the water resources matters are to be transferred to local government (Kabupaten/Kota). In order to administrate issues in the water resources sector, the local governments have established Dinas, i.e., Dinas Pekerjaan Umum Kota Gorontalo and Dinas Pekerjaan Umum dan Prasarana Wilayah Kabupaten Gorontalo. These two Dinas will have very big job. Formerly the jobs in these regions were only operation and maintenance of irrigation facilities carried out by branch offices of provincial Dinas.

(2) Present Socio-Economic Situation

Relevant Kabupaten/Kota: The area of 94% of the LBB basin is located in Kabupaten Gorontalo, 2% in Kota Gorontalo and 4% in Kabupaten Bolaang-Mongondow. Most of the developed area of Kabupaten Gorontalo and whole of Kota Gorontalo is located in the plain area to be protected from flood and sediment disasters.

Population: According to the census 2000, the population was estimated 445,000 in the LBB basin, among which urban population was 205,000 comprising 120,000 in Kota Gorontalo and 85,000 in Kabupaten Gorontalo.

Regional Account: Per capita gross regional domestic products (GRDP) was estimated at Rp.1,160,000 (US$122 equivalent) for Kabupaten Gorontalo and Rp.2,388,000 (US$251 equivalent) for Kota Gorontalo, which respectively correspond to only 18% and 38% of the national average. The economic activity in Kabupaten Gorontalo is

specialized for agriculture, while that in Kota Gorontalo for services in particular.

(3) Frameworks of National Development

Long-Term Development Program: In 1994, the "Second Long-Term National Development Program (PJP-II, Program Pembangunan Jangka Panjang Tahap ke-II), 1994-2019" was announced by the government as national guidelines for development. During the period of the first PJP (PJP-I: 1969-1994), the national economy attained a remarkable economic growth, an average GDP growth of nearly 7% per annum. The PJP-II was expected to attain the same prospects as carried out in the PJP-I, but it was baffled after the collapse of the Soeharto administration. In the PJP-II, the long-term physical frames were projected as shown in Table 4.1.1.

National Development Program: The "National Development Program (PROPENAS) of 2000-2004" was established as a five-year development plan. The PROPENAS is based on decentralization policy in all aspects of national development.

Among various aspects of national development, economic development policy was directed in the macro-economic framework. The framework was composed of the following prospects.

1) To accelerate economic rescue and recovery so as to enable the real sector to recover
2) To attain a reasonable level of interest rates, inflation under control, and to attain a stable and realistic exchange rate
3) To restructure the state budget, by reducing budget deficits, gradually reducing subsidies and foreign loans and make the tax structure progressive and equitable, and economize expenditures
4) To accelerate banking recapitalization and restructure corporate debt
5) In coordination with other policy efforts, to reduce poverty and unemployment
6) To support the development of the people oriented grassroots' economy.

In order to make the framework definite forms, the plan proposes macro-economic growth indicators in the planning period as shown in Table 4.1.1.

(4) Roles of Flood Mitigation

Per capita GRDP of the Study Area is far low comparing with the national average. The basin's economic activities have been constrained by the flood and sediment disasters. Flood mitigation is one of the basic infrastructures to support implementation of the development plan and is duly necessary to attain sound economic development of the basin, and accordingly to stabilize people's livelihood and alleviate poverty of the Study Area.

4.1.3 Approach to Planning

In order to cope with the problems mentioned above, the Flood Mitigation Master Plan (FM-MP) is to be planned placing importance on the following:

1) Basin-wide approach: River is a continuous channel system to transport water and sediment from any point of the basin to the river mouth. Therefore, flood mitigation measures must be discussed from basin-wide viewpoint.
2) Comprehensive flood mitigation plan: In order to cope with the natural and social issues related to the flood and sediment disasters, the FM-MP of the LBB basin should be formulated in comprehensive manner, employing every possible measure, i.e., structural and nonstructural measures.
3) Sustainable implementation of flood mitigation activities: The flood mitigation activities should be conducted and sustained keeping up with the changes of the physical and social features of the basin. Therefore, the flood mitigation activities should be sustained by the local government with participation of local communities.

4.1.4 Principles for Planning Flood Mitigation Master Plan

(1) Flood Mitigation Master Plan

Flood mitigation master plan (FM-MP) for the LBB basin was studied along the following principles:

1) **Objective of Master Plan:** The FM-MP aims to direct or guide the flood mitigation activities that will be conducted toward the target year by various agencies and organizations concerned.

2) **Scope of Planning:** Flood mitigation, in the present study, includes the mitigation of flood damages and sediment induced disasters. The FM-MP shall cover structural and non-structural measures. The structural measures discussed in the master plan are limited to the primary facilities to mitigate flood and sediment damages of the area.

3) **Target Year:** In line with the phasing of National Five-Year Plan, target year of the FM-MP was set at the end of Tenth Five-Year Plan in 2019. The proposed project will be implemented to support basin's socio-economic conditions at the target year.

(2) Design Scale of Facility

Return period of 20 years was decided to be applied to the Flood Mitigation Master Plan of the LBB basin, judging from the physical conditions of the basin and channels, design scale of other similar rivers and socio-economic situation of the basin as shown in the paragraph below. Flood control facilities are designed based on the 20-year flood, then, the economic and financial soundness shall be examined.

Design Scale: Design scale of the flood control facilities shall be determined in general, considering characteristics of runoff and topography, capacity of existing facilities, design scale of other rivers in similar conditions, importance of properties to be protected at present and in future, fund available for the construction and maintenance works, and economic viability.

Design Scale of Rivers in Indonesia: Design discharges of rivers in Indonesia are summarized in Table 4.1.2 together with their design scales. As seen in the Table, various return periods ranging from 10 years to 50 years are adopted for the design of channels. The 50- and 40-year floods are applied to the long-term plans and the 10 year floods are to the short-term or urgent plan. The 20- and 25-year floods are applied to the design of many rivers in Indonesia.

Recommended Design Scale: According to "Recommended Minimum Return Period of Design Flood" in Flood Control Manual (DGWRD, 1993) shown in Table 4.1.3, the design scale of river is stated as follows:

Project type	Initial phase	Final phase
Emergency project	5-yr.	10-yr.
New project	10-yr.	25-yr.
Updating project		
- For rural or urban with population <2,000,000	25-yr.	50-yr.
- For urban with population >2,000,000	25-yr.	100-yr.

Return Period of Recent Storms: Only for reference to the design scale, return period of recent floods was examined. Rainfall record is the only data available for the examination. Looking over the return periods corresponding to respective annual maximum rainfalls, return periods of the recent major storms are less than 20-year, except for those in 1989 and 2000 at Jalaluddin Airport and in 1997 at Boidu Tapa. These three records give extremely high return period as point rainfall. However, considering the records available at other stations in the same year, areal rainfall values, which have close correspondence with the magnitude of flood, are 67mm in 1989, 91mm in 1997 and 104mm in 2000 by using the arithmetic-mean method.

4.2 Studies on Component Schemes for Flood Mitigation

4.2.1 Applicable Measures and Schemes

Structural and non-structural measures were discussed to cope with flood and sediment disasters in the Study Area. Applicable measures and schemes would be primarily broken down to (1) river improvement, (2) flood diversion, (3) flood and sediment runoff retention, (4) watershed management, and (5) flood plain management.

River Improvement: River improvement is the fundamental measure for flood mitigation. It includes works for channel normalization, dike, bank protection and flood diversion. The channel normalization work aims to secure smooth passage of flood water, by means of smoothening channel alignment, widening and deepening channel section, and normalizing sections at the constriction due to river crossing structures and natural obstacles. The dike work is intended to prevent floodwater from spilling over the river bank, and the bank protection work to prevent bank erosion and to stabilize the river course. The following schemes were selected for the Study.

1) Bone-Bolango river system: Improvement of the Bone, Tamalate and Bolango rivers
2) Lake Limboto system: Improvement of the Biyonga, Meluopo, Marisa, Alo-Pohu and Rintenga rivers

Flood Diversion: The flood diversion work includes construction of floodway and intercepting channel to lead flood water away from the area to be protected. The following schemes were selected for the Study:

1) Tamalate floodway scheme to divert the Tamalate flood water to the Bone River bypassing the urban area of Gorontalo.
2) Bolango-Limboto floodway scheme to divert the Bolango flood water to Lake Limboto.

Flood Runoff Retention: Flood control dam and flood retardation pond are conceivable to retain floodwater so as to lower the flood peak in the lower reaches. Following three schemes were selected for the study:

1) Kayu-Merah dam scheme on the Biyonga river to alleviate flood peak in

Limboto City

2) Toheti-Dehua dam scheme on the Bolango river to alleviate flood peak in Gorontalo City
3) Lake Limboto management scheme to regulate discharge at the outlet of the lake so as to mitigate flooding in Gorontalo City. The scheme may include improvement of outlet channel (the Tapodu River) with construction of hydraulic control gate (Tapodu Gate), construction of lake dike, etc.

Watershed Management: Watershed management is the activities to manage watershed area so as to retain rainwater in the watershed area and alleviate flood and sediment runoff to the lower basin. Main activities for the watershed management include:

1) Afforestation,
2) Conservation of existing forest,
3) Regulation of deforestation,
4) Conservation of natural flood retardation areas, and
5) Guidance to local people for appropriate forest use and conservation of mountain slope.

Flood Plain Management: The flood plain management is the activities to manage flood plain area so as to reduce and avoid occurrence of flood damages. Main activities for the flood plain management include:

1) Land use adjustment to reduce damageable properties in flood vulnerable areas,
2) Encouragement of peoples' water-proofing activities,
3) Establishment of flood forecasting and warning system, and
4) Promotion of flood fighting activities by community organization.

4.2.2 River Improvement Schemes

Outline of Scheme: Existing channels of the Bone, Tamalate and Bolango rivers of the Bolango-Bone river system; and the Biyonga, Meluopo, Marisa, Alo-Pohu and Rintenga rivers of the Lake Limboto system are improved so as to have enough capacity to carry flood water of 20-year return period. The river improvement includes the works for channel excavation, dike embankment, bank protection, and drainage sluice across the dike.

Channel Design: River channel was designed as follows:

1) Design discharge applied to the channel design are shown in Figure 4.2.1 based on 20-year flood.
2) Design high water level was set as low as possible considering the surrounding ground elevation and design high water levels at the river mouth (MHWL: +0.673 m,MSL) and at Lake Limboto (+5.50 m,MSL).
3) Minimum river width between the dikes and dike section are assumed tentatively for the Master Plan as shown in Figure 4.2.2 according to the standards and practice in Japan.
4) The low water channel is improved by means of excavation so that the river channel has enough capacity to carry 20-year flood discharge below the design high water level set in the above.
5) Channel flow calculation was made assuming the coefficient of roughness n = 0.030 for low water channel and n = 0.060 for high water channel.
6) Bank protection works are necessary at the sections where the low water channel is close to the dike and/or important properties to be protected are located. For the purpose of overall cost estimate for the Master Plan, bank protection works were assumed for the whole river banks, since rivers in the Study Area are steep located on and adjacent to the alluvial fan.

Drainage Sluice: Drainage sluices are provided to drain the excess water across the dike and also to prevent the intrusion of flood water from the river. Following considerations were given to the design of these drainage sluices:

1) Conduit type sluice: The box culvert type will be applied to sluiceway conduit design. Standard designs will be adopted to the box culvert type
2) Gate type sluice: Manually operated slide gate will be applied because the slide gate has higher reliability of operation performance. General design drawing is shown in Figure 4.2.3.

Bridge Structures: Reconstruction of bridges becomes necessary as appurtenant works of river improvement works. Following considerations were given to the design of these bridges:

1) Bridge type: Bridge types will be decided taking into consideration the site

conditions for construction works and economic advantage, etc.

2) Bridge length and width: Length of each bridge depends on the river width between dikes at bridge site. Width of carriageway is designed at 4 m and 7 m without the sidewalk in accordance with the standard of Bina Marga.
3) Abutment: Abutment of the bridge is designed, so that front face of the abutment does not thrust into the river flow below the design high water level.

Relationship with Other Alternative Schemes: The river improvement schemes designed above are the fundamental solutions to attain flood mitigation in the Study Area. The scheme may be replaced with other alternatives discussed below after comparing them from technical, financial, economical, social and environmental aspects.

4.2.3 Floodway Schemes

Two floodway schemes were considered for the Study, i.e., Tamalate floodway and Bolango-Limboto floodway schemes.

(1) Tamalate Floodway Scheme

Outline of Scheme: The Tamalate River has a total basin area of 70 km^2 including mountainous basin. Floodwater from the basin flows down to the urban area of Gorontalo City and drained into the Bone River just upstream of the Bone-Bolango junction. The Tamalate floodwater is one of main causes of flooding in the southeastern part of Gorontalo City and its high water makes urban drainage difficult. In order to protect the urban area from the Tamalate floodwater, Tamalate floodway scheme was considered. The floodway will divert all the flood runoff of the Tamalate River at the divergence (120 m^3/s) to the Bone River, alleviating the flood runoff in the lower reaches of the Tamalate River. The existing Tamalate River downstream from the floodway divergence will serve as a trunk drainage channel of the urban area. The Tamalate floodway scheme includes works of construction of new floodway, diversion at the head of the floodway, and closing dike at the head of the existing Tamalate River with intake sluice to supply water during dry season.

Design of Floodway: The floodway and the related facilities were designed as follows:

1) Design Discharge: Design discharge distributions without and with floodway

are shown in Figure 4.2.4.

2) Floodway Route: The route connecting Alitalango of the Tamalate and Oluhuta of the Bone River was proposed as shown in the Figure 4.2.4. The floodway length is the shortest at this site (1.5 km) and the land is mostly farmland.
3) Floodway Channel: Open channel with low dike embankment was designed in the same procedures as channel design mentioned in the previous sub-section.
4) Closing Dike: The Tamalate River is divided into the upper and lower Tamalate River by a closing dike at Alitalango section. During flood season the flood water from the upper Tamalate will be diverted to the Bone River via floodway and the lower Tamalate will serve as a trunk drainage channel of the Gorontalo City. An intake gate will be provided with the closing dike to supply water to the urban area during dry season for water use and maintenance purposes.

Design of Diversion Weir: Major function of this weir is to consolidate riverbed at the inlet of floodway controlling diversion water. The weir has no gate and designed with concrete slab and concrete blocks on riverbed and with wet-rubble masonry on both sides of bank slopes. The size of weir is 50 m in length and 26 m in width. General design drawing is shown in Figure 4.2.5.

Selection of Alternative: The Tamalate floodway will reduces the improvement works of the lower Tamalate River. For the selection of the optimum scheme following alternatives were established and designed preliminarily for comparison:

1) Alternative [Ch] : Channel improvement of the existing Tamalate River
2) Alternative [Fw＋Ch] : Construction of Tamalate floodway with minor channel improvement of the lower Tamalate River

Project features of these schemes were compared as shown in Table 4.2.1. In conclusion, Alternative [Fw＋Ch] was selected mainly due to lower cost and firm flood mitigation effects.

(2) Bolango-Limboto Floodway Scheme

Outline of Scheme: The Bolango River passes through the urban area of Gorontalo City. The Bolango River flooded frequently in the urban area since the channel capacity of the lower Bolango River is low. In order to reduce flood discharges to the urban area, Bolango-Limboto floodway scheme was considered. The floodway will

divert major part of flood water exceeding the existing capacity of the Bolango River (100 m^3/s) to Lake Limboto.

Design of Floodway: The floodway and the related facilities were designed as follows:

1) Design discharge: Design discharge distributions without and with floodway are shown in Figure 4.2.6.
2) Floodway route: The floodway diverts from the Bolango River at Batato to Lake Limboto near Lupoyo 1, taking route on the paddy field with less settlements as shown in the Figure 4.2.6. The total floodway length is 6.3 km.
3) Floodway Channel: Open channel with low dike embankment was designed in the same procedures as channel design mentioned in the previous sub-section.
4) Diversion Structures: In order to divert 650 m^3/s of flood water to floodway and 100 m^3/s to lower reaches of the Bolango River under 20-year flood, culvert was designed across the Bolango River and fixed weir at the inlet of the floodway.

Selection of Alternative: The floodway scheme will reduce the improvement works of the Bolango River in the downstream reaches. For the selection of the optimum scheme, following alternatives were established and designed preliminarily for comparison:

1) Alternative [Ch] : Channel improvement of the existing Bolango River up to the Bone confluence.
2) Alternative [Fw+Ch] : Construction of Bolango-Limboto floodway with minor channel improvement of the existing Bolango River

Project features of these schemes were compared as shown in Table 4.2.2. In conclusion, Alternative [Ch] was selected mainly due to lower cost and less sediment and environmental problems.

4.2.4 Flood and Sediment Retention Schemes

Within the frame of the LBB Basin Water Management Master Plan (WM-MP) formulated in March 1999 with technical assistance of CIDA, two multi-purpose dams have been proposed. Objectives of these dams are as follows:

1) Toheti-Dehua multi-purpose reservoir on the Bolango River: To provide a reliable water supply for irrigation, domestic, and industrial supplies; to augment water supply to Lake Limboto; to provide flood control facilities, hydropower; and retention of sediment in order to improve agricultural production, increase farmers' incomes, improve health standards and the Lake Limboto environment, and reduce flooding in Gorontalo City.
2) Kayu Merah multi-purpose reservoir on the Biyonga River: To construct a small multi-purpose reservoir for irrigation, domestic water supply, flood control, and retention of sediment, in order to increase agricultural production, reduce flood damage in the city of Limboto, provide a more reliable source of water for domestic use, and reduce the amounts of sediment being deposited in Lake Limboto and the downstream irrigation system.

Besides these dam schemes, the WM-MP has also proposed Lake Limboto Management Scheme. These schemes are expected to serve for flood control as one of the multi-purpose functions. Therefore, these schemes were adopted for the present study as alternative flood mitigation measures.

(1) Toheti-Dehua Flood Control Dam

General features: Candidate site of the dam is located on the Bolango River, immediately downstream of the confluence with the Mongillo River. Basin area upstream of the dam is 357 km^2.

Dam: In order to estimate the cost for flood mitigation function, the dam exclusive for flood mitigation was assumed for the study. Stage-area-volume (H-A-V) curves are shown in Figure 4.2.7. The dam scheme was planned and designed based on the design for the WM-MP, adjusting for storage capacity. Design discharge distributions without and with dam are shown in the Figure 4.2.7.

Selection of Alternative: The dam scheme will reduce the improvement works of the Bolango River in the lower reaches. For the selection of the optimum scheme, following alternatives were established and designed preliminarily for comparison:

1) Alternative [Ch]: Channel improvement of the existing Bolango River up to the Bone confluence.
2) Alternative [Dm + Ch]: Construction of Toheti-Dahua flood control dam with

channel improvement of the existing Bolango River.

Project features of these schemes were compared as shown in Table 4.2.3. In conclusion, Alternative [Ch] was selected mainly due to lower cost and immediate realization of the flood mitigation effects.

(2) Kayu-Merah Flood Control Dam

General features: Candidate site of the dam is located on the Biyonga River with basin area of 58 km^2 at dam site.

Dam: In order to estimate the cost for flood mitigation function, the dam exclusive for flood mitigation was assumed for the study. Stage-area-volume (H-A-V) curves are shown in Figure 4.2.8. The dam scheme was planned and designed based on the design for the WM-MP, adjusting for storage capacity. Design discharge distributions without and with dam are shown in the Figure 4.2.8.

Selection of Alternative: The dam scheme is an alternative measure for the Biyonga River improvement scheme. For the selection of the optimum scheme, following alternatives were established and designed preliminarily for comparison:

1) Alternative [Ch]: Channel improvement of the existing Biyonga River up to Lake Limboto.
2) Alternative [Dm＋Ch]: Construction of Kayu-Merah flood control dam with channel improvement of the existing Biyonga River.

Project features of these schemes were compared as shown in Table 4.2.4. In conclusion Alternative [Ch] was selected mainly due to lower cost and immediate realization of the flood mitigation effects.

(3) Multipurpose Dams

Flood Control Dam: According to the alternative studies in the previous sub-sections, Toheti-Dahua and Kayu-Merah flood control dams were not adopted for the FM-MP. This decision, however, does not mean to deny the proposed multi-purpose dam schemes.

Multi-purpose Dam: The multi-purpose dam, notwithstanding with flood control component or without, serves for flood peak reduction and sediment control in the lower river reaches. In view of this the construction of multi-purpose dam is favorably accepted from flood and sediment control viewpoint.

Uncertainty of Time of Implementation: Primary component of Toheti-Dahua and Kayu-Merah multi-purpose dams would not be flood control and implementation of dam schemes depend on the programs of other sectors, which makes difficult to incorporate these multi-purpose dams into the FW-MP.

(4) Lake Limboto Management

The flood mitigation function of the lake should be maintained and the sound development of lake side area and other existing functions of the lake should be secured. From this viewpoint, Lake Limboto management scheme was proposed mainly for flood and sediment disaster mitigation. The Lake Limboto management scheme includes sediment trap works of the Biyonga and Alo-Pohu rivers, lake dikes, and the Tapodu River improvement with gate.

Sediment Traps Works: Major sources of sediment of Lake Limboto are the Biyonga, Alo-Pohu, Meluopo and Marisa rivers. In order to prevent the sediment spread over the lake, sedimentation area was specified in the northern part of the lake bounded by sediment trap works. Lower reaches of the Biyonga and the Alo-Pohu rivers are adjusted to lead the sediment to the specified area. The sediment trap works consist of palm piles and bamboo net to trap sediment with crest elevation of +4.0 m,MSL.

Lake Dikes: Lake dikes were proposed primarily to protect low-lying land adjacent to the lake and secondarily to demarcate the lake area. The dike was designed with crown elevation of 6.5 m,MSL taking free board of 1 m, crown width of 4.0 m considering future use as rural road, and side slope of 1 on 3. Drainage sluices were also considered for the local drainage.

Tapodu River Improvement with Gate: The Tapodu River is the only outlet of the lake. The river channel is equipped with gate at the confluence of the Bolango River. The gate (Tapodu Gate) shall have dual function, i.e., 1) to prevent Bolango flood water from flowing into the lake and 2) to maintain lake water level at +4.0 m,MSL at the lowest.

Design of Tapodu Gate: The proposed structure is a concrete structure with dimensions of 36 m in length and 28 m in width having a compound section providing dike on both sides. General design drawing is shown in Figure 4.2.9. Following considerations were given to the design of Tapodu gate:

1) Freeboard: When the gate is fully open, the bottom of the gate leaf will be at least 1.0 m above the design high water level
2) Gate opening: Two (2) gate openings will be provided in case that a gate could not be lifted by some accident such as mechanical trouble.
3) Height of gate: Height of the gate will be determined based on the design high water level of the channel considering the required freeboard.
4) Bed consolidation works: Length of aprons constructed with concrete slab will be more than 3.0 m for intake and 5.0 m for outlet work. The apron will be extended more than 10.0 m for intake and 15.0 m for outlet work with gabion or equivalent.

4.2.5 Watershed Management Schemes

Watershed management is the activities to encourage following activities by the government agencies concerned and relevant local communities so as to retain rain water in the watershed area and alleviate flood and sediment runoff in the lower basin:

1) Construction of erosion control facilities
2) Afforestation and land use control
   - Afforestation
   - Conservation of existing forest
   - Regulation of deforestation
   - Conservation of natural flood retardation areas
3) Publicity activities: Guidance to government agencies concerned and local community people for appropriate use and conservation of mountain slope, etc.

4.2.6 Flood Plain Management Schemes

The flood plain management is the activities to support and guide the community people in the flood prone areas so as to reduce and avoid accurrence of flood damages. The activities for the flood damage deduction in the flood prone areas would include the

following:

1) Community mobilization: To organize the community peoples to cope with fhe floods.
2) Local coping measures: To support and guide the community people to reduce actual flood damages from self-help viewpoint through:
   - Land use adjustment to reduce damages in flood vulnerable areas,
   - Encouragement of peoples' water-proofing activities, and
   - Promotion of flood fighting activities by community organization
3) Community-based sustainable measures: To encourage and support community people to develop and carry out flood mitigation works/activities in sustainable manners, by deriving additional benefits for improving their livelihoods

4.2.7 Proposed Flood Mitigation Master Plan

As a result of studies on component schemes, the proposed flood mitigation Master Plan is summarized below.

(1) Flood and Sediment Disasters

Suffering Areas: Major stricken areas of the flood and sediment disasters are located in the southern part of Gorontalo City, middle reaches of the Bolango River, Limboto area, Isim-Pohu area, and western area of Lake Limboto. Among these, problems are more serious in the southern part of Gorontalo City near the confluence of the Bolango and Bone rivers. Major types of flood disaster in the Study Area are flooding and inundation, and those of sediment disasters are bank erosion, silting-up of riverbeds, and sedimentation of Lake Limboto.

Roles of Flood Mitigation: Per capita GRDP of the Study Area is far low comparing with the national average. Flood mitigation is one of the basic infrastructures of the basin and is duly necessary to support sound economic development of the basin and to stabilize people's livelihood, accordingly to alleviate poverty of the region.

(2) Principles for Planning

Flood Mitigation Master Plan (FM-MP) for the LBB basin will be formulated along the following principles:

1) **Objective of Master Plan:** The FM-MP aims to direct or guide the flood mitigation activities that will be conducted by various agencies and organizations concerned.
2) **Scope:** The FM-MP shall cover structural and non-structural measures. The structural measures discussed in the master plan are limited to the primary facilities to mitigate flood and sediment damages of the area.
3) **Target Year:** In line with the phasing of National Five-Year Plan, target year of the FM-MP was set at the end of Tenth Five-Year Plan in 2019. The proposed project will be implemented to support basin's socio-economic conditions at the target year.
4) **Design Scale:** Facilities for the FM-MP are planned and designed based on 20-year flood.

(3) Component Works of FM-MP

Figure 4.2.10 shows general location map of the component works for the FM-MP.

1) Bone- Bolango River System:
   - River improvement: Bone, Bolango and lower Tamalate rivers (Figures 4.2.11 through 4.2.13)
   - Tamalate floodway (Figure 4.2.14)
2) Lake Limboto System:
   - River improvement: Biyonga, Meluopo, Marisa, Alo-Pohu and Rintenga rivers (Figures 4.2.15 through 4.2.19)
   - Lake Limboto management (Figure 4.2.20 for general plan and Figure 4.2.21 for Tapodu River)
3) Watershed Management: To encourage;
   - Construction of erosion control facilities,
   - Afforestation and land use control, and
   - Publicity activities.
4) Flood Plain Management: To promote and guide for the community people to take activities for;
   - Community mobilization,
   - Local coping measures, and
   - Community-based sustainable measures.

4.3 Estimation of Project Cost

Project cost was estimated only for the structural measures. The non-structural measures such as watershed management and flood plain management are not project type but rather have administrative nature to be performed as a routine work of the managing offices in charge of flood mitigation.

(1) Sub-Projects and Works for FM-MP

Sub-projects for FM-MP: The FM-MP is composed of following sub-projects:

Bone- Bolango River System

1) Bone River Improvement
2) Tamalate River Improvement with Floodway
3) Bolango River Improvement

Lake Limboto System

4) Biyonga River Improvement
5) Meluopo River Improvement
6) Marisa River Improvement
7) Alo-Pohu River Improvement
8) Rintenga River Improvement
9) Lake Limboto Management

Major Work Items: The following are the major works included in these sub-projects. The project and work costs will be estimated for these work items.

Earth works

1) Excavation work
2) Embankment work
3) Sediment trap work
4) Sodding work

Structural work

5) Structural concrete work
6) Wet rubble masonry work
7) Drainage sluice work
   DS type-1 (1m x 1m)
   DS type-2 (3m x 3m)

8) Metal work
9) Bridge work
   Br. type-1 (w = 4m)
   Br. type-2 (w = 7m)

(2) Basis of Cost Estimate

Project cost for the proposed master plan was estimated on the basis of the following conditions.

1) **Price Level:** The project cost and other related unit costs are expressed under the economic conditions prevailing in November 2001.

2) **Exchange Rate of Currencies:** Exchange rate of currencies are assumed as follows:
   US$1.00 = Rp.9,600 = ¥124 (¥1 = Rp.77.4)

3) **Constitution of Project Cost:** Project cost is composed of direct cost, land acquisition and compensation cost, administration cost, engineering service cost, and physical contingency. Project cost is estimated based on the following procedures and assumptions:
   (1) Direct cost: Unit cost basis
   (2) Land acquisition and compensation cost: Unit cost basis
   (3) Administration cost: 5% of (1) + (2)
   (4) Engineering service cost: 15% of (1)
   (5) Sub-total = (1) + (2) + (3) + (4)
   (6) Physical contingency = 10% of (5)
   (7) Price contingency: Annual escalation rate of 5% was assumed considering the rate of 0% for foreign currency portion and 10% for local currency portion

(3) Unit Work Costs

The work cost is estimated based on the quantity of works multiplied by standard unit work cost. The unit work costs were assumed based on the cost data of similar works executed in Sulawesi. The standard work costs applied to the Master Plan are listed below.

	(Work)	(Unit)	(Cost: Rp.)
1)	Excavation work	m^3	15,000
2)	Embankment work	m^3	28,000
3)	Sediment trap work	m	265,000
4)	Sodding work	m^2	20,000
5)	Concrete work	m^3	550,000
6)	Wet masonry work	m^3	220,000
7)	Drainage sluice work		
	Type-1 (1m x 1m)	pcs	45,000,000
	Type-2 (3m x 3m)	pcs	350,000,000
8)	Metal work	m^2	130,000,000
9)	Bridge work		
	Type-1 (w = 4m)	m	17,000,000
	Type-2 (w = 7m)	m	35,000,000

As to the land acquisition and compensation cost, following unit prices were assumed based on the information in Gorontalo.

1) Farmland : Rp. 3,000/ m^2
2) Urban area : Rp. 20,000/ m^2

(4) Project Costs

Cost of sub-projects was estimated as shown in Table 4.3.1 for summary and Table 4.3.2 for its breakdown. The results are summarized below.

	(Sub-projects)		(Rp. Million)
1)	Bone River Improvement	:	75,042
2)	Tamalate River Improvement with Floodway	:	189,477
3)	Bolango River Improvement	:	44,532
4)	Biyonga River Improvement	:	30,203
5)	Meluopo River Improvement	:	15,286
6)	Marisa River Improvement	:	23,683
7)	Alo-Pohu River Improvement	:	109,032
8)	Rintenga River Improvement	:	23,865
9)	Lake Limboto Management	:	43,905
	TOTAL		555,025

The total project cost for the FM-MP amounts to Rp.555,025 million (US$57.814 million or ¥7,169.1 million equivalent) at November-2001 fixed price, of which breakdown is as follows:

(Cost items)	(Cost: Rp. million)
1) Direct cost	: 361,974
2) Land acquisition and compensation cost	: 66,853
3) Administration cost	: 21,442
4) Engineering service cost	: 54,297
5) Physical contingency	: 50,459
TOTAL	555,025

4.4 Implementation of Master Plan

4.4.1 Stage Construction

Strategy: The Flood Mitigation Master Plan (FM-MP) is proposed to support the socio-economic conditions at the target year of 2019. The project works must be carried out effectively in orderly manner toward the target year. It is also important to realize the flood mitigation effects as early as possible in the course of implementation corresponding to the progress of work. In order to activate the flood mitigation activities in the basin, the FM-MP is proposed to be implemented stage-wise as follows (Figure 4.4.1):

1) Preparatory stage : Until end of 2004
2) Intensive implementation stage : From beginning of 2005 to end of 2009
3) Sustainable implementation stage : From beginning of 2010 to end of 2019

Sub-projects: The project works of the FM-MP can be divided into following self-standing sub-projects:

Bone-Bolango River System

1) Bone River Improvement: Lower and middle Bone river improvement
2) Tamalate River improvement: Tamalate floodway and lower Tamalate river improvement
3) Bolango River improvement: Lower and middle Bolango river improvement

Lake Limboto System

4) Biyonga River improvement including realignment of lower Biyonga river with east sediment trap work
5) Meluopo River improvement
6) Marisa River improvement
7) Alo-Pohu River improvement including realignment of lower Alo-Pohu river with west sediment trap work
8) Rintenga River improvement
9) Tapodu River improvement with Tapodu gate
10) Dikes of Lake Limboto: East and west lake dikes

(1) Preparatory Stage

During this stage until the end of the Seventh National Five-Year Plan in 2004, various preparatory works and activities should be performed for forthcoming full-scale project implementation. Main works and activities are presented below. Some activities below are to be continued in the remaining stages.

1) Feasibility Study: The study would cover the following:
   - River survey
   - Restudy of Master Plan
   - Feasibility Study
2) Fund Arrangement
3) Definite Plan/Detail Design
4) Preservation of Lands: Land acquisition is one of the crucial issues of the works in urban area like Gorontalo. This should start immediately after the preparation of definite flood mitigation plan.
5) Research and Investigation: Throughout the implementation period of the FM-MP, research and investigation activities should also be conducted in parallel, for development of engineering tools to support the project.
6) Coordination with Relevant Agencies and Communities: The coordination with various agencies and organization concerned should be started especially for the watershed management and the flood plain management.

(2) Intensive Implementation Stage

Intensive Implementation: During the period of the 8th National Five-Year Plan from 2005 to2009, actual construction works at site and activities for watershed management and flood plain management will be implemented intensively. The projects to be implemented in this stage must be the basic facilities and activities for flood mitigation and the priority ones expected to yield higher outcome. Through the intensive implementation, it is expected that the flood mitigation activities in the basin will be stimulated and related personnel and administration will be trained and adjusted toward effective implementation of the project.

Projects to be Selected for Intensive Implementation: The projects for the intensive implementation should be selected considering the following matters:

1) Urgency of implementation
2) Important facilities and areas to be protected

3) Site in more critical conditions
4) Magnitude of favorable social impacts
5) Engineering sequence of implementation

Non-structural Measures: In parallel with the structural measures, watershed management and flood plain management should also be implemented at several sites and villages as pilot projects to disseminate the activities.

(3) Sustainable Implementation Stage

During the period of the 9th and 10th National Five-Year Plans from 2010 to 2019, the remaining sub-projects will be carried out in sustainable manner in parallel with the watershed management and flood plain management activities.

Structural Measures: After completion of the sub-projects selected for the intensive implementation, remaining sub-projects of the FM-MP are to be implemented in this stage are. With completion of the remaining sub-projects, basic flood mitigation facilities of the LBB basin will be facilitated based on 20-year probable flood.

Non-structural Measures: In parallel with the structural measures, watershed management and flood plain management will be carried out continuously in other sites and villages improving them based on the experience through the pilot projects, in coordination with the relevant agencies and by encouraging community people.

4.4.2 Organizational and Institutional Arrangements

(1) Water Resources Management Authority

Administrative Authorities: According to the Act No. 22 of 1999 pertaining Local Government Administration, the authorities of Kabupaten/Kota covers all administrative issues except for the policies of foreign affairs, deference and security, judicature, money and finance, religion, etc. A diagram of shearing authorities and responsibilities is shown in Figure 4.4.2.

Authority Shearing: The shearing of authorities and responsibilities among central and local governments with respect to water resources management are as follows:

1) The central government has the authorities and responsibilities to conduct water resources management, covering policy of national planning and the control macro-national development, efficiency in water resources use, strategic and high technology, conservation and national standardization;
2) The authorities of provincial government cover those inter-Kabupaten/Kota administrative issues. As to public work/water resources the authorities of provincial government cover:
   - Determination of water resources standard in inter-Kabupaten/Kota,
   - Support for cooperation among Kabupaten/Kota,
   - Support for resources management, and
   - Permission for changing and demolishing water structures for the use of inter-Kabupaten/Kota.
3) Beside the above, provincial government can implement the authority which Kabupaten is not able to implement.

Decentralization and De-concentration of Authority: The decentralization means the transferring authorities owned by the central government to the local governments, while the de-concentration system is an implementation procedure of the authorities of the central government to be implemented by the local government.

The authorities of province in de-concentration and those to be done for Kabupaten are shown in Table 4.4.1.

(2) Institution for Flood Mitigation in LBB Basin

Relevant Agencies: There are three government institutions which carry out flood mitigation in the LBB Basin. They are:

1) Dinas of Public Works/Settlement and Regional Infrastructure (Dinas PU/ Kimpraswil) of Gorontalo Province,
2) Dinas of Public Works (Dinas PU) of Kota Gorontalo, and
3) Dinas of Public Works and Regional Infrastructure (Dinas PU-Praswil) of Kabupaten Gorontalo.

Dinas PU/Kimpraswil of Gorontalo Province: The organizational setup of Dinas PU/Kimpraswil of Gorontalo Province is shown in Figure 2.7.3 in Chapter 2. Plan and design for flood mitigation are to be prepared by Technical Planning Section, while implementation, operation and maintenance by Operation and Maintenance Section. The Technical Implementation Unit (TIU or UPTD) and Group of Functional Jobs are

not yet established.

Dinas PU of Kota Gorontalo: Dinas PU of Kota Gorontalo is in charge of management of water resources matter in Kota Gorontalo. The Dinas PU is an administrative implementation element of the public works sector having obligation for implementation part of the autonomous authority under the decentralization framework of the city. The organization of Dinas PU of Kota Gorontalo is shown in Figure 2.7.4 in Chapter 2.

Dinas PU-Praswil of Kabupaten Gorontalo: The flood mitigation activities in the Kabupaten Gorontalo are carried out by Dinas PU-Praswil of Kabupaten Gorontalo. The organization of the Dinas PU-Praswil is shown in Figure 2.7.5 in Chapter 2.

Organizations for Coordination: According to the Public Work Minister's Decree No. 67/PRT/1993, it is necessary to establish Provincial Water Resources Management Committee (Panitia Tata Pengaturan Air Propinsi: PTPA) and River Basin Water Resources Management Committee (Panitia Pelaksana Tata Pengaturan Air: PPTPA) for coordination. PTPA has jobs to assist Governor in coordination for water and water resources management. PPTPA has jobs to respond the development demand and assist PTPA in the river basin concern. The roles of PTPA and PPTPA are very important for the all activities of water resources management. As an example, mechanism of arrangement in planning and implementing flood control is shown in Figure 4.4.3. In Gorontalo Province, PTPA and PPTPA are not yet established, but will be soon established since provincial governor's decree on this matter has already been issued. These will be finally incorporated in the Balai PSDA for integrated water resources management. An organization forum was established in Kabupaten Gorontalo for water resources management, by the name Team Kerja/Sekretariat PPTPA Wilayah Sungai Kabupaten Gorontalo (Working Group/Secretariat PPTPA River Basin in Kabupaten Gorontalo) based on Bupati Decree No. 52/2001.

(3) Organization and Institution for Implementation of FM-MP

Job Shearing in Flood Mitigation: Schematic location of the LBB basin is shown in Figure 4.4.4 in relation with Kabupaten Gorontalo, Kota Gorontalo and Kabupaten Boalemo. The LBB basin extends crossing the border of Kabupaten Gorontalo and Kota Gorontalo in Gorontalo Province. In this case Gorontalo Province has authority to manage the LBB-Basin in cooperation with Kabupaten and Kota of Gorontalo,

according to the Government Regulation No. 25/2000 concerning Authority of Government and Province. The job and authority of central government, province and kabupaten/kota for flood mitigation are shown in Table 4.4.2 in comparison with those before and after implementation of decentralization. As shown in the Table, under the decentralization system, the flood mitigation authorities will be transferred to the Kabupaten and Kota in principle. However, province will implement the authorities as ever until Kabupaten / Kota will have capability for implementation. Province will also implement de-concentrated authority from the Central Government. Central Government will budget and control some important construction and rehabilitation projects which are not capable of Province.

Implementation under De-concentration: Implementation of the FM-MP may be executed through "de-concentration system". The de-concentration is an implementation system to transfer the authorities of central government to Governor as a representative according to the law (Gov. Reg. No. 39/2001, Article 2 and Article 3). In carrying out of the authority de-concentrated, a special unit tentatively called as "Flood Mitigation Project in LBB Basin" will be organized in the province separately from autonomous authority on responsibility and budgeting. The Flood Mitigation Project in LBB Basin will be responsible to Directorate General of Water Resources (DGWR) and operational activities, under guidance of the DGWR, to Dinas PU/Kimpraswil of Gorontalo Province through Sub-Dinas of Water Resources Management.

Organizational Arrangement: Organizational arrangements for the implementation of the Project are proposed as shown in Figure 4.4.5. The organization is composed of mainly three elements, i.e., managerial, staffing and implementation. The unit for the Flood Mitigation Project will be organized mainly with the staff of the Gorontalo Province, Kabupaten and Kota. It is essential to promote capacity building of these relevant agencies in collaboration.

Obligation and Authority: The Project Manager has obligation and authority for managing, regulating and coordinating the implementation of all project works giving direction and guidance, supervising works and controlling the staff and Implementation Element during the project implementation. The Project Manager will be responsible to Director General of Water Resources Development and operation to the chief of Dinas PU/Kimpraswil of Gorontalo Province through Sub-Dinas of Water Resources Development.

4.5 Project Evaluation

4.5.1 Procedures for Evaluation

The Flood Mitigation Master Plan (FM-MP) technically justified so far is then subject to the examination from the economic, financial and environmental aspects.

The economic viability of the master plan will be evaluated in the process of cost-benefit analysis. Flood damage reduction benefit accruing from the implementation of the plan will be compared with the economic cost to be invested. The discussions on the financial aspects are made mainly on the financial sources. Past trend of public financing to flood control sector will be reviewed. The initial environmental examination (IEE) will be conducted chiefly for the screening of natural and social environmental issues that may be affected by the implementation of the plan.

4.5.2 Economic Evaluation

(1) Method of Estimation of Project Benefits

Structure of Project Benefits

Flood Control Benefit: Flood control benefit is generally defined as the reduction of potential flood damage attributed to designed works. The reduction is obtained as the difference of the flood damages estimated under with- and without- project conditions. For estimation of the benefit, thus, it is the first step to identify and to quantify potential flood damages in the flood prone area under without-project condition.

In addition to the flood damage reduction benefit, a flood control project will make the people in the area protected by the project enjoy its sophisticated environment. This improvement of spatial environment fosters land's appreciation. Furthermore, an investment to flood control project will give incentive to related economic sectors. Thus, the project reinvigorates the regional economy. These effects are also considered as indirect benefits.

Flood Damage: The flood damage is generally classified into two categories, i.e., direct damage and indirect damage. The direct damage is furthermore classified into two damages: damage to human lives and damage to general assets. The damage to

general assets is composed of (1) damage to assets such as buildings, equipment, furniture, movables, and inventory stock, (2) damage to agricultural production in crop fields and inland fishery, and (3) damage to infrastructures including road, bridge, railway, river facilities, water supply, sewerage, electric power, city gas supply, telecommunication, irrigation, etc. The indirect damage comprises the following three components: (1) damages to daily activities during flooding period such as usual business activities and household tasks, (2) damages to supporting systems after flood, and (3) damages of mental influence to people affected by flood.

Damage Components Adopted for Project Benefits: Current study adopts the following damage components for project benefits taking account of the reports of flood control in Indonesia and data availability. They are (1) direct damages, (2) infrastructure damages and (3) indirect damages. The estimation procedures are discussed as follows.

Direct Damages

Components of Direct Damage: The components of direct damage in this study are selected taking inventory of existing facilities and data availability into consideration. They are as follows:

1) Residential building
2) Manufacturing establishment
3) Wholesale and retail trading establishment
4) Educational facility
5) Medical facility
6) Crop production (paddy, maize and vegetable)
7) Fishpond production

Distribution of Assets: Distribution of damageable assets is worked out in the form of grid information. A mesh block is 250 m interval squares. The inventory of damageable assets in every square is read or estimated on the basis of 1:10,000 topographic maps prepared for the Study, the 1:50,000 existing topographic maps, administrative boundary maps, in addition to socio-economic data and information given through the surveys to agencies concerned.

Estimation of flood Damages: Flood damages are worked out as a sum of damage estimated for each mesh block. The damage amount in a mesh block is calculated based on the damageable assets multiplied by the damage rates depending on the flooding condition and the type of asset.

Values of damageable assets in economic terms are shown in Table 4.5.1. The rates of flood damage to the respective assets are also tabulated in Table 4.5.2. The rates are based on the "Manual for Economic Study on Flood Control" published by Ministry of Land, Infrastructure and Transport (MLIT) of the Japanese government.

Infrastructure Damage

Infrastructure damage has rarely been recorded, although it is occasionally larger than the damage to building properties and agricultural production. There is no standard information regarding infrastructure damages. In the manual of MLIT, the infrastructure damage rates to the direct damages are set as follows.

Facility	Road	Bridge	Sewer-age	Urban facilities	Public utilities	Crop lands	Irrigation facilities	Total
D.R.(%)	61.6	3.7	0.4	0.2	8.6	29.1	65.8	169.4

Note: These damage rates (D.R) were calculated as an average of the actual flood damage records in Japan during nine years from 1987 to 1996.

Meanwhile the ratio of infrastructure damage was estimated at 30% in the report of "Ciliwung-Cisadane River Flood Control Project". Although this rate seems to be quite small as compared with the rates of MLIT, this rate might be reasonable taking into consideration of the regional conditions of the Study Area. The damage rate of infrastructures was assumed at 30% of the direct damages.

Indirect Damage

The following components of indirect damage were selected taking account of data availability.

1) Loss of housekeeping to clean and repair residence, household effects, etc.
2) Business losses of private business establishments
3) Other indirect damages such as costs for emergency activities, medical care and

cure for victims, preventive activities against crimes, etc.

Particularly in cities, the other indirect damages could be sufficient to require inclusion in the flood damage computation. Although the actual computation of the other indirect damages was not undertaken, it was presumed to be 10% of the direct damage.

(2) Basic Conditions for Economic Evaluation

Conversion Factors and Elements for Real Economic Values

Transfer Payments: Market values are usually distorted by transfer payments such as taxes and subsidies. These transfer payments are transferred to the government which acts on behalf of the society. Then, they should not be treated as cost. These have to be eliminated from the market values of cost and benefit as a whole. In Indonesia, the taxes concerning to the construction works are enumerated as follows: the value added tax (VAT), excise tax, income tax, customs duties, real property tax, tax on aggregate such as sand and gravel, various local taxes, etc.

Conversion Factors: In the Master Plan Study, composite costs and benefits estimated at market prices are converted to economic costs applying a standard conversion factor (SCF). It is clearly impracticable to trace procurement sources for all the detailed components. Thus, taking this situation into consideration and referring to Table 4.5.3, the economic costs are assumed to be 90% of the market values.

Land Value: Market price of land has its peculiar characteristics as compared with other commodities, especially in urban areas. Land price should be evaluated on the basis of productivity of the land for productive plots such as crop cultivation, and balance of supply and demand for non-productive land such as residential plots. In this Master Plan, land acquisition takes place in urban area, crop land, and grass areas. In terms of crop cultivation land, its land value is evaluated on the basis of productivity, i.e., production of paddy for the project life of the proposed projects. In urban area, the market value of land is assumed that it reflects opportunity cost in the market. Thus, the economic value is estimated as a product of the market value of land and the SCF. Other areas are considered as no values from the economic point of view, because they are considered to be simply diverted to other land utilization from the original usage.

Schedule and Evaluation Period

1) Base Year: Beginning of 2004 for detailed design and land acquisition
2) Construction Period: The years from 2005 to 2019 for construction of major works in accordance with three five-year development plan period
3) Disbursement Schedule: Disbursed in accordance with construction schedule during the construction period above
4) Economic Life: 50 years after the completion of the project
5) Evaluation Period: 65 years including preparatory works such as detailed design and construction period, and economic life of the project scheme (2004-2069)
6) Timing of Benefits Accruing: In proportion to the progress of the construction works for river improvement scheme.
7) Social Discount Rate: 12 % per annum. Based on the "Guidelines for the Economic Analysis of On-going Projects in PIADP" supported by World Bank

Future Damageable Assets

Socio-economic Growth: Socio-economic conditions in Gorontalo will be improved in accordance with the growth of regional economy. Likewise those in LBB Basin will also be improved in the future. Then, the damageable assets would increase along with the growth of socio-economic conditions. In other word, the flood mitigation benefit would increase. This could be estimated on the basis of socio-economic projection such as population increase, improvement of people's living standard, growth of economic activity in various industries and expansion of infrastructures in the basin as well as agricultural production based on improvement cultivation technology.

Residential Units: The number of residential units in the respective Desa or Kelurahan was assumed to increase in proportion to population growth (household growth). Their damageable value was assumed to increase in proportion to GRDP per capita in LBB Basin. Incidentally, GRDP in 2020 in the basin was estimated as 3.17 times of that in 2001 as projected in Chapter 2. Accordingly, their assets will increase in proportion to GRDP growth (3.17 times of the present values) in 2020, as a result.

Industrial Establishments: In terms of industrial establishments such as manufacturing, trading and others, the increment of their assets holdings was assumed to increase in proportion to the GRDP growth rate. The increment is also revealed based on the

increase of the number of establishments and the growth of their production. In the basin, the increment of these phenomena was assumed to be absorbed in the same Desa or Kelurahan.

Agricultural and Fishery Production: Paddy production in irrigated fields was assumed to increase its yield from 5.0 ton/ha to 6.0 ton/ha by the year 2020. Rain fed crop production, however, was assumed to keep the same yield even in the future. In the same manner, fishpond production was assumed to maintain the same production yield as done in the basin.

(3) Annual Average Economic Benefit

Flood control benefit is defined as the damage reduction by the proposed project. The benefit consists of direct damages, infrastructure damage and indirect damage. The direct damages are estimated as a product of the number of facilities inundated, unit damageable value of inundated property and damage rate in accordance with inundation depth. The inundation depth in the area was estimated by the flood runoff analysis.

Distribution of Damageable Assets

The table below summarizes the present distribution of facilities and croplands in the potential flood area for 5-year, for 20-year and for 50-year return periods (as of 2000). Details of the distribution are tabulated in Table 4.5.4.

Item	2-year flood	20- year flood	50- year flood
Inundation area (km^2)	33	70	80
Population (1000)	12	86	110
Housing units	3,040	22,070	28,200
Manufacturing	172	1,780	2,290
Trading, hotel & restaurant	200	2,030	2,700
Educational facility	20	170	220
Medical facility	18	100	130
Agricultural lands (ha)	1,662	3,513	3,963
Irrigated fields	1,440	3,120	3,550
Rain-fed fields	200	370	390
Fishpond	22	23	23

Economic Unit Values: Economic values of damageable assets are calculated for the respective facilities from financial values applying a conversion factor. The unit values of damageable properties in economic terms are listed below.

Damageable Property	Unit	Present	2020
Housing unit			
Kota	Rp. million/unit	16.1	43.1
Kabupaten	Rp. million/unit	6.9	22.0
Manufacturing	Rp. million/unit	2.5	7.5
Trading	Rp. million/unit	0.9	5.1
Educational facility	Rp. million/unit	396.0	1,059.3
Medical facility	Rp. million/unit	16.7	44.8
Irrigated paddy production	Rp. million/ha	6.0	7.4
Rain fed crop production	Rp. million/ha	3.2	3.2
Fishpond production	Rp. million/ha	22.5	22.5

Annual Average Benefit: The annual average benefit is defined as the reduction of probable damage under with- and without-project conditions. The project was proposed based on 20-year probable flood. The annual benefit accruing from the implementation of the Flood Mitigation Master Plan in the LBB Basin was estimated at Rp.36.3 billion under the present basin conditions as shown in the tale below.

Return Period	Flood Damage (Rp. billion)			Average (Rp. bill.)	Expectation	Benefit (Rp. bill.)
	Without Project	With Project	Reduction			
2 Year	20.7	0	120.7	10.3	0.500	5.2
5 Year	63.7	0	63.7	42.2	0.300	12.7
10 Year	113.4	0	113.4	88.5	0.100	8.9
20 Year	170.4	0	170.4	141.9	0.050	7.1
50 Year	250.2	250.2	0	85.2	0.030	2.6
				Total annual benefit:		**36.3**

In the same manner as estimation under present conditions, the annual benefits are calculated at Rp.101.3 billion under future conditions. The annual benefit of the proposed plan was summarized as follows.

Socio-economic condition	Annual benefit (Rp. billion)
1. Under present condition	36.3
2. Under future condition	101.3

(4) Economic Project Cost

Economic project cost of the propose Master Plan was calculated from the financial project cost applying the conversion factor of 0.9 as follows:

(Unit: Rp. billion)

Objective project	Financial cost	Economic cost
1. Direct construction cost	362.0	325.8
2. Land acquisition and compensation	66.9	39.9
3. Government administration	21.4	16.3
4. Engineering	54.3	48.9
5. Physical contingency	50.5	43.1
Total	555.0	474.0

Note: * Agricultural lands were not included.

The lands to be acquired consist of agricultural land and residential land in urban areas. Since agricultural lands were evaluated as negative benefit during the evaluation period, their values included in the financial cost were not included in the economic cost.

As a result, the economic project cost is calculated as Rp.474.0 billion in total. Annual disbursement schedule of the economic project costs was prepared disbursing the cost in compliance with the construction schedule.

Operation and maintenance (O&M) cost is annually required during the project life. The annual O&M cost was estimated at Rp.1.63 billion in economic term, assuming to be 0.5% of the direct construction cost.

(5) Results of Economic Evaluation

The annual stream of benefit and cost under present socio-economic conditions is shown in Table 4.5.5. The economic internal rate of return (EIRR) of the proposed Master Plan was estimated to be 6.0% under the present basin conditions. Incidentally, the cost-benefit ratio (B/C) was worked out at 0.47 and net present value (NPV) at Rp.-99 billion discounted at 12%.

These indices for economic evaluation, however, improve under the future socio-economic conditions. The EIRR was calculated at 14.7% under the future basin conditions as shown in Table 4.5.6, yielding higher rate than the social discount rate of 12%. The proposed Master Plan is viable from the economic viewpoint. In other words, the proposed project should be implemented from this time forth taking consideration of the future viability of the project. Results of economic evaluation are summarized shown below.

Item	EIRR (%)	B/C*1	NPV*1 (Rp. billion)
Under present socio-economic conditions	6.0	0.51	-99
Under future socio-economic conditions	14.7	1.28	57

Note: *1 Discounted at 12%

4.5.3 Financial Aspects

Basic Stance of Financial Evaluation: Unlike other public and private undertaking, no business income directly accrues from the undertaking of flood control although its economic benefits are expected. This section, thus, deals with whether or not the project costs are available from the public finance of the national government. Furthermore, the financial constraints that the national government has for investment onto flood control projects are discussed taking account of present financial situation. They comprise the burden of external debts, financial sources and limit of investment.

Public Finance for Flood Control: The financial requirement for the implementation of the proposed Master Plan was estimated at Rp.555 billion at 2001 market prices. This amount has to be procured between 2004 and 2019. According to the data of past expenditure, the rate of 0.0037% of the national development expenditure was spent for Gorontalo Province, in particular for LBB Basin. Then, the expected investment accumulated to the year 2019 was estimated at Rp.96 billion at 2001 prices for Gorontalo Province, if the rate was applied to the estimation. This is only 17% of the financial requirement for the proposed Master Plan.

Status of Foreign Aid and Public Debt: Total debt stocks of Indonesia aggregated to US$150 billion as of the end of 1999. This debt accounted for 106% of GDP in 1999. Of this total, US$120 billion or 80% was procured as long-term debt, mostly for capital

investment. Due to this external debt, the total debt service aggregated to US$17.8 billion in 1999. Then, the debt-service ratio (DSR), a kind of country risk assessment factors, was 30.3%. This rate has been almost at the same condition, as shown in the table below. The DSR has kept a critical position for these years, exceeding critical level of DSR of 20%. Thus, Indonesia is already below difficult position to increase degree of dependence on loan.

(Unit: US$ billion)

Item	1995	1996	1997	1998	1999
Debt outstanding of long-term debt	98.4	96.7	100.3	121.7	119.8
Total debt service	16.4	21.5	19.7	18.3	17.8
Principal repayment	10.2	14.9	13.0	11.2	11.7
Interest payment	6.2	6.6	6.7	7.1	6.1
Exports of goods and services	54.9	58.8	65.8	57.7	58.8
Debt service ratio (DSR)*1	29.9	36.6	30.0	31.7	30.3

Note: *1 A ratio of total debt service over exports of goods and services.

Overcoming Financial Constraints: Even if the national government allots Rp.96 billion for the flood control during the period from 2005 to 2019, the capital requirement will still be short more than 83%.

The following measures should be sought for taking account of the financial conditions reflecting the national and international circumstances:

1) To increase capital investment for flood control in the national budget
2) To procure loans of low interest and long-term payment period
3) To procure grant sources
4) To formulate construction consortium by stakeholders

Especially in the intensive implementation stage, the external financial sources mentioned about are important to activate basin's flood mitigation activities under such conditions that the local financial source due to decentralization process is not fully established.

In the sustainable implementation stage, the governments concerned will be able to appropriate their budgets for the flood control schemes proposed in the master plan in accordance with their financial capability. It is essential to execute the flood mitigation works continuously step by step using the budget as available, since the flood

mitigation effects would be in hand in proportion to the input even though the progress of works is behind the initial schedule.

It would be still difficult with their own budget to implement the whole schemes by the end of tenth five-year development plan. In order to catch up with the schedule, the governments should search for the financial sources as in the intensive implementation stage, taking account of national and international circumstances.

4.5.4 Social Aspects

Besides the project benefit discussed in the previous subsection, implementation of the flood mitigation projects bring about favorable effects in local communities as presented below, though they are almost intangible in monetary term.

1) Creation of job opportunity and activation of regional economy
2) Stabilization of people's livelihood
3) Enhancement of land use and encouragement of economic activity
4) Improvement of social amenity and public hygiene

4.5.5 Initial Environmental Examination (IEE)

(1) Project Description

The projects proposed in the Flood Mitigation Master Plan are classified into five types of schemes: (1) River improvement schemes, (2) Floodway scheme, (3) Lake Limboto management schemes, (4) Watershed management schemes, and (5) Flood plain management schemes. The components of these schemes and overview of environmental impacts are as follows:

River Improvement Schemes: River improvement is proposed for the schemes consist of the following components: Bone-Bolango system (the Bone, Bolango and Tamalate rivers), the Lake Limboto system (the Biyonga, Meluopo, Marisa, Alo-Pohu and Rintenga rivers), and the Tapodu River, which connects the two systems.

These river improvement schemes include such activities as dike construction, bank protection and channel normalization work. The channel normalization work is to be undertaken by means of smoothing channel alignment, widening and deepening channel

section, and normalizing channel section by means of dredging. These activities will accompany physical and structural modifications in and around river channels, which may cause impacts on natural environment in the river channels and social environment along them.

Floodway Scheme (Tamalate Floodway): Tamalate floodway scheme includes such activities as constructions of flood diversion channel by means of excavation work and a weir set up by which runoff discharge is diverted and controlled. These activities will accompany physical and structural modification, which may cause impacts on both natural and social environment in and around the newly constructed floodway as well as on natural environment in the existing rivers.

Lake Limboto Management Schemes: Lake Limboto management schemes consist of the following components:

1) Tapodu Gate (Hydraulic control gate),
2) Lake dike, and
3) Sediment trap.

The construction of Tapodu Gate at the outlet of Lake Limboto may cause impacts on water regime of the lake and aquatic ecology in it, and on social environment of surrounding area in terms of settlements and fisheries.

Watershed Management Schemes: Watershed management schemes consist of the following components:

1) Erosion control facilities,
2) Afforestation in the upstream areas and land use control, and
3) Publicity activities.

These components relate to natural environment in the LBB basin, especially on forest functions, as well as on social environment in terms of awareness building on the forest functions, especially its water retention capability.

Flood Plain Management Schemes: Flood plain management schemes consist of the following components:

1) Community mobilization,
2) Local coping measures, and
3) Community-based sustainable measures.

These components are intended to organize flood fighting activities and systems at the community level, and promote them, aiming at strengthening local people's preparedness or coping capacity for the mitigation of flood damage in a sustainable manner. These are more closely related to social environment rather than natural environment.

(2) Methodology of Examination

IEE: Initial environmental examination (IEE) was carried out to identify conceivable impacts to natural and social environment due to implementation of the project, and to scope the environmental components for further study.

Environmental Components for Examination: The impacts on natural and social environment were examined for the following environmental components:

Natural environmental components:
- Topography (including sedimentation),
- Soil erosion,
- Groundwater,
- Water regime (river flow regime and lake water level),
- Flora and fauna (terrestrial and aquatic ecology, but not include sea ecology),
- Protected area,
- Meteorology, and
- Landscape.

Physical environmental components:
- Air quality,
- Water quality,
- Soil contamination,
- Noise and vibration,
- Land subsidence, and
- Odor.

Social environmental components:

- Resettlement of the residents,
- Livelihood (Access to open water),
- Economic activities,
- Local opposition,
- Access to public and cultural/religious facilities and traffic,
- Community split,
- Historical and cultural heritage,
- Waste, and
- Disaster.

Access to open water of the rivers and the lake is included as a component, because the life of people in the region is highly related to such water resource in terms of daily life for washing clothes, bathing and a privy.

Magnitude of Impact: Evaluation of impacts on each environmental component was conducted comprehensively, considering (1) positive or negative; (2) nature of impact such as reversibility, possibility to avoid and duration; (3) spatial extent of the impact; and (4) population of affected people or wild life. The magnitude of impact was judged by orderly scale giving five grades as follows:

- Major positive impact (+2),
- Minor positive impact (+1),
- Negligible impact (±0),
- Minor negative impact (-1),
- Major negative impact (-2), and
- Whether positive or negative depends on design of interventions (±)

(3) Conceivable Impacts and Possible Mitigation/Enhancement Measures

Conceivable Impacts: Conceivable impacts of the proposed Master Plan projects are summarized in Table 4.5.7 for natural environment and Table 4.5.9 for social environment. The relationship between impact activities/programs and environmental components are also shown in Table 4.5.8 for natural environment and Table 4.5.10 for social environment, with giving the magnitude of the conceivable impacts.

Mitigation Measures for Natural Environment: Basically, the candidate projects are

not such that generate toxic or hazardous substances, nor that involve dangerous structures, but that improve the river environment in terms of reducing flood risks. Accordingly, the project cannot act as a source of public pollution or danger. Looking carefully into the candidate projects, however, each activity involved in the schemes may cause the impacts on both physical and ecological environment. The possible mitigation/enhancement measures for each impact are summarized in Table 4.5.11.

Mitigation Measures for Social Environment: For the implementation of the proposed projects, land acquisition is not avoidable. Land acquisition and eventual relocation of people and its repercussions were examined in addition to other impacts on social environment. Land acquisition mainly makes an impact at the pre-construction stage of the projects and other impacts occur at all the project stages (pre-construction, construction and operation and maintenance). The possible mitigation/enhancement measures for each conceivable impact are summarized in Table 4.5.12.

(4) Summary of Evaluation from Natural Environmental Viewpoint

Negative Impacts: No major negative impacts on natural environment will be brought about by the implementation of the Master Plan, except for some physical impacts such as air pollution, water pollution (turbid water flow) and noise and vibration. These negative impacts will be caused by the construction works, especially made by construction machinery and transportation vehicles. Therefore, these impacts will be confined within construction stage. Among all the construction sites, these negative impacts would be significant only at the lower Biyonga, the lower Bolango and the lower Tamalate river reaches because these areas are densely populated. The other negative impacts, minor or negligible, include habitat disturbance of aquatic ecology in rivers, topographic modification and consequent negative impacts such as change of groundwater level and the ground stability near the excavated area.

Positive Impacts: Positive impacts, on the other hand, include reduction of soil erosion at river bank and upland areas, reduction of sedimentation in Lake Limboto, improvement of groundwater retention in forest lands, reduction of flood peaks, stability of water level of Lake Limboto, habitat creation and landscape improvement by restoration of forests. Most of these positive impacts are not limited during a certain period, but will last for a long time during operation and maintenance stage. Among those positive impacts, reduction of sedimentation and stability of water level in Lake Limboto are major ones. In addition, watershed management schemes will bring about

several major positive impacts such as reduction of soil erosion and stability of water regime if candidate projects in the scheme are properly and successfully undertaken.

Conclusion: As a conclusion, the candidate projects in the Master Plan are considered not to bring about serious negative impacts. Most of the negative impacts are minor or negligible judging from its duration and area to be affected. On the contrary, the candidate projects would bring about many positive impacts. Stability of water regime in Lake Limboto will be effective not only on aquatic ecology but also for fishery in the lake. Thus, the Master Plan candidate projects are considered to be valid from the view point of natural environment.

(5) Summary of Evaluation from Social Environmental Viewpoint

Negative Impacts: Possible negative impacts would occur from early pre-construction stage throughout operation and maintenance stage. The most significant one is various disturbance of people's daily life brought about by resettlement. The relocation of public service and religious facilities and the release of land rights of farming lands would be needed as well. These events occur especially at pre-construction stage. The magnitude of such impacts depends partly on the size of facility and partly on the population density of affected areas. Another negative impact is the limitation of access to local resources such as river/lake waters and existing traffic with the opposite riverside. Such access is essential in people's daily life and flood control structures such as dike can be a disturbance. The disappearance of traffic between the riversides could cause a split of community along rivers.

Positive Impacts: In respect to positive impacts, temporary job would be available at the local level during construction. The positive impacts by the non-structural measures of the Master Plan can be sustainable and beneficial to local residents in the long term, although they require long-term and continuous efforts and commitment to attain the goals. But, the most important positive impact is, of course, the reduction of flood risks especially in highly populated areas at the lower reaches of treated rivers, once the Master Plan is properly and successfully implemented. Free from fear or insecurity in livelihood, the people as well as the local government including various agencies, will be able to make use of their resources in terms of money, time and efforts for individual and regional development of. Other positive impacts such as traffic improvement along the ring dike, better collaboration among agencies can be supportive factors to such development.

Conclusion: To conclude, although the candidate projects of the Master Plan may bring negative impacts on social environment in a short run, most of such impacts can be mitigated by various means. For example, the significance of impacts caused by resettlement can be reduced and minimized by carefully designing the magnitude of constructing facilities so as to affect minimal residents at project sites. The Master Plan as a whole can also bring long-term solutions vis-a-vis flood disaster. In particular, non-structural measures would strengthen local people's preparedness or coping capacity in terms of flood problem. Provided that non-structural and structural measures are implemented in a harmonic and strategic manner, the candidate projects of the Master Plan are valid as a whole in terms of social environment in the long term.

4.5.6 Overall Evaluation

Economic Evaluation: The economic internal rate of return (EIRR) of the FM-MP was estimated to be 14.7% under future conditions and was evaluated economically viable exceeding the social discount rate of 12%, though the EIRR under the present conditions was worked out to be 6.0%.

Financial Aspects: A study on financial sources based on the past trend of public expenditure of the national government resulted in disclosing financial constraints of Gorontalo Province. It is substantial to implement the plan mobilizing communities in participatory manners from self-support standpoint as basic activities to cope with flood and sediment disaster. In addition, external inputs are also deemed necessary to activate flood mitigation activities, and to change past trend of economic circle of the region.

IEE for Natural Environment: The result of initial environmental examination clarified that the FM-MP will not bring about serious negative impact to natural environment of the basin, except for some physical impacts during the construction works mostly by construction equipment. On the contrary, the plan is considered to extend favorable impact to natural environment stabilizing water regime in Lake Limboto.

IEE for Social Environment: Although the candidate projects of the Master Plan may bring negative impacts on social environment in a short run, most of such impacts will be able to be mitigated by carefully designing and implementing the project. The

FM-MP as a whole can bring long-term solutions for flood disaster. Provided that non-structural and structural measures are implemented in a harmonic and strategic manner, the candidate projects of the FM-MP are valid as a whole in terms of social environment in the long term.

Recommendation: The proposed flood mitigation master plan (FM-MP) is evaluated economically viable. The plan will bring about less negative natural and social environmental impacts. The FM-MP is evaluated to be valid from the view points of natural and social environment. The basin is suffering from frequent flood disasters constraining sound economic activities and people's livelihood. Implementation of the FM-MP in early stage is recommended.

4.6 Selection of Priority Projects

(1) Procedures for Selection

Selection of the Priority Project is discussed only for the structural measures. The non-structural measures should be performed continuously as a routine work by the managing offices in charge of flood mitigation, since these measures are not project type but rather have administrative nature.

Sub-Projects for Selection of Priority Projects: Sub-projects of the Flood Mitigation Master Plan (FM-MP) formulated in the previous Chapter were further broken down for the purpose of selection of the Priority Projects as follows:

1) Bone River Improvement:
   ① Lower Bone River Improvement (BNl)
   ② Middle Bone River Improvement (BNm)
2) Tamalate River Improvement with Floodway:
   ① Lower Tamalate River Improvement (TMl)
   ② Tamalate Floodway (TF)
3) Bolango River Improvement:
   ① Lower Bolango River Improvement (BLl)
   ② Middle Bolango River Improvement (BLm)
4) Biyonga River Improvement (BY)
5) Meluopo River Improvement (ML)
6) Marisa River Improvement (MR)
7) Alo-Pohu River Improvement (AP)
8) Rintenga River Improvement (RT)
9) Lake Limboto Management:
   ① Tapodu River Improvement with Gate (TP)
   ② Lake Dike (LD)
   ③ Sediment Trap Works in Lake Limboto (ST)

Parameters for Selection: Priority projects subject to the Feasibility Study are regarded as those to be implemented in the intensive implementation stage. The priority projects for the intensive implementation were selected considering the following parameters:

1) Urgency of implementation due to damages confronted (Damages)
2) Importance of damageable properties in the protected area (Properties)
3) Severity of site due to poor facilities (Facilities)
4) Magnitude of favorable social impacts (Benefishery)
5) Engineering sequence of work (Work order)

Evaluation: The above parameters were applied to each of the sub-projects mentioned above to evaluate their priority for implementation. The evaluation was made by giving marks, namely "1" for higher priority and "0" for not so high priority respectively for each evaluation parameters. The sub-project which gets higher mark as a sum of whole parameters is judged to be higher priority. Process and result of the evaluation are shown in Table 4.6.1. As a result, following six (6) sub-projects that got full marks were selected as Priority Projects for intensive implementation (Figure 4.6.1):

1) Lower Bone River Improvement
2) Lower Bolango River Improvement
3) Tapodu River Improvement with Tapodu Gate
4) Tamalate Floodway
5) Sediment Trap Works in Lake Limboto

Expected Effects: By the implementation of the above sub-projects, following physical effects for flood mitigation are expected:

1) Flood mitigation in the urban area of Gorontalo City will be secured,
2) Water level of Lake Limboto will be controlled and the drainage of retained water will be improved, and
3) Sedimentation problems of Lake Limboto will be alleviated.

Non-structural Measures: In parallel with the structural measures mentioned above, watershed management and flood plain management will be implemented at several sites and villages selected for pilot projects to disseminate the activities.

1) Watershed management by encouraging activities such as construction of erosion control facilities, afforestation and land use control and publicity activities in the watershed areas in coordination with the Department of Forest and Plantation.

2) Flood plain management by encouraging and promoting Local Coping Measures and Community-based Sustainable Measures to be undertaken by the community people in the flood plain areas.