CHAPTER VII APPROACH TO MASTER PLAN

7.1 General

The master plan is arranged to attain the maximum flood control effects of the Laoag River Basin with limited financial resources, targeting 20 years after. For this purpose, an integrated approach of structural and non-structural measures is necessary.

The structural measures are planned to confine the design flood with a certain return period within the river channel. In this case, however, the Laoag River, especially the alluvial fan rivers may aggrade their riverbeds due to excessive sediment runoff from the mountains. The alluvial fan rivers have formed a number of streams on the alluvial fan, scattering sediment there. The confinement of flood water within one river channel will concentrate sediment discharge to the river, resulting in riverbed aggradation.

Hence, sediment runoff from the mountains will firstly be reduced by sabo dam or other sediment control measures to control the riverbed aggradation in the alluvial fan rivers. The river channel improvement will be successfully planned only for such controlled riverbed conditions. Then, sediment control and river channel improvement projects will be integrated.

It is considered not economical and impractical to protect all potential flood areas by structural measures or to secure complete safety of structural measures. Hence, non-structural measures are necessary to supplement or support the structural measures.

7.2 Design Flood Discharge

The design flood discharge is the most basic index for the design of structural measures. It is determined as follows.

The design flood discharge of a certain river basin should be determined so that it may well match the hydrological characteristics, socio-economic importance and financial capability of the river basin. It should also meet the criteria similarly required of the other river basins in the country. Hence, the design flood probability of the Laoag River Basin was evaluated and compared with the design flood probability of the major river basins in the Philippines.

The design flood discharge probabilities of the 10 major rivers and volcanoes in the Philippines along with their salient features are given in Table I.7. The main features of the Laoag River Basin are also given in the table.

The design flood discharge probability for the Master Plan of the Laoag River is proposed to be 25 years, based on the following considerations.

(1) The area of the Laoag River Basin is not large enough and economic development is not so high compared with the other 10 major river basins. The flood prone areas and affected population are less than those of the other major river basins. Hence, the design flood discharge probability of the Laoag River should aptly not exceed those of the other 10 major rivers.

(2) The largest flood in the Laoag River during the 1967 Typhoon Gening has a recorded peak discharge equivalent to a return period of 25 years.

(3) Approximately 90% of the flood damage in the Laoag River Basin are caused by floods below a 25-year return period (see, Chapter III, 3.3.4).

The design flood discharge with a 25-year return period is estimated at 10,900 m^3/s at Gilbert Bridge of Laoag City. Its distribution to the tributaries is shown in Fig. I.23.

7.3 Possible Structural and Non-structural Measures

7.3.1 Sediment Control Measures

As discussed in Chapter V, the Basin is affected by two (2) kinds of sediment problems, as follows:

(1) Excessive annual sediment runoff from the mountains

The river receives sediment exceeding the transport capacity every year, resulting in the riverbed aggradation. However, the rate of riverbed aggradation is not high except in some critical river sections. The measures to cope with this problem should be determined from the long term viewpoint and implemented step by step. Reforestation and construction of sabo dam are considered effective for mitigation of this annual excessive sediment runoff.

(2) Large amount of sediment runoff during a large flood

Sediment runoff exceeds the sediment transport capacity of river channels, causing a large sediment deposition at the fan apex. This problem does not occur every year. However, when this happens, the sediment runoff will breach the existing river structures and bring about critical damage to the alluvial fan area. To prevent catastrophic disasters, structural measures with high reliability should be adopted. Only the construction of sabo dam is considered practicable to prevent catastrophic disasters at a large flood. Construction of sand pocket is usually conceived as an alternative to the sabo dam, however, no possible site has been identified in the Basin.

7.3.2 Flood Control Measures

The following six (6) measures are generally conceived for flood control:

(1) Construction of dike
(2) River dredging
(3) Construction of dam
(4) Construction of retarding basin
(5) Construction of cutoff channel
(6) Construction of floodway

Among them, the construction of dam and retarding basin is obviously inapplicable for this Basin due to topographical constraints. On the other hand, the necessity of cutoff channel and floodway is not identified to mitigate the existing flood problems. Hence, only the construction of dikes and river dredging are considered as technically practical measures.

(1) River Dredging

River dredging is one of the most preferable measures to attain flood control with high degree of effectiveness. However, in the Laoag River with excessive sediment runoffs, river dredging must be done for long river stretches to produce a satisfactory flood control effect. Partial dredging may not be effective because the dredged river section will soon be filled up and as a result, periodic dredging may become necessary.

The dredging of approximately 20 million m^3 and 30 million m^3 is required for the tributaries in the alluvial fan and for the Laoag Main River, respectively, to solve the existing flood problems by river dredging. However, spoil banks which can accommodate such large volumes of sand/gravel are not available in the Basin except the sea or sand dune seacoast. This is not economically feasible.

(2) Integration of River Dredging and Aggregate Production

River dredging and aggregate production can be integrated to save in flood control cost and exploit the mineral resources to the maximum extent. However, aggregate demand in the Basin is small and hence, the feasibility of export of dredged sands/gravel is further studied.

With regard to the market for this aggregate exportation, only Japan is considered prospective at present, because it is actually importing a considerable volume of aggregates from the southernmost part of China.

In this study, the feasibility on the following three (3) cases of aggregate production were examined.

Case I	:	Aggregates produced in the alluvial fan rivers are shipped from the existing Currimao Port.
Case II	:	Aggregates produced in the alluvial fan rivers are shipped from the newly constructed Laoag Pier.
Case III	:	Aggregates produced in the lowermost reaches of Laoag River are shipped from the newly constructed Laoag Pier.

The present aggregate production costs including excavation, sieving, inland transportation, new pier construction and ship loading costs are summarized below.

Case I	:	US\$9.45/ton (US\$15.12/m^3)
Case II	:	US\$8.21/ton (US\$13.14/m^3)
Case III	:	US\$3.38/ton (US\$5.41/m^3)

On the other hand, it is considered that the FOB price at the loading port should be US\$3/ton to US\$4/ton (US\$4.8/m^3 to US\$6.4/m^3), or less, to make the export feasible although it may vary depending on the market situation.

As shown from the above, the aggregate export from the Basin to Japan is considered financially feasible only for the production in the lowermost reaches of the Laoag River. The export from the alluvial fan areas and middle reaches of Laoag River is not feasible due to the high inland transportation cost between the dredging site and the loading port.

However, the river dredging in the lowermost reaches of the Laoag River is not given priority in the overall flood control of the Basin although it is preferable for mitigation of the flood problems. Hence, the integrated project of river dredging and aggregate production is not applied even for the lowermost reaches of the Laoag River.

From the above discussions, the construction of dikes is applied as the principal measure for the flood control of the Laoag River including the tributaries.

7.3.3 Non-structural Measures

The non-structural measures necessary to supplement or support the structural measures include the following:

(1) Watershed management (reforestation) to supplement the sediment control of sabo dam.

(2) Flood forecasting and warning to facilitate flood fighting, evacuation and other flood preparedness activities.

(3) Flood fighting to minimize flood disasters due to damage of river structures.

(4) Flood plain management (land use control in flood plain) to minimize flood damage potention in high flood risk areas.

7.4 Planning Approach

The master plan will be prepared through the following planning procedures:

(1) Determination of Design Flood Discharge

As mentioned above, the design flood discharge with a 25-year return period will be adopted in this master plan.

(2) Evaluation of Potential Flood Prone Area

The design flood of a 25-year return period will inundate 17,300 ha in 19 districts. These flood prone areas were delineated and evaluated in Chapter III.

(3) Preparation of Sabo Dam Full Plan

Necessary sabo dams to control excessive sediment runoff will be identified in the upstream of the alluvial fan rivers and planned to attain the following targets:

(a) To decrease sediment runoff to the downstream river below its sediment transport capacity at the design flood time.

(b) To control annual riverbed aggradation in the downstream river below an allowable limit.

(4) Preparation of River Improvement Full Plan

Necessary river improvement projects to protect the above potential flood prone areas (19 districts, 17,300 ha) will be identified and planned to carry the design flood discharge safely.

(5) Selection of Master Plan Components of Structural Measures

It is considered not economical and impractical to complete the above full plan of sabo dam and river improvement within 20 years. Project components of the structural master plan will be selected from the sabo dam and river improvement full plans. The selection will be made from economical, social, technical and environmental aspects.

(6) Formulation of Master Plan of Structural Measures

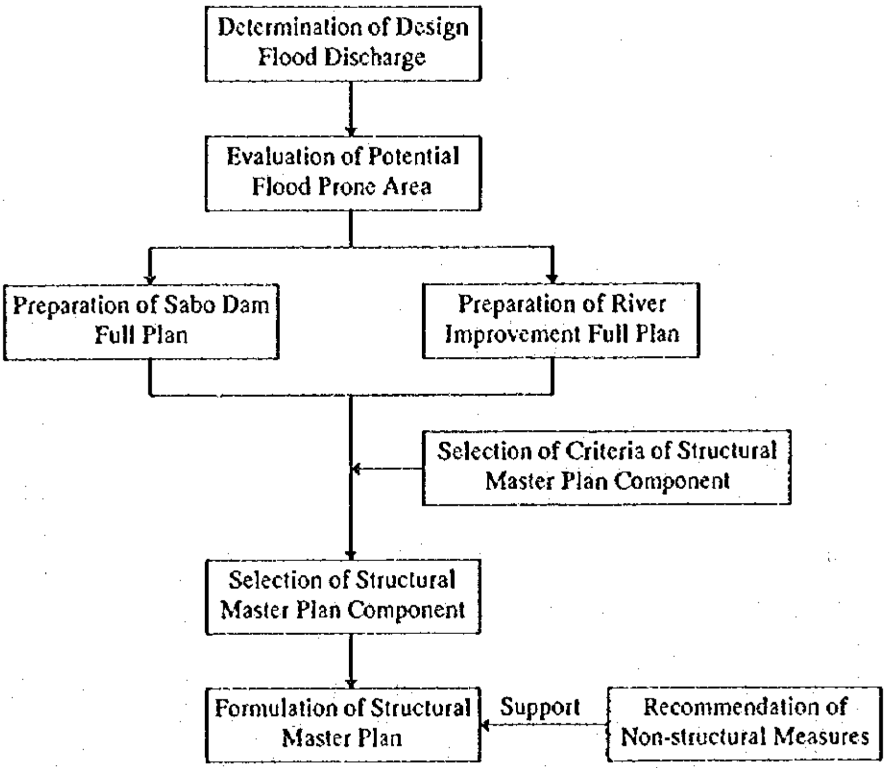
The master plan of structural measures will be formulated by integrating the above selected project components. The master plan will be evaluated from economical, social and financial aspects, and further, its impacts on the environment will be evaluated.

(7) Recommendation of Non-structural Measures

Necessary non-structural measures to supplement or support the above master plan of structural measures will be recommended.

Flow of the above planning procedures is shown in the following chart.

Planning Flow Chart



CHAPTER VIII MASTER PLAN OF STRUCTURAL MEASURES

8.1 Sabo Dam Plan Study

Sabo dams are proposed at sites immediately upstream of the existing irrigation dams or intakes in the Cura, Labugaon, Solsona, Madongan, Papa and Bongo rivers to control the excessive sediment runoff in the downstream reaches. Locations of the potential sabo dam sites are shown in Fig. I.24.

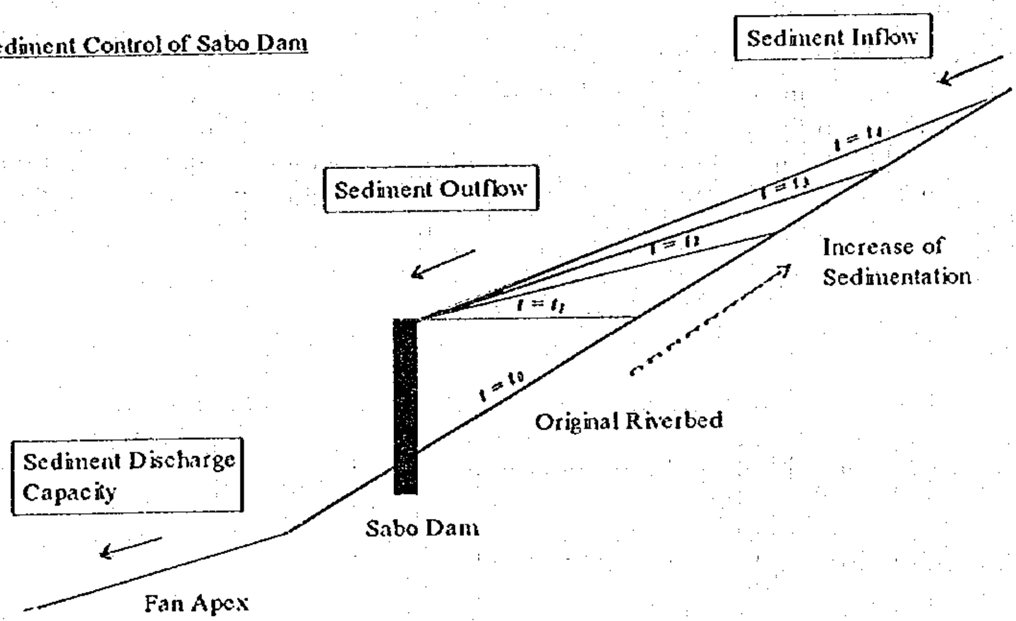
8.1.1 Sediment Control Effects

After construction of a sabo dam, sediment runoff from the mountains to the sabo dam (sediment inflow to sabo dam) are all trapped by the empty sedimentation basin of the sabo dam until the basin is fully filled up and no sediment is discharged from the sabo dam to the downstream. Once the sabo dam is filled up, it begins to discharge sediment. On the other hand, the sedimentation gradient of the sabo dam becomes steeper with the lapse of time.

Sediment outflow of the sabo dam increases according to the growth of sedimentation gradient. Finally, the sedimentation slope of the sabo dam gets near the original slope of the riverbed. As a result, sediment outflow of the sabo dam becomes equal to its inflow, resulting in the production of no sediment control effect. However, if the sabo dam is provided with a sufficient sedimentation capacity, it will be able to continue producing sediment control effects for a long period.

The sediment control effects of sabo dam are schematized as follows.

Sediment Control of Sabo Dam



Note: *The sediment outflow is always smaller than the sediment inflow until the sedimentation slope returns to the slope of the original riverbed. It results in decrease of annual sediment deposition in the downstream river.*

Excessive sediment deposition at fan apex at flood time is prevented. Such sediment control benefits will be produced until the sediment outflow becomes bigger than the sediment discharge capacity at the fan apex.

Through the above sediment control mechanism, the sabo dam produces three (3) kinds of beneficial effects in the alluvial fan rivers: (1) prevention of excessive sediment deposition at the fan apex at flood time; (2) reduction of the annual sediment deposition on the riverbeds; and, (3) reduction of the runoff of large size sediment to the downstream.

(1) Prevention of Excessive Sediment at Fan Apex at Flood Time

Sediment runoff from the mountains to the alluvial fans at a big flood much exceeds the sediment transport capacity of the river channel. It temporarily results in a large riverbed aggradation in the river channel, especially at its fan apex. Sabo dam can control such excessive sediment deposition.

The sediment outflow of sabo dam in each river at the time of the design flood for a 25-year return period were calculated for the various sedimentation slopes of sabo dam. The sediment discharge capacity at the respective fan apexes were also computed. The calculation results are compared in the following table.

River	Outflow of Sabo Dam (10^3m^3)				Discharge Capacity at Fan Apex (10^3m^3)
	Original Slope	1/2 of Original Slope	2/3 of Original Slope	3/4 of Original Slope	
Cura	71.3	20.2	35.4	43.5	42.6
Labugaon	185.2	61.1	97.8	118.5	112.8
Solsona	166.9	46.5	79.5	99.2	108.9
Madongan	454.5	120.8	213.0	266.5	302.8
Papa	147.3	41.0	70.8	88.0	93.0
Bongo	97.5	32.2	51.7	62.1	63.4

As shown from the above calculations, the sediment outflow of sabo dam in the rivers is within the design sediment discharge capacity at the respective fan apexes until the sedimentation slope of sabo dam rises up to nearly 3/4 of the original slope. If proper sedimentation capacities are provided in the proposed sabo dams, this sediment retention effect will last for a long time.

(2) Reduction of Annual Sediment Deposition

The existing alluvial fan rivers are affected by a considerable amount of riverbed aggradation: 3.0 cm/year in Cura/Labugaon River, 5.1 cm/year in Solsona/Madongan River, 4.8 cm/year in Papa River, and 1.6 cm/year in Upper Bongo River on annual average (see Chapter V, 5.2.2). These riverbed aggradations can be mitigated by sabo dam. The mitigation effect varies depending on the sediment capacity of the sabo dam.

(3) Reduction of Large Size Sediment Runoff

The shear force of floods suddenly decreases in the sedimentation basin of sabo dam, resulting in deposition of sediment, especially large size sediment. Ratio of cobbles and boulders to total sediment at fan apex is estimated to decrease from 5-10% in the case of without sabo dam to 0-6% in the case of with sabo dam when the sedimentation slope reaches 1/2 of the original.

This is called the sieving effect of sediment. It will prevent the deposition of cobbles and boulders at the fan apex which is one of the major causes of channel shifting.

Further, it will increase the sediment transport capacity in the downstream rivers, resulting in curbing down riverbed aggradation.

8.1.2 Study on Alternatives

(1) Sabo Dam Sites

The required sediment control in each river can be attained by a large single dam or a series of small dams. A large single dam generally costs cheaper than a series of small ones. However, in the former development case it is difficult to perform a stepwise construction and as a result, enforces some advance investment.

In the Cura, Madongan, Papa and Bongo rivers, all the potential dam sites have sufficient sediment storage capacities. In the Solsona and Labugaon rivers, the sediment storage capacity of one dam site is limited due to the topographical constraints and therefore, at least two (2) dams are necessary to attain the target sediment control. Hence, the following two (2) development cases are compared.

Case I	:	Cura No. 1, Labugaon No. 1 / No. 2, Solsona No. 1 / No. 2, Madongan No. 1, Papa No. 1 and Bongo No. 1
Case II	:	Cura No. 1 / No. 2, Labugaon No. 1 / No. 2, Solsona No. 1 / No. 2, Madongan No. 1 / No. 2, Papa No. 1 / No. 2, and Bongo No. 1 / No. 2

Salient features of the respective sabo dam sites are shown below. For location of sabo dam sites, see Fig. I.24.

River	Dam Site	Catchment Area (km^2)	Dam Site Width (m)	Existing Riverbed Slope (%)
Cura	No. 1	68.2	170	1.08
	No. 2	63.1	70	1.08
Labugaon	No. 1	100.5	100	1.15
	No. 2	90.9	160	1.15
Solsona	No. 1	72.2	30	2.58
	No. 2	68.2	90	2.58
Madongan	No. 1	153.8	120	1.52
	No. 2	101.9	300	1.52
Papa	No. 1	51.4	210	2.08
	No. 2	35.3	210	2.08
Bongo	No. 1	56.0	170	1.17
	No. 2	52.8	100	1.17

(2) Design Dam Height and Sedimentation Volume

The design dam height and sedimentation volume of the sabo dam are determined to satisfy the following conditions or assumptions.

(a) The design sedimentation slope of sabo dam is determined so that the dam will discharge the sediment outflow equivalent to the sediment discharge capacity at the fan apex of the downstream river in the design flood. As mentioned before, the design sedimentation slope of the proposed sabo dams is determined at 3/4 of the original slope.

(b) The design sedimentation volume of sabo dam will be determined so that the sedimentation slope will not exceed the design one for the required period of time (design life of sabo dam). In this study, the design life of sabo dam is set at 20 years.

(c) The design height or design sedimentation volume of sabo dam will be determined so that the sediment control of sabo dam will curb the average annual riverbed aggradation in the downstream rivers below an allowable level for 20 years. In this study, the allowable level is set at 2.5 cm/year, taking into consideration the additional mitigation of riverbed aggradation due to the sediment control effects of the ongoing reforestation projects and sediment sieving effects of sabo dam.

(d) In rivers where two (2) sabo dams are proposed, the lower dam (No. 1) is constructed first. The upper dam (No. 2) is not constructed until the sedimentation slope of the lower dam reaches the design one. The design life of the lower dam is set at 10 years in this study.

The design dam height and sedimentation volume of the proposed sabo dams are determined as follows.

River	Case I			Case II		
	Dam Site	Dam Height (m)	Design Volume (10^3 m^3)	Dam Site	Dam Height (m)	Design Volume (10^3 m^3)
Cura	No. 1	9.0	750	No. 1	6.5	391
				No. 2	4.5	150
Labugaon	No. 1	10.0	1,043	No. 1	10.0	1,043
	No. 2	7.0	511	No. 2	7.0	511
Solsona	No. 1	10.0	233	No. 1	10.0	233
	No. 2	10.0	233	No. 2	10.0	233
Madongan	No. 1	7.0	2,192	No. 1	5.5	1,353
				No. 2	8.0	1,011
Papa	No. 1	7.0	707	No. 1	5.5	436
				No. 2	4.0	262
Bongo	No. 1	9.0	692	No. 1	6.5	361
				No. 2	4.0	137
Total			6,361			6,121

(3) Comparison of Cost

The sediment control effects of both cases (Case I and Case II) in each river are the same. Therefore, the construction costs of the two cases are compared in present value to determine the optimum combination of the sabo dams in the Basin. The present value of cost is calculated under the following conditions.

(a) Discount rate is 15%.

(b) The sabo dams are constructed in stages. The upper dam is constructed 10 years after the construction of the lower dam.

The gross construction costs of the two (2) cases and their present values are summarized below. For details, see Table I.8.

River	Case I		Case II	
	Gross Cost	Present Value	Gross Cost	Present Value
Cura	82.0	82.0	79.7	61.0
Labugaon	140.0	91.6	140.0	91.6
Solsona	88.9	51.6	88.9	51.6
Madongan	65.7	65.7	169.4	81.5
Papa	65.9	65.9	84.9	59.4
Bongo	67.3	67.3	70.5	53.2
Total	509.8	424.1	633.4	398.4

(Unit: million P at 1996 prices)

(4) Optimum Development

As evident from the above table, Case I is more recommendable for the Madongan River, and Case II is more applicable for the Cura and Bongo rivers.

For the Papa River, Case II is more economical than Case I in terms of the present value of cost. However, the economical advantage is negligibly small. Hence, Case I is applied for the Papa River.

The optimum sabo dam developments are summarized below.

River	Dam Site	Dam Height (m)	Design Volume (10^3 m^3)
Cura	No. 1	6.5	391
	No. 2	4.5	150
Labugaon	No. 1	10.0	1,043
	No. 2	7.0	511
Solsona	No. 1	10.0	233
	No. 2	10.0	233
Madongan	No. 1	7.0	2,192
Papa	No. 1	7.0	707
Bongo	No. 1	6.5	361
	No. 2	4.0	137
Total			5,958

8.1.3 Verification of Sediment Control Effects

(1) Variation of Sediment Control Efficiency

The control efficiency of sabo dam is larger than the designed one (100%) until the sedimentation of sabo dam reaches the design sedimentation volume. Even after the design sedimentation volume is reached, a considerable extent of control efficiency will be maintained. It will take a long time before the control effect completely expires.

The variations of sabo dam control efficiency in the respective rivers are calculated by defining the control efficiency as follows:

Control Efficiency = $(Q_{in} - Q_{out}) / (Q_{in} - Q_{apex})$

Where, Q_{in} : Sediment inflow to sabo dam

Q_{out} : Sediment outflow from sabo dam

Q_{apex} : Sediment discharge capacity at fan apex

The estimated variations of sabo dam control efficiency in each river are shown Fig. I.25.

(2) Control of Riverbed Aggradation

The height or sedimentation volume of the sabo dams is designed to control the average annual aggradation rate of the riverbeds in the alluvial fan rivers during 20 years below 2.5 cm/year. The estimated average annual aggradation rates during 20 years in the cases with and without project are compared as follows:

River	Average Annual Aggradation (cm/year)	
	Without Sabo Dam	With Sabo Dam
Cura/Labugaon	3.0	0.7
Solsona/Madongan	5.1	2.5
Papa	4.8	2.3
Upper Bongo	1.6	0.6

The above riverbed aggradations will be further decreased by the ongoing reforestation projects and the sediment sieving effects of the sabo dams.

8.2 River Improvement Plan Study

As concluded in Section 7.3, the usefulness of flood control of the Laoag River Basin is attained by the river improvement works principally consisting of diking system in addition to the sabo works. The major design components of the river improvements are river alignment, longitudinal profile of riverbed and high water levels, and river width. These components are determined as follows.

8.2.1 Laoag-Bongo River

(1) River Alignment

The existing alignment of the river is comparatively smooth except for the large meander in the river sections between Sarrat and the confluence with Guisit River. However, a cutoff channel at this large meandering section is not feasible (see Supporting Report, Appendix G). Further, the flooding of the Laoag-Bongo River is caused by overflow of the existing banks and the flooded areas are limited to the narrow low-lying stretches along the river course.

Hence, the design river alignment is set at the existing one and dikes, when necessary, will be constructed along this alignment.

(2) Longitudinal Profile

The aggradation of the riverbed is not much. The average annual aggradation rate in this river stretch is estimated at 0.5 cm/year in the Laoag River, 0.4 cm/year in the Lower Bongo River, and 1.6 cm/year in the Upper Bongo River (see Chapter V, 5.2.2).

From the above discussions, the design high water level of the Laoag-Bongo River is determined, based on the existing riverbed profile.

(3) River Width

The existing river channel is wide enough to carry the design flood discharge with a moderate high water depth above the riverbanks. Hence, no widening of the river channel is necessary.

8.2.2 Solsona, Madongan and Papa Rivers

(1) River Alignment

These rivers were improved by the urgent disaster prevention works in 1991-1993. The existing river alignments are smooth. Hence, the design river alignment is set at the existing one. The existing dikes will be strengthened as required.

(2) River Profile

These rivers are prone to excessive sediment deposition every year. The average annual riverbed aggradations are estimated to be 5.1 cm/year in Solsona/Madongan rivers, and 4.8 cm/year in Papa River (see Chapter V, 5.2.2).

On the other hand, the proposed sabo dams are expected to reduce the annual riverbed aggradation to 2.5 cm/year in Solsona/Madongan rivers and 2.3 cm/year in Papa River on an average. These riverbed aggradations will be further decreased by the ongoing reforestation projects and the sieving effects of the sabo dams.

As known from the above discussions, the Solsona, Madongan and Papa rivers will cause no significant riverbed aggradation in the future. Hence, the design high water levels of the above rivers are determined based on the existing riverbed profiles.

(3) River Width

According to the Regime Theory, the river width in the alluvial fans is designed to be between $3.5 \times Q^{1/2}$ and $7.0 \times Q^{1/2}$ to secure the stability of river channel. Q is the design discharge.

The required river widths of the Solsona, Madongan and Papa are calculated as shown below.

River Section	Design Discharge (m^3/s)	Required Width (m)	Existing Width (m)
Upper Solsona	1,030	113 - 225	230
Middle Solsona	1,120	117 - 234	230
Lower Solsona	3,490	207 - 414	330
Madongan	1,970	155 - 311	300
Papa	690	92 - 184	223

The existing river widths of the Solsona and Madongan rivers fall within the range of the Regime Theory, while that of the Papa River exceeds a little. However, this excess will not disturb the stability of the river channel.

From the above discussions, no change of the existing river width is proposed.

8.2.3 Cura/Labugaon River

(1) River Alignment

The following three (3) alternative alignments are considered for the improvement of the Cura/Labugaon River.

Plan-A	:	To join the Labugaon River to Cura River at the fan apex and to improve the existing Cura River.
Plan-B	:	To separate the Labugaon and Cura rivers until the middle reaches and thereafter, to join Labugaon River to Cura River.
Plan-C	:	To separate the Labugaon and Cura rivers until the confluence to the Bongo River.

The river alignments of the three (3) alternatives are shown in Fig. I.26. The required construction works, land acquisition, house resettlement and construction costs of the above alternatives are compared as follows.

Item	Plan-A	Plan-B	Plan-C
River Improvement Length (km)	15	20	26
Construction Works			
Dredging (million m^3)	1.50	3.20	4.80
Embankment (million m^3)	0.35	0.45	0.58
Revetment (km)	22	33	45
Bridge Improvement (place)	1	1	2
Land Acquisition (farmland, ha)	1	8	65
House Resettlement (house)	1	9	25
Construction Cost (million P)	324	558	821

As shown in the above table, Plan-A is the most economical. Hydraulically, the alignment of Plan-A is the most preferable since it runs along the lowest route of the Cura/Labugaon valley and it requires no river widening, differing it from the other plans. In social aspects, the house resettlement and land acquisition of Plan-A are very small, compared to the other plans. Further, in Plan-B and Plan-C, four (4) communities (110 houses) and five (5) communities (130 houses) are enclosed by two (2) rivers, respectively.

From the above discussions, Plan-A is proposed.

(2) Longitudinal Profile

The Cura/Labugaon River is also affected by excessive sediment deposition. The average annual aggradation rate of the riverbed is estimated at 3.0 cm/year. While the proposed sabo dams are expected to curb this aggradation rate to 0.7 cm/year, the riverbed aggradation will be further decreased by the ongoing reforestation projects and sieving effects of the sabo dams.

Hence, in principle, the design riverbed profile is set at the existing one.

(3) River Width

The design river width is determined by the Regime Theory as follows.

Cura River (before confluence)	:	200 m
Labugaon River (before confluence)	:	250 m
Cura River (after confluence)	:	340 m

8.3 Full Plan of Sabo Dam and River Improvement

A total land of 17,300 ha is inundated by the design flood with a return period of 25-year in the Basin. This inundation covers the 19 inundation sub-districts mentioned in Chapter III. To completely relieve the 19 inundation sub-districts from floods, dikes of 135.8 km, revetment of 88.0 km and 10 sabo dams need to be constructed. The total construction works and compensation requirements are summarized below.

Item	Quantity
Sabo Dam	10 dams (124,000 m^3 concrete)
River Improvement	
Dike	135.8 km (3,820,000 m^3)
Channel Excavation	1,532,000 m^3
Revetment	88.0 km (938,000 m^2)
Other Works	1 l.s.
Land Acquisition	117 ha
House Resettlement	22 houses

Note: Other works include spurdike, sluiceway, groundsill and bridge improvement.

Breakdown of the above works by inundation sub-district is shown in Table I.9. In the breakdown by inundation sub-district, it is assumed that the sediment control effects of the sabo dams are limited to their immediate downstream alluvial fan rivers.

Locations of the above sabo and river improvement works are shown in Fig. I.27. These sabo and river improvement works are a full plan to meet the design flood. However, they may not all be included in the master plan which is to be implemented within 20 years.

8.4 Selection of Master Plan Components

The projects to be included in the master plan are selected in due consideration of their economical efficiency, social importance, technical validity and environmental impacts. The economic efficiency is evaluated in EIRR and social importance is assessed in flood protected population.

(1) Project Cost

The total financial project cost of the sabo and river improvement works is estimated at 3,058.2 million pesos at 1996 prices consisting of sabo dam at 510.7 million pesos and river improvement at 2,547.5 million pesos. The total financial project cost of 3,058.2 million pesos is converted to the total economic project cost of 2,538.8 million pesos.

The said financial and economic costs are distributed among 19 sub-projects as shown in Table I.10.

(2) Benefits

The project will produce the following beneficial effects.

Flood Mitigation	:	All the flood damages below 25-year return period will be removed.
Land Loss Prevention	:	The farmland of 56 ha in the alluvial fan areas are lost by floods on annual average. This land loss will be prevented.
Land Restoration	:	The existing river wash area and bush/grass land of 1,800 ha will be converted to lands for grazing, upland crop cultivation and rice cultivation.

The total average annual matured economic benefits which will be generated after the completion of the project is estimated at 242.3 million pesos under the present socio-economic conditions and 700.7 million pesos in 2020 under the future socio-economic conditions at 1996 constant prices. The above average annual economic benefits by sub-project are shown in Table I.11.

(3) Economic Efficiency

The economic efficiency of the project is estimated in terms of EIRR. The EIRR by sub-project under the present and future socio-economic conditions are shown in Table I.12.

The flood protection area, flood protected population, project cost, EIRR, technical validity and environmental adverse effects by sub-project are summarized in Table I.12. The sub-projects which satisfy the following criteria are selected as the components of the master plan.

(1) Protected population: approximately more than 1,000
(2) EIRR under present socio-economic condition: more than 7-8%
(3) EIRR under future socio-economic condition: approximately more than 15%
(4) No technical problem is expected.
(5) No significant environmental adverse effects are predicted.

As indicated in Table I.12, some technical problems are expected in the sub-projects of San Marcos and San Cristobal in Sarrat, Guisit/Mandaloque, Lower Bongo and Upper Bongo.

Dike construction in the narrow river sections of San Marcos and San Cristobal, Sarrat may enlarge the backwater effects, resulting in the increase of flood risk in the upstream reaches. The dikes in Guisit/Mandaloque area and the left banks of Lower Bongo and Upper Bongo cross a number of small rivers/creeks joining the Laoag-Bongo River. The dikes may block the flood flow of these small rivers/creeks, causing secondary flood problems (local inner floods) in the hinterlands of the dikes.

The following 12 sub-projects are selected based on the evaluation shown in Table I.12. The other seven (7) sub-projects are excluded from the master plan.

Sub-project	Sub-project	Sub-project
Tangit, Laoag	Poblacion, San Nicolas	Cura/Labugaon River
Suyo, Laoag	San Manuel, Sarrat	Solsona River
Poblacion, Laoag	Suyo, Dingras	Madongan River
Camangaan, Laoag	Poblacion, Dingras	Papa River

8.5 Possibility of Multipurpose Development of Sabo Dam

A single purpose sabo dam is generally constructed on the riverbed as a floating type structure in case the riverbed is covered by thick sediment deposits. Further, it is provided with some drain holes. Hence, no water is stored in the dam.

However, the proposed sabo dams can be developed for irrigation water supply or hydropower purposes by constructing cutoff walls on the foundations and providing the drain holes with control gates. The possibility of such multipurpose development is checked below.

(1) Irrigation Water Supply

The proposed sabo dams are estimated to have a total water storage capacity of 477,000 m^3, assuming that the void ratio of sediment deposits in the sabo dams is 35%. This water storage can be used to supplement the irrigation water requirements in the INIP I area in dry periods.

The dry spells of the Basin occur not only in the dry season but also even in the rainy season. According to the INIP I Plan, the irrigable areas of the project in the design drought year of a 5-year return period are estimated as follows.

Diversion Dam	Project Area (ha)	Irrigable Area (ha) Wet Season	Irrigable Area (ha) Dry Season
Labugaon	1,560	1,560	780
Solsona	2,140	2,140	610
Madongan	3,190	2,290	720
Papa	2,560	1,340	400
Nueva Era	750	750	450
Total	10,200	8,080	2,960

The proposed sabo dams can extend the irrigable areas in the design drought year by 870 ha in wet season and by 70 ha in dry season. As a result, this irrigation water supply project is expected to yield an additional paddy of approximately 1,483 tons and upland crops (garlic) of 21 tons per annum, according to the design cropping pattern of INIP I. This increased crop production is expected to generate a total annual benefit of 9.9 million pesos/year at 1996 market prices.

On the other hand, the required cost for this extra project is only the construction cost of the cutoff walls and outlet gates since the irrigation system has already been in existence. Some amount for annual O&M cost for the existing irrigation system will be borne by this project. The construction cost and annual O&M cost are estimated to be 45.1 million pesos and 1.4 million pesos, respectively, at 1996 prices.

The benefit and cost ratio (B/C) is calculated to be 0.87 under the condition of 15% discount rate. For details, see Supporting Report, Appendix I, Chapter II.

The sabo dam with irrigation water supply is economically infeasible. Hence, the irrigation water supply purpose is not included in the master plan.

(2) Hydropower Development

The proposed sabo dams can dam up the river water and as a result, generate hydropower. Among the proposed eight (8) sabo dams, Labugaon No. 1 and No. 2, Madongan and Papa dams will be constructed immediately upstream of the existing irrigation dams. There are no spaces to construct hydropower stations between the sabo dams and irrigation dams. Further, Cura No. 1 and No. 2 cannot harness a sufficient hydraulic head. Accordingly, the possibility of hydropower development of Solsona No. 1 and No. 2 sabo dams are examined.

The Solsona No. 1 hydropower development project will make use of the hydraulic head between the proposed sabo dam site and the existing Solsona irrigation dam. The power station will be constructed at the right riverbank immediately upstream of the irrigation dam. The water taken from the sabo dam is conveyed by a headrace channel/tunnel for a distance of 2.2 km to develop a gross head of 38.1 m.

The slope of the Solsona River ultimately becomes steep in the upstream of the Solsona No. 1 dam. Hence, the Solsona No. 2 hydropower project can later be developed with a much larger gross hydraulic head of 80.6 m. The power station is proposed at the same location as Solsona No. 1. The headrace tunnel/channel has to be extended upwards by 1.5 km.

The salient features of the above two (2) hydropower developments are shown below.

Item	Solsona No. 1	Solsona No. 2
Effective Head (m)	34.0	75.0
Max. Discharge for Hydropower (m^3/s)	4.1	3.9
Installed Capacity (kw)	1,200	2,400
Annual Energy Production (Mwh)	6,907	14,514
Construction Cost (million ₱)	182	295

Further, the kwh costs of the above projects are roughly compared with those of the diesel power development alternatives as shown below.

Item	Solsona No. 1	Solsona No. 2
kwh Cost of Hydropower (₱/kwh)	4.48	3.46
kwh Cost of Diesel (₱/kwh)	2.89	2.83

The Solsona No. 1 hydropower development project is not economically feasible. Solsona No. 2 is considered prospective from the following points.

(a) The kwh cost is close to that of diesel alternative.
(b) Hydropower is clean energy.
(c) It can save the import of fossil fuel.

However, Solsona No. 2 may not be able to generate power in some dry periods due to shortage of the river water although it can produce a large amount of energy annually. Hence, it cannot distribute stable energy to the users until it is integrated into the other power system.

More detailed study is necessary to reach a final conclusion of the Solsona No. 2 hydropower development. Therefore, the hydropower development purpose is not included in the master plan.

8.6 Proposed Master Plan

8.6.1 Target Flood Protection Area

The master plan of structural measures consisting of sabo dams and river improvement works is proposed to meet the design flood of a 25-year return period. By the design flood, the total inundation area of the Basin is estimated to be 17,300 ha with a resident population of 61,100. This inundation area consists of 19 inundation sub-districts, and the proposed master plan of structural measures will protect 12 inundation sub-districts with a total inundation area of 15,300 ha and relieve some 57,600 residents. The remaining seven (7) inundation sub-districts of 2,000 ha with a population of 3,500 will remain unprotected.

The target flood protection districts, protected area and existing protected population are shown below. Locations of the target flood protection districts are shown in Fig. I.28.

Protection District	Protected Area (ha)	Protected Population (existing)
Tangit, Laoag	600	3,945
Suyo, Laoag	200	1,054
Poblacion, Laoag	130	5,149
Camangaan, Laoag	480	2,039
Poblacion, San Nicolas	230	5,835
San Manuel, Sarrat	550	1,339
Suyo, Dingras	200	2,317
Poblacion, Dingras	550	4,228
Cura/Labugaon River	3,900	11,115
Solsona River	2,280	7,152
Madongan River	4,180	8,764
Papa River	1,950	4,651
Total	15,250	57,588

8.6.2 Salient Features of Proposed Project

Eight (8) sabo dams and 12 river improvement sub-projects are proposed to protect the above-mentioned 12 target areas from floods. Their locations are shown in Fig. I.29.

(1) Sabo Dam

Eight (8) sabo dams are proposed to control the sediment runoff to the alluvial fan rivers of Cura/Labugaon, Solsona, Madongan and Papa, as listed below.

River	Sabo Dam
Cura	Cura No. 1, Cura No. 2
Labugaon	Labugaon No. 1, Labugaon No. 2
Solsona	Solsona No. 1, Solsona No. 2
Madongan	Madongan
Papa	Papa

The salient features of the proposed sabo dams are shown in Table I.13. The plan and longitudinal profile of the sedimentation basin of the sabo dams are shown in Fig. I.30(1) to Fig. I.30(6). The structural layout of the sabo dams are shown in Fig. I.31.

(2) River Improvement Works

(a) Laoag-Bongo River

A total length of 30 km of important river sections of the Laoag-Bongo River between the river mouth and Poblacion Dingras will be improved by eight (8) sub-projects. These sub-projects are composed of flood protection dikes with necessary appurtenant works. Salient features of the projects are summarized below. The alignment, longitudinal profile and cross-section of the river are shown in Fig. I.32(1).

Location	Design Discharge (m^3/s)	Improvement Length (km)
Tangid, Laoag	10,900	6.5
Suyo, Laoag	10,900	2.1
Poblacion, Laoag	10,900	1.5
Camangaan, Laoag	10,900	4.0
Poblacion, San Nicolas	10,900	3.0
San Manuel, Sarrat	10,900	3.6
Suyo, Dingras	8,700	3.7
Poblacion, Dingras	3,220 - 8,700	5.6
Total		30.0

(b) Cura/Labugaon River

The existing Cura/Labugaon River consists of a number of distributaries with braided river streams. The master plan proposes one (1) river channel by uniting the existing distributaries. The Labugaon River is designed to join the Cura River at its fan apex. The proposed river channel will be provided with dikes and revetments with necessary appurtenant works for all river sections. The salient features of the project are summarized below. The alignment, longitudinal profile and cross-section of the river are shown in Fig. I.32(2).

River	Design Discharge (m^3/s)	Improvement Length (km)	River Width (m)	Design High Water Slope
Cura	2,360 - 850	11.7	340-200	1/324 - 1/154
Labugaon	1,260	1.8	250	1/92

(c) Solsona, Madongan and Papa rivers

The temporary diking system for a total of 27.0 km of river sections of the Solsona, Madongan and Papa rivers was completed in 1991-1993. This master plan proposes to strengthen the existing dikes by providing revetments with necessary appurtenant works for the entire river section. The salient features of the project are summarized below. The alignment, longitudinal profile and cross-section of the rivers are shown in Fig. I.32(3) to Fig. I.32(5).

River	Design Discharge (m^3/s)	Improvement Length (km)	River Width (m)	Design High Water Slope
Solsona	3,490 - 1,030	11.0	330 - 230	1/1,100 - 1/67
Madongan	1,970	9.0	300	1/285 - 1/72
Papa	690	7.0	223	1/230 - 1/55

8.6.3 Construction Works and Cost Estimate

(1) Construction Works

(a) Sabo Dam

The total construction works of the proposed eight (8) sabo dams are summarized below. The construction works of each sabo dam are shown in Table I.14.

Item	Quantity
Main Dam	8 units
Apron	8 units, 212 m
Counter Dam (Sub-dam)	8 units
Total Concrete Volume	113,150 m^3
Total Excavation Volume	148,300 m^3
Land Acquisition	negligible
House Resettlement	none

(b) River Improvement Works

The total construction works of the proposed river improvement are summarized below. The construction works of each river improvement sub-project are also shown in Table I.14.

Item	Quantity
Earth Dike & Floodwall	67.8 km, 1,577,000 m^3
Channel Excavation	1,532,000 m^3
Revetment & Toe Protection	65.8 km, 719,000 m^2
Spurdike	50 units
Sluiceway	37 units
Groundsill	4 units
Bridge Improvement	1 unit
Land Acquisition	50 ha
House Resettlement	21 houses

(2) Cost Estimate

The total cost of the proposed project is estimated to be 2,178 million pesos at 1996 prices with the breakdown shown below. Details of the project cost are shown in Table I.15.

Item	Cost
	(Unit: million ₱ at 1996 prices)
1. Construction Cost	1,714.3
(a) Preparatory Works	157.7
(b) Sabo Dam	301.5
(c) River Improvement	1,099.9
(d) Miscellaneous Works	155.2
2. Compensation Cost	8.0
(a) Land Acquisition	4.9
(b) House Resettlement	3.1
3. Administration Cost(5% of 1+2)	86.1
4. Engineering Service(10% of 1)	171.4
5. Physical Contingency(10% of 1+2+3+4)	198.0
Total	2,177.8

8.6.4 Implementation Program

The proposed master plan project will be implemented in three (3) phases; namely, Phase I (1999-2003), Phase II (2004-2009) and Phase III (2010-2012). The implementation schedule is prepared based on the following considerations. The implementation program is shown in Fig. I.33.

(1) The sabo dams are prerequisite to the flood control of the Cura/Labugaon, Solsona, Madongan and Papa rivers. Therefore, the sabo dam and river improvement works will be dealt as a package project in the said four (4) rivers.

(2) The sabo dams of Cura, Labugaon and Solsona will be constructed in stages. The proposed Cura No. 1, Labugaon No. 1 and Solsona No. 1 sabo dams will maintain an effective function for at least 10 years. Hence, Cura No. 2, Labugaon No. 2 and Solsona No. 2 will be constructed 10 years after the completion of the No. 1 dams.

(3) The river improvement works of the Cura/Labugaon, Solsona, Madongan and Papa rivers are expected to produce far larger beneficial effects compared to the other river improvement sub-projects. Accordingly, these river improvement works are given priority.

(4) The existing temporary dikes of the Solsona, Madongan and Papa rivers have been easily breached, especially in the upper half river reaches. Dike protection works in the upper half reaches are urgently necessary. On the other hand, no flood control works are provided in the Cura/Labugaon River at present. Early dike construction with some river dredging is considered necessary for the entire river sections to confine floods within the proposed river course. Further, dike protection works in the upper reaches are also considered urgent.

(5) The river improvement works for the urban areas of Laoag, San Nicolas and Dingras are also given priority in view of the high economic efficiency of the areas.

(6) From the above discussions, the following works will be implemented in Phase I as priority projects:

   (a) Cura No. 1, Labugaon No. 1, Solsona No. 1, Madongan and Papa sabo dams.

   (b) Dike protection works for the upper half river sections of Solsona, Madongan and Papa rivers and related works.

   (c) Dike construction for the entire reaches and dike protection works for the upper half reaches of Cura/Labugaon River and related works.

(d) Dike construction and related works at poblacions of Laoag, San Nicolas and Dingras.

(7) Prior to Phase I implementation, financial arrangement for the projects shall be completed in 1998. In Phase I, the detailed design will be conducted in 1999 and construction will commence in 2000.

(8) The remaining river improvement works will be implemented in stages during Phase II.

(9) Cura No. 2, Labugaon No. 2 and Solsona No. 2 will be implemented in Phase III.

The financial disbursement by phase is shown below. The annual disbursement schedule is shown in Table I.16.

Phase I (1999 - 2003)	:	1,496.6 million pesos
Phase II (2004 - 2009)	:	537.1 million pesos
Phase III (2010 - 2012)	:	144.1 million pesos
Total	:	2,177.8 million pesos

8.6.5 Economic Evaluation

(1) General

The economic viability of the proposed project is checked by calculating its economic internal rate of return (EIRR). Besides EIRR, net present value (NPV) and cost-benefit ratio (B/C) are presented as supplementary indices, for which costs and benefits are discounted at 15% per annum.

The above economic indices are calculated by comparing the economic cost and benefit based on the following conditions and assumptions:

(a) The economic cost is estimated by multiplying the financial cost with the following conversion factors:
   (i) 82% for local portion
   (ii) 120% for foreign potion applying shadow exchange rate

(b) The economic benefits of crop production are estimated based on the international market prices. The other economic benefits are estimated by multiplying the benefits counted at the local market prices with the conversion factor of 82%.

(c) The value of the land to be used for the project is evaluated through crop production lost by the land acquisition as negative benefit.

(d) Economic life is 50 years.

(e) The basic price level for estimates is set at August, 1996. The prevailing exchange rate is set at US$1.00 = 26 Pesos = 105 Yen. The shadow exchange rate is assumed to be 1.20 times of the prevailing market rate.

(f) The economic benefits of the project are estimated for the present and future socio-economic conditions. The benefits are assumed to increase in the future in proportion to the increase of the flood damage potential of the Basin. The flood damage potential is further assumed to increase in proportion to the growth of the population and the GRDP. The average annual growth rates of the population and GRDP of the Basin are assumed as follows:
   (i) Population: 0.9% up to 2020

(ii) GRDP: 6.2% up to 2000; 4.65% for 2000 to 2010; and, 3.1% for 2010 to 2020

(2) Economic Cost

The financial cost of the project is estimated at 2,177.8 million pesos. This financial cost is converted to economic cost of 1,806.1 million pesos.

(3) Economic Benefit

The project will produce flood damage mitigation and land use benefits.

(a) The flood mitigation benefit includes the flood damage reduction of house and household effects, industrial establishments, crops, infrastructures and indirect damage. The average annual matured benefit which is generated after completion of the project is estimated at 217.4million pesos under the present socio-economic conditions and 519.9 million pesos in 2020 under the future socio-economic conditions.

(b) The land use enhancement benefit includes the benefits of land loss prevention and land use restoration. The farmland of 52 ha is assumed to be washed away in the target alluvial fan areas annually under the present situation. This land loss will be prevented by the project. On the other hand, the project is expected to restore the existing devastated lands of 1,833 ha to lands for grazing, upland crop cultivation and rice cultivation. The average annual matured benefit of the land use enhancement is estimated at 80.2 million pesos under the present socio-economic conditions and 174.6 million pesos in 2020 under the future socio-economic conditions.

(4) Economic Evaluation

EIRR, NPV and B/C of the project are calculated as shown below. The annual flow of economic costs and benefits under the present and future socio-economic conditions are shown in Table I.17 and Table I.18, respectively.

Particulars	EIRR (%)	NPV (million ₱)	B/C
Present Condition	13.1	- 130.1	0.87
Future Condition	20.6	493.0	1.50

8.6.6 Financial Evaluation

The financial requirement of the project is estimated at 2.2 billion pesos at 1996 prices. This amount needs to be procured between 1999 and 2012.

On the other hand, the total capital investment for flood control by the national government in the future is estimated, based on the following assumptions:

(1) The total expenditure by the national government increases in proportion to the GDP growth. The ratio of government expenditure to the GDP is assumed to be 22.1%, referring to past records between 1990 and 1995.

(2) The annual growth rate of GDP is assumed to be 7.20% up to 2000, 5.40% for 2000-2010 and 3.60% for 2010-2020.

(3) 0.4% of the total expenditure is allocated for flood control, referring to past records between 1990 and 1995.

The total capital investment for flood control by the national government is expected to be 2.5 billion pesos in 2000, 3.8 billion pesos in 2010 and 5.9 billion pesos in 2020 at 1995 prices. The accumulated flood control investment of the national government between 1999 and 2012 is estimated at 43.9 billion pesos at 1995 prices, or 48.3 billion pesos at 1996 prices.

From the above, 4.5% of the total flood control budget of the national government needs to be allocated for the proposed master plan project during the period of 1999 to 2012. This allocation may be possible considering that the GRDP ratio of Ilocos Norte Province to the whole country was 3.1% in 1995.

8.6.7 Social Evaluation

The project will produce the following social beneficial effects:

(1) Improvement of social amenity and public hygiene. Approximately 57,000 people will be relieved from the menace of floods under the present socio-economic conditions.

(2) Enhancement of land use in the Basin, especially in the alluvial fan areas. The project will prevent the continued loss of farmland of 52 ha per year and convert the existing devastated farmlands of 1,833 ha into arable lands.

(3) The upper alluvial fan areas are economically depressed by recurrent flood disasters. The project will improve this situation, resulting in mitigation of economic disparity in the Basin.

(4) Job opportunities will be created and the regional economy will be activated.

8.6.8 Environmental Impact Assessment

(1) Physico-chemical Aspects

(a) Surface Water

The sabo dam and river dredging in the Cura/Labugaon River may make the river water in the downstream turbid. The adverse effects are considered minor because the riverbed materials on the construction sites contain little silt and clay.

(b) Groundwater

River dredging is proposed only for the Cura/Labugaon River and the dredging depth is shadow. Hence, the surrounding groundwater table will not be affected.

The sabo dams will be constructed on the river deposits as floating structure. Therefore, they will not affect the existing subsurface flow of the rivers.

(c) Topography

The sabo dams will change the existing topographic features of the valleys. However, no significant impacts are predicted.

(d) Air, Noise and Offensive Odor

The proposed construction works will generate dust and unpleasant noise. The impacts are negligibly small in the rural areas. The impacts in the urban areas are also considered minor because of the small volume and short period of the construction works. No offensive odor will be emitted by the project.

(2) Biological and Geological Aspects

There are no endangered and threatened species of flora and fauna in the project area. Biological and geological disturbance by the project will not occur, except the impacts on the growth of aquatic fauna. Further studies are necessary to evaluate the above impacts.

(3) Socio-economic Aspects

(a) Economic Activities

The construction of the project is an investment. The project will activate the regional economy and increase the local employment opportunity.

(b) Land Use

Farmlands of 50 ha will be acquired and 21 houses will be resettled. These adverse effects are considered small compared to the magnitude of the beneficial effects generated by the project.

On the other hand, the project will enhance land use in the alluvial fan areas including land loss prevention of 52 ha per annum and land use restoration of 1,833 ha.

(c) Transportation and Traffic

The existing traffic volume is small. Most of the construction works will be performed within the river area. The impact on traffic is considered negligibly small.

The road networks in the alluvial fan areas are disconnected due to the recurrent floods. The project will facilitate the development of the road networks.

(d) Historical and Archeological Interests

There are no valuable historical and archeological assets in the project area.

(e) Health and Social Services

A considerable number of hospitals and schools are prone to floods at present. The project will improve the medical and educational services in the project area by protecting the hospitals and schools from floods.

(f) Lifestyle and Community

The existing communities along the Cura/Labugaon River are separated by the braided river channels, causing inconveniences in their daily life. The project will improve this situation by uniting the braided river channels and connecting communities.

(g) Cultural Community

Some ethnic minorities are living in the upstream of the proposed sabo dams in the Labugaon River. The construction of the sabo dams may affect their lives. Further studies are necessary to evaluate the impacts.

The above environmental impacts are integrally assessed by the environmental interaction matrix shown in Table I.19.

CHAPTER IX NON-STRUCTURAL MEASURES

The principal non-structural measures to be applied for flood mitigation in the Laoag River Basin are: (1) watershed management (reforestation); (2) flood forecasting and warning; (3) flood fighting; and, (4) flood plain management (land use control in flood plain). In this Chapter, the existing institutional systems for execution of the above non-structural measures are discussed and further, some recommendations/guidelines for promotion of the non-structural measures in the Laoag River Basin are presented.

9.1 Existing Institutional System

9.1.1 Watershed Management (Reforestation)

Records of the Forest Management Bureau, DENR, show that the deforestation rate in the country is among the highest in the world. The average deforestation rate has been as high as 300,000 hectares per year in the late 1960's and was at rates higher than 150,000 hectares per year in the early 1980's, although the rates were estimated to be less than 100,000 hectares in 1990.

To address the fundamental causes of forest destruction, the government has taken a number of steps and among these are the launching of the nationwide reforestation program. Records from the 1994 Philippine Forestry Statistics show that as of 1975 a total of about 190,000 hectares have been reforested by the government. From 1976 to 1994, a total of 1,235,000 hectares was reforested; 783,000 hectares by the government and 452,000 hectares by non-government sectors.

The DENR through its field offices in 13 administrative regions, and the Environment and Natural Resources Office in every province (PENRO) and Community Office (CENRO) established in every municipality whenever feasible, are tasked to carry on the forest development and conservation programs of the government. In the Laoag River Basin there are two (2) CENRO under the PENRO of Ilocos Norte.

With the continuing program of the DENR, particularly on reforestation, surface soil erosion and siltation of rivers will be considerably reduced, which will ultimately lead to the reduction of losses due to floods.

9.1.2 Flood Forecasting and Warning

Flood forecasting and warning system projects as non-structural measures have been established by the government as early as of 1973. The system through the application of advanced telecommunication technology, can give early warnings of an impending flood to affected areas so that residents can take the necessary precaution to minimize loss of lives and damage to properties.

There are at present five (5) systems installed in some major rivers in Luzon, the first in the Pampanga River Basin. In addition, flood forecasting and warning systems have been installed in the Angat, Pantabangan, Ambuklao, Binga, and Magat Dams, to give warning to areas located immediately below the dam, before releasing excess flood water from the reservoir.

The PAGASA through its National Flood Forecasting Office is responsible for the operation of these systems, with the participation of other agencies such as the DPWH, NPC, NIA and the Office of Civil Defense.

9.1.3 Flood Fighting

Flood fighting is one of the activities embodied in P. D. No. 1566 dated June 11, 1978. This decree calls for the strengthening of the Philippine disaster control capability and establishing the national program on community disaster preparedness. A follow-up to this law is the Calamities and Disaster Preparedness Plan, issued by the National Disaster Coordinating Council (NDCC), dated August 24, 1988.

The NDCC acts as the top coordinator of all disaster management efforts, and is headed by the Secretary of National Defense, with department secretaries, the Director of the Philippine National Red Cross, the Chief of Staff of the Armed Forces of the Philippines, and some other key officials of the Philippine Government as members. The Civil Defense Administrator is a member and the Executive Officer of the Council.

At the regional, provincial, municipal, city and barangay level, a disaster coordinating council is a must. In the Province of Ilocos Norte, the PDDC is headed by the Governor as Chairman, the Philippine National Police Provincial Director as Vice Chairman, and all organic as well as national officials assigned in the province as members. The City of Laoag, and municipalities and barangays in the province have also their respective disaster coordinating councils.

Transmission of information on an impending disaster to the affected regions and provinces is done by the Office of Civil Defense National Disaster Management Center. The respective disaster coordinating councils will thereafter assume their roles and assigned tasks.

With the passage of the Local Government Code of 1991, the municipal mayors and/or the city mayors being the chief executives of their respective local government units are now empowered to remove illegally constructed houses along banks of rivers and waterways. However in the removal of these structures, the government has to comply with the provisions of R. A. No. 7279, otherwise known as the Urban Development and Housing Act of 1992.

9.1.4 Flood Plain Management (Land Use Control in Flood Plain)

Past experiences show that unregulated and uncontrolled use and development of the flood plain result in the increase of flood damage. Under the provisions of the Water Code of the Philippines, the Secretary of Public Works and Highways may declare flood control areas for the coordinated protection of flood plains, and promulgate guidelines governing flood plain management plans in these areas.

On the other hand, a city or municipality under the provision of the Local Government Code may through an ordinance passed by the Sanggunian (Council) after conducting public hearings, authorize the reclassification of agricultural lands and provide for the manner of their utilization and disposition. The local government units in conformity with existing laws, shall continue to prepare their respective land use plans enacted through zoning ordinances, which shall be the primary and dominant bases for future use of land resources.

As mandated by Executive Order No. 648, the Housing and Land Use Regulatory Board shall, among others, promulgate zoning and other land use control and standards and guidelines which shall govern the land use plans and zoning ordinances of the local government, the zoning components of civil works and infrastructure projects of the national, regional and local governments, etc., including review, approval and disapproval of land use development plans.

Placing the tasks of the above agencies into an integrated and coordinated program will lead to a more effective land use control in the flood plains.

9.2 Recommendations for Non-structural Measures

9.2.1 Watershed Management

The eastern watersheds of the Laoag River Basin yield excessive sediment runoff to the downstream rivers, causing large aggradation of the beds of the Cura, Labugaon, Solsona, Madongan and Papa rivers. The average annual aggradation rate in the rivers is estimated to be 3.0 cm/year in Cura/Labugaon River, 5.1 cm/year in Solsona/Madongan River, and 4.8 cm/year in Papa River. These aggradation rates will be decreased to a considerable extent by the proposed sabo dams. However, some amount of aggradation, i.e., 0.7 cm/year in Cura/Labugaon River, 2.5 cm/year in Solsona/Madonga River and 2.3 cm/year in Papa River will still be left to the sediment control of the other measures. For details, see Chapter VII.

On the other hand, DENR is undertaking eight (8) reforestation projects with a total area of 47,111 ha in the eastern watersheds. For the location, see Fig. I.17. These projects are expected to supplement the sediment control of the proposed sabo dams. However, the ongoing reforestation project area in the Madongan and Papa rivers is limited to only a small part although the sediment runoff of these rivers are the most critical in the Laoag River Basin. Extension of the ongoing reforestation project in the Madongan and Papa river basins is necessary.

9.2.2 Flood Forecasting and Warning

No flood forecasting and warning system has been established in the Laoag River Basin. However, the establishment of a flood forecasting and warning system is necessary to achieve a successful flood fighting and evacuation.

The flood traveling time from the mountain top to Laoag City is estimated to be approximately four (4) hours. This is considered too short to make a quantitative forecasting of flood discharge or water level in advance. The flood fighting and evacuation in the Basin need to be performed based on real time hydrological information and qualitative flood forecasting. Hence, a simple but speedy flood forecasting and warning system is proposed. The proposed system is composed of (1) hydrological observation network; (2) data transmission; (3) flood forecasting; and, (4) flood warning.

(1) Hydrological Observation Network and Data Transmission

The flood forecasting and warning in the Basin is performed based on the data of river water level but not rainfall data in principle since the installation and management of rainfall gauges in the mountain areas are difficult.

Nine (9) water gauging stations are considered necessary for the flood forecasting and warning in the Basin. Three (3) automatic stream gauging stations were earlier installed during the Study at Gilbert Bridge, Cauplasan Bridge and Solsona Irrigation Dam along with staff gauges. Six (6) other water gauging stations (staff gauges) will be installed at the following sites:

(a) Irrigation dams or intakes at Cura, Labugaon, Madongan, Papa and Upper Bongo rivers.

(b) Guisit River at Poblacion Piddig.

Locations of the above stations are shown in Fig. I.34.

Observed flood water level is transmitted to the Provincial Disaster Operation Center (PDOC) through the DPWH District Engineering Office by portable telephone every one hour during flood. A small building with a portable telephone will be constructed near each gauging station.

(2) Flood Forecasting and Warning

Flood forecasting on a qualitative basis will be performed in PDOC by using the collected data of river water level along with the typhoon information forecast by PAGASA. Based on the above flood forecasting, flood warning will be issued from PDOC to all the MDCC in the basin by telephone or portable telephone. MDCC will promptly disseminate the flood warning to the related BDCC after receiving the flood warning from PDCC. BDCC will take the necessary actions for flood fighting and evacuation.

9.2.3 Flood Fighting

In the Laoag River Basin, no large systematic flood fighting has been performed and evacuation from flood appears to be the major activity. The JICA Study Team conducted an interview survey on the performance of flood preparedness and flood fighting with all the barangay captains (115 persons) in the potential flood area. The results are summarized below.

Activities	No. of Barangays	
	Alluvial Fan Area	Other Areas
A. Flood Preparedness before Flood		
(1) Barangay officials instruct people to evacuate or advise people to prepare for possible evacuation	5	32
(2) People construct temporary riverbank protection/other works under control of barangay captain	36	8
(3) DPWH constructs spur dikes, revetment and other works	4	3
(4) People transfer furniture/commodities/livestock to higher grounds	2	-
(5) No Activity	9	14
B. Flood Fighting during Flood		
(1) People evacuate to higher grounds under control of barangay captain	20	37
(2) People transfer furniture to higher grounds under control of barangay captain	-	2
(3) People construct emergency riverbank protection under control of barangay captain	7	-
(4) No activity	28	21

A considerable number of barangays construct riverbank protection or other works before flood season to cope with coming floods and construct emergency riverbank protection during floods. Such structural flood preparedness and fighting activities are mostly performed in the alluvial fan areas while evacuation is the major flood activity in other areas. However, these structural works are all small due to lack of technology, equipment and financial sources.

According to the interview survey, seven (7) barangays out of 115 barangays have undertaken flood fighting activities for the tributaries or small rivers in the alluvial fan areas. Requests, directions, supervision and discharge of the flood fighting activities were carried out by barangay captains. Though the number of those who undertook the activities was not recorded, the necessary number for the activities have responded under the strong leadership of the barangay captain. The major activities were construction of emergency river dike bank by using common and handy materials and equipment such as gravel, soil, bamboo, wood, hand shovel, jeepney, etc. These activities were voluntary.

Flood fighting in the Basin will be further promoted by a more technical and systematic flood fighting in the barangay level and by establishing a financial support system.

The flood fighting and evacuation system for the Basin has been institutionally established based on the Calamities and Disaster Preparedness Plan of Ilocos Norte Province. However, no detailed operation manual has been prepared. The guidelines for preparation of the operation manual are suggested in the following sections.

(1) Flood Fighting Team

Floods in the Basin cause a rapid rising of river water. The flood rising time between half of the flood peak and flood peak at a large flood is estimated to be 5-6 hours. Not much time is spent before reaching the flood fighting site.

Hence, the barangays located near the river should be responsible for the flood fighting, in principle, because the other barangays far from the river cannot timely participate in the flood fighting due to the difficulty of access to the river, especially in the alluvial fan areas.

The responsible barangays should organize the flood fighting teams and prepare the necessary materials and equipment. The flood fighting team should work under the control of BDCC.

The city or municipality should bear the flood fighting costs since the flood fighting will produce beneficial effects on a wide area covering many barangays. The provincial government should extend necessary financial support to the city or municipality.

(2) Objective Facilities of Flood Fighting

The existing major river facilities to be protected by flood fighting in the Basin are river dikes and bank protection works. Their total length is estimated at 50 km. The length will increase to 110 km after completion of the proposed master plan. For location of the existing and future objective facilities, see Fig. I.21 and Fig. I.29, respectively.

(3) Priority Watching Site

The above-mentioned dikes and bank protection works will be continuously watched during flood to achieve a successful flood fighting. The priority watching sites at present are given below.

(a) Fan apexes of Solsona, Madongan and Papa rivers: The river sections of 2-3 km distance downward from the respective irrigation dams are subject to severe sediment deposition, resulting in river course shifting and dike breaching.

(b) Fan apex of Cura/Labugaon River: The Labugaon River joining the Cura River at its fan apex tends to branch away damaging the downstream villages and farmlands.

(c) River sections where river stream converges.

(d) River sections where irrigation intake is provided, bridge crosses or tributary joins.

(4) Alert Water Level

An alert water level will be designated beforehand to timely commence flood fighting activities. The alert water level will be given at the nine (9) water gauging stations of the proposed flood forecasting and warning system.

The alert water level is tentatively proposed to be 2-3 year probable flood water level (in terms of flood discharge, it is equivalent to about 50% of the design discharge), taking into consideration the required time length for flood fighting preparation, critical water level which may cause serious damages and speed of river water rising.

9.2.4 Flood Plain Management

Land use in the following flood plains will be controlled to minimize flood damage.

(1) Flood Area Unprotected by Structural Measures

The total flood area by the design flood with a 25-year return period in the Laoag River Basin is estimated at 17,300 ha of which 15,260 ha or 88% will be protected by the proposed structural measures. However, the remaining 2,040 ha or 12% will remain unprotected. Such unprotected areas and the present resident population are estimated as shown below.

River	Location	Unprotected Area (ha)	Present Resident Population
Bongo	Upper Bongo	550	1,528
Bongo	Lower Bongo	400	480
Laoag/Guisit	Guisit River / Mandaloque, Dingras	730	1,058
Laoag	San Marcos / San Cristobal/Sto.Tomas / San Felipe, Sarrat	360	464
Total		2,040	3,530

Locations of the above unprotected flood areas are shown in Fig. I.35. Construction of new buildings will be regulated in these unprotected areas.

(2) Alluvial Fan Area with High Flood Risk

The fan apex areas of the Cura/Labugaon, Solsona, Madongan and Papa rivers will be protected by the proposed structural measures. However, these areas, especially the river sections of 2-3 km distance downward from the irrigation dams/intakes will still be highly exposed to flood even after the completion of the structural measures. Once a large flood exceeding the design flood occurs, the river dikes may be breached and, as a result, the fan apex areas will suffer from severe damage due to the cascading high flood-waters carrying much sediment. The inundation area and depth by a 100-year flood is estimated as shown in Fig. I.15.

Construction of new buildings will be regulated in the following flood risk areas:

(a) Fan apex flood area in the left bank of Cura/Labugaon River
(b) Fan apex flood area in both banks of Solsona River
(c) Fan apex flood area in the left bank of Madongan River
(d) Fan apex flood area in both banks of Papa River

(3) Closed Branch River Area in Alluvial Fan

The Solsona, Madongan and Papa rivers have many old branch rivers of which entrances were temporarily closed by the urgent disaster prevention works in 1991-1993. These entrance closures will be completed in the proposed master plan. The Labugaon River joining the Cura River branched away to the left side at its fan apex during the large floods in the recent years. This branch will also be closed in the master plan.

However, these branch river areas will still be exposed to a higher flood risk compared to the other flood plains. If a flood exceeding the design level occurs, the floodwaters will easily flow down the former branch rivers.

Construction of new buildings within the major former branch rivers will be regulated. The leftside branches of the Cura/Labugaon River are the typical regulated areas. For locations of the existing and former branch rivers in the alluvial fans, see Chapter IV, Fig. I.18.

TABLES

Table I.1 Washed Out and Recovered Farmland during Recent 20 Years

River Flood Zone	Washed Out (ha)	Recovered (ha)
Bongo River	40	17
Dong-dong River	40	20
Lading Creek	14	0
Cabittauran Creek	5	0
Papa River	64	26
Madongan River	142	110
Cuyep-cuyep River	39	8
Solsona River	202	30
Cura River	334	0
Labugaon River	250	0
Total	1,130	211

Table I.2 Land Convertible to Productive Area

(unit : ha)

Area	Not Usable	Grazing (A)	Grazing (B)	Upland Crops	Paddy	Others	Total
Papa Left	0.0	11.9	105.1	11.8	0.0	7.5	136.3
Papa Right	0.0	30.4	115.2	0.0	0.0	7.7	153.3
Madongan Left	44.6	276.3	354.2	267.3	227.8	138.8	1,309.0
Madongan Right	9.9	36.6	5.9	23.9	0.0	4.9	81.2
Solsona Left	68.5	171.4	47.9	0.8	42.4	25.8	356.8
Solsona Right (upper)	10.9	52.6	9.2	0.0	0.0	3.3	76.0
Solsona Right (lower)	9.5	0.0	0.0	0.0	20.5	6.8	36.8
Cura Left	70.1	144.8	171.0	141.4	139.8	78.9	746.0
Cura Right	0.0	28.6	10.3	67.4	71.0	33.2	210.5
Total	213.5	752.6	818.8	512.6	501.5	306.9	3,105.9

Note : Others are road, canal and creek area

Table I.3 Inundation Area and Affected Population for Each Return Period

	Inundation Area (ha)						Affected Population					
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
Tangit, Laoag	130	400	550	600	1,050	1,300	824	2,190	3,338	3,945	8,428	9,758
Suyo, Laoag	30	130	150	200	230	230	-	1,026	1,054	1,054	1,528	1,528
Poblacion, Laoag	30	50	100	130	150	180	2,283	3,376	3,376	5,149	5,149	5,149
Camangaan, Laoag	180	250	250	480	630	780	967	1,020	1,020	2,039	2,404	2,404
Poblacion, San Nicolas	100	150	180	230	580	830	1,295	1,851	2,596	5,835	10,499	12,730
San Manuel, Sarrat	100	150	180	550	550	650	425	425	573	1,339	1,339	2,416
San Felipe, Sarrat	-	50	80	100	130	130	-	55	130	182	182	258
Sto. Tomas, Sarrat	100	100	130	150	150	180	-	25	76	107	107	156
San Marcos, Sarrat	-	30	30	30	30	30	-	102	102	102	102	102
San Cristobal, Sarrat	30	50	80	80	80	80	16	40	73	73	73	73
Guisit/Mandaloque	510	560	630	730	730	760	434	691	917	1,058	1,058	1,286
Suyo, Dingras	150	150	200	200	200	200	1,356	1,438	2,317	2,317	2,317	2,317
Poblacion Dingras	80	280	480	550	780	780	1,176	3,267	4,228	4,228	5,283	5,283
Cura River	3,350	3,630	3,750	3,900	3,980	4,000	8,994	10,231	10,552	11,115	11,115	11,115
Solsona River	1,900	2,150	2,230	2,280	2,300	2,550	4,721	5,358	5,358	7,152	7,152	7,811
Madongan River	3,700	3,930	4,130	4,180	4,280	4,380	8,131	8,605	8,745	8,764	8,918	9,358
Papa River	1,730	1,880	1,900	1,950	1,980	2,000	3,495	3,926	4,494	4,651	4,769	4,769
Lower Bongo River	330	380	400	400	430	430	199	280	379	480	480	480
Upper Bongo River	350	480	500	550	730	730	1,160	1,498	1,498	1,528	1,865	1,865
Total	12,800	14,800	15,950	17,290	18,990	20,220	35,476	45,404	50,826	61,118	72,768	78,858

Table I.4 Present Value of Damageable Assets in Inundation Area

(unit : million P)

Inundation Sub-district	Living Quaters				Crop Production		Industrial Establishment				Infrastructures							
	Buildings		Furnitures				Manufaturing		Trading		Education		Health		Road		Irrigation	
	25-yr	100-yr	25-yr	100-yr	25-yr	100-yr	25-yr	100-yr	25-yr	100-yr	25-yr	100-yr	25-yr	100-yr	25-yr	100-yr	25-yr	100-yr
Tangit, Laoag	39.0	96.9	29.6	73.6	9.0	20.2	0.0	0.0	6.3	16.0	5.3	12.3	0.4	16.4	9.0	19.6	20.2	45.2
Suyo, Laoag	9.6	13.6	7.3	10.3	2.5	2.6	0.0	0.0	1.6	2.9	1.8	3.5	0.4	0.4	1.5	1.7	5.6	5.9
Poblacion, Laoag	52.2	52.2	39.6	39.6	0.9	1.0	0.6	0.6	11.3	11.3	43.8	50.8	32.8	32.8	1.2	1.6	2.1	2.3
Camangaan, Laoag	20.3	23.9	15.4	18.1	7.9	13.2	0.2	0.2	4.5	6.1	3.5	7.0	15.7	15.7	3.4	5.5	17.7	29.0
Poblacion, San Nicolas	59.5	129.4	45.2	98.3	2.0	11.6	2.5	6.0	5.9	14.2	8.8	19.3	0.4	17.5	3.3	11.9	4.5	24.9
San Manuel, Sarrat	13.7	24.3	10.4	18.4	8.0	9.8	0.2	0.4	4.7	6.3	0.0	1.8	0.0	0.0	8.4	9.9	16.7	20.8
San Felipe, Sarrat	1.8	2.6	1.4	1.9	2.3	2.6	0.0	0.0	4.1	6.1	0.0	1.8	0.0	0.4	1.0	1.4	5.2	5.9
Sto. Tomas, Sarrat	1.1	1.6	0.8	1.2	0.8	1.1	0.0	0.0	1.1	1.4	0.0	0.0	0.0	0.0	1.4	1.7	1.6	1.6
San Marcos, Sarrat	1.0	1.0	0.8	0.8	0.4	0.4	0.0	0.0	0.7	0.7	0.0	0.0	0.0	0.0	0.2	0.2	0.7	0.7
San Cristobal, Sarrat	0.8	0.8	0.6	0.6	0.7	0.7	0.4	0.4	0.0	0.0	5.3	5.3	0.4	0.4	1.0	1.0	0.8	0.8
Guisit/Mandaloque	10.4	12.8	7.9	9.7	6.9	7.3	0.1	0.1	3.4	3.6	5.3	5.3	0.0	0.0	5.4	5.7	15.5	16.3
Suyo, Dingras	23.3	23.3	17.7	17.7	2.8	2.8	0.2	0.2	0.9	0.9	3.5	3.5	0.0	0.0	2.3	2.3	5.7	5.7
Poblacion Dingras	41.6	51.6	31.6	39.2	7.2	11.7	0.4	0.6	0.9	0.9	10.5	12.3	16.7	17.1	5.2	7.3	16.1	26.3
Cura River	112.2	112.2	85.2	85.2	57.2	57.5	0.6	0.6	7.4	7.4	15.8	17.5	1.5	1.5	19.2	19.7	127.2	128.0
Solsona River	69.8	76.0	53.0	57.8	32.1	36.2	0.8	0.8	5.4	5.9	15.8	15.8	1.4	1.4	11.7	13.1	70.9	80.1
Madongan River	85.6	91.5	65.0	69.5	48.2	51.9	0.1	0.1	6.5	6.5	17.5	19.3	0.7	0.7	40.0	41.9	108.0	115.9
Papa River	45.5	46.7	34.6	35.5	28.6	30.0	0.2	0.2	3.2	3.2	10.5	10.5	0.0	0.4	18.0	18.5	63.2	66.2
Lower Bongo River	4.6	4.6	3.5	3.5	3.0	3.5	0.0	0.0	0.7	0.7	0.0	0.0	0.4	0.4	5.5	5.9	6.8	8.0
Upper Bongo River	14.1	17.1	10.7	13.0	7.3	9.8	0.0	0.0	1.6	1.6	1.8	1.8	0.4	0.4	7.3	9.7	16.3	21.9
Total	605.7	781.5	460.3	593.9	228.0	274.0	6.4	10.3	70.0	95.4	148.8	187.3	71.0	105.2	145.0	178.5	504.9	605.3

Table I.5 Probable Flood Damage under Present Socio-economic Situation

Inundation Sub-district	Inundation Area(ha)			Affected Population			Damage(million P)		
	5-year	25-year	100-year	5-year	25-year	100-year	5-year	25-year	100-year
Tangit, Laoag	400	600	1,300	2,190	3,945	9,758	12.2	29.5	56.4
Suyo, Laoag	130	200	230	1,026	1,054	1,528	2.5	7.8	15.9
Poblacion, Laoag	50	130	180	3,376	5,149	5,149	30.8	79.8	110.3
Camangaan, Laoag	250	480	780	1,020	2,039	2,404	7.7	21.0	25.5
Poblacion, San Nicolas	150	230	830	1,851	5,835	12,730	7.5	27.0	54.0
San Manuel, Sarrat	150	550	650	425	1,339	2,416	4.1	9.8	15.8
San Felipe, Sarrat	50	100	130	55	182	258	1.2	3.4	6.0
Sto. Tomas, Sarrat	100	150	180	25	107	156	0.2	1.0	1.9
San Marcos, Sarrat	30	30	30	102	102	102	0.2	0.5	1.1
San Cristobal, Sarrat	50	80	80	40	73	73	3.5	6.7	7.7
Guisit/Mandaloque	560	730	760	691	1,058	1,286	10.2	20.5	23.0
Suyo, Dingras	150	200	200	1,438	2,317	2,317	7.8	14.0	20.7
Poblacion Dingras	280	550	780	3,267	4,228	5,283	13.5	28.0	44.9
Cura River	3,630	3,900	4,000	10,231	11,115	11,115	131.4	157.2	178.6
Solsona River	2,150	2,280	2,550	5,358	7,152	7,811	79.7	99.3	122.8
Madongan River	3,930	4,180	4,380	8,605	8,764	9,358	89.7	113.0	137.8
Papa River	1,880	1,950	2,000	3,926	4,651	4,769	33.7	44.2	50.2
Lower Bongo River	380	400	430	280	480	480	8.3	13.5	15.3
Upper Bongo River	480	550	730	1,498	1,528	1,865	14.8	20.1	25.7
Total	14,800	17,290	20,220	45,404	61,118	78,858	458.8	696.1	913.8

Note : Damage are at 1996 market prices.

Table I.6 Average Annual Flood Damage below 25-year and 100-year Floods

(unit : million P at 1996 prices)

Inundation Sub-district	Below 25-year Flood				Below 100-year Flood			
	Present	2000 year	2010 year	2020 year	Present	2000 year	2010 year	2020 year
Tangit, Laoag	5.9	7.1	10.4	14.0	7.0	8.4	12.5	16.8
Suyo, Laoag	1.0	1.3	1.9	2.5	1.3	1.6	2.4	3.3
Poblacion, Laoag	12.2	15.3	23.5	31.8	14.6	18.3	28.0	37.8
Camangaan, Laoag	4.0	4.8	7.0	9.4	4.6	5.5	8.0	10.7
Poblacion, San Nicola	3.5	4.3	6.5	8.7	4.5	5.6	8.4	11.2
San Manuel, Sarrat	2.1	2.6	3.7	5.0	2.4	2.9	4.2	5.7
San Felipe, Sarrat	0.7	0.8	1.2	1.6	0.8	1.0	1.4	1.9
Sto. Tomas, Sarrat	0.1	0.1	0.2	0.3	0.2	0.2	0.3	0.4
San Marcos, Sarrat	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
San Cristobal, Sarrat	1.3	1.6	2.4	3.3	1.4	1.8	2.8	3.8
Guisit/Mandaloque	6.3	7.7	11.3	15.2	6.9	8.4	12.3	16.6
Suyo, Dingras	4.1	5.0	7.4	9.8	4.6	5.6	8.2	11.0
Poblacion Dingras	5.4	6.6	10.0	13.4	6.3	7.7	11.6	15.6
Cura River	67.8	81.7	119.2	160.2	72.1	86.9	126.8	170.5
Solsona River	44.1	53.3	78.2	105.2	46.8	56.7	83.2	111.8
Madongan River	47.4	57.2	83.7	112.5	50.6	61.1	89.4	120.1
Papa River	19.8	24.0	35.1	47.2	21.1	25.4	37.3	50.2
Lower Bongo River	4.7	5.7	8.4	11.2	5.0	6.1	9.0	12.0
Upper Bongo River	7.6	9.2	13.5	18.1	8.2	9.8	14.4	19.3
Total	238.1	288.2	423.6	569.7	258.4	313.0	460.3	618.9

Note : damage amounts are expressed in terms of economic value

Table I.7 Design Flood Discharge Probability of Major Rivers in the Philippines

Item	Cagayan River	Agno River	Pampanga River	Mt. Pinatubo	Pasig River	Mt. Mayon	Panay River	Agusan River	Ilog-hilabagan River	Jaro-Iloilo River	Laoag River
1. Project Area											
River Drainage Basin(km^2)	27,300	7,640	10,503	322	4,678	699	2,181	1,140	2,162	505	1,332
Project Area(km^2)			3,200	1,296	981			199			
Nos. of Cities/Municipalities	107	83	12*	9*	17*	23	17	2*	4		11
Total Pop.(1,000)	2,136	2,324	1,792*	736*	5,926*	419	448	134*	347	310	197
Pop. Density(per km^2)	78	304	599*	568*	6,040*	599	187	673*	160	613	148
Ratio of Urban Pop. (%)	19	26		59*	mostly*	20	14	mostly*	20	mostly	29
GRDP of Agriculture(%)	47	37	37	24*	0*	52	38		32		42
GRDP of Industry/Service(%)	53	63	63	76*	100*	48	62		68		58
Developed Land Use(%)	20	30	40	53*	51*	65	49	69*	51		20
2. Potential Damage											
Flooded Area(km^2)	1,860	2,465	1,448*	393*	110*	184	338	79*	120	41	202
Affected Pop.(1,000)		1,457		205*	1,100*	70	121	115*	47	149	79
3. Design Probability											
Framework(year)	100	100	100		100		100	100			
Master Plan(year)	25	25			100	50	25		100	50	
Short-term(year)	25	10	20	20	30		10	30	25	20	
4. Implement. Period											
Framework(year)	not	not	not		not		not	not			
Master Plan(year)	20	20			30	10	30		20	20	
Short-term(year)	10	10	10	10	10		10	10	10	10	

Note : 1) * shows the figures for project area, while others are for drainage basin.
2) not" in implementation period means not specified".

Table I.8 Breakdown of Construction Costs of Sabo Dams (Cases I and II)

(1) Case I

Unit : million pesos

Sabo Dam		Civil Works	Compensation	Administration	Engineering	Physical Cont.	Total	Grand Total
Cura	No.1	64.9	0.0	3.2	6.5	7.4	82.0	82.0
Labugaon	No.1	59.8	0.0	3.0	6.0	6.9	75.7	
	No.2	50.9	0.0	2.5	5.1	5.8	64.3	140.0
Solsona	No.1	31.1	0.0	1.6	3.1	3.6	39.4	
	No.2	39.1	0.0	2.0	3.9	4.5	49.5	88.9
Madongan	No.1	51.9	0.0	2.6	5.2	6.0	65.7	65.7
Papa	No.1	52.1	0.0	2.6	5.2	6.0	65.9	65.9
Bongo	No.1	53.2	0.0	2.7	5.3	6.1	67.3	67.3
Total		403.0	0.0	20.2	40.3	46.3	509.8	509.8

(2) Case II

Unit : million pesos

Sabo Dam		Civil Works	Compensation	Administration	Engineering	Physical Cont.	Total	Grand Total
Cura	No.1	43.4	0.0	2.2	4.3	5.0	54.9	
	No.2	19.6	0.0	1.0	2.0	2.2	24.8	79.7
Labugaon	No.1	59.8	0.0	3.0	6.0	6.9	75.7	
(same as Case I)	No.2	50.9	0.0	2.5	5.1	5.8	64.3	140.0
Solsona	No.1	31.1	0.0	1.6	3.1	3.6	39.4	
(same as Case I)	No.2	39.1	0.0	2.0	3.9	4.5	49.5	88.9
Madongan	No.1	41.6	0.0	2.1	4.1	4.9	52.7	
	No.2	92.2	0.0	4.6	9.2	10.7	116.7	169.4
Papa	No.1	40.3	0.0	2.0	4.0	4.6	50.9	
	No.2	26.8	0.0	1.3	2.7	3.2	34.0	84.9
Bongo	No.1	37.5	0.0	1.9	3.8	4.3	47.5	
	No.2	18.2	0.0	0.9	1.8	2.1	23.0	70.5
Total		500.5	0.0	25.1	50.0	57.8	633.4	633.4

Table I.9 Breakdown of Sabo and River Improvement Works by Sub-district

Work Items	Sabo Works: Sabo Dam Nos.	Sabo Works: Sabo Dam Excavation (m3)	Sabo Works: Sabo Dam Concrete (m3)	River Improvement Works: Dike Length (m)	River Improvement Works: Dike Volume (m3)	Channel Excavation (m3)	Revetment Length (m)	Revetment Area (m2)	Spurdike (units)	Sluiceway (units)	Groundsill (units)	Bridge Ext. /Reconst. (m2)(nos.)	Compensation: Land (ha)	Compensation: House (units)
(1) Tangid, Laoag	-	-		6,450	176,000	-	-	-	10	2	-	-	10	-
(2) Suyo, Laoag	-	-		2,100	72,300	-	-	-	-	2	-	-	4	-
(3) Poblacion, Laoag	-	-		1,500 *1	-	-	-	-	-	3	-	-	-	-
(4) Camangaan, Laoag	-	-		4,000	195,000	-	-	-	-	3	-	-	8	1
(5) Poblacion, San Nicolas	-	-		3,000	140,000	-	-	-	10	2	-	-	6	-
(6) San Manuel, Sarrat	-	-		3,600	86,000	-	-	-	-	2	-	-	5	20
(7) San Felipe, Sarrat	-	-		3,700	156,000	-	300	2,540	10	4	-	-	7	-
(8) Sto. Tomas, Sarrat	-	-		4,800	66,000	-	-	-	-	3	-	-	5	-
(9) San Marcos, Sarrat	-	-		2,250	36,000	-	-	-	-	3	-	-	3	-
(10) San Cristobal, Sarrat	-	-		1,850	78,000	-	1,850	19,000	-	2	-	-	3	-
(11) Guisit R./Mandaloque	-	-		18,300	978,000	-	700	3,700	10	20	-	-	30	1
(12) Suyo, Dingras	-	-		3,700	104,000	-	-	-	-	3	-	-	5	-
(13) Poblacion, Dingras	-	-		5,600	205,000	-	-	-	10	3	-	-	10	-
(14) Cura/Labugaon River	4	37,500	53,200	21,900	350,000	1,532,000	22,200	206,500	20	4	1	315(1)	1	-
(15) Solsona River	2	10,700	21,500	10,950 *2	173,000	-	13,700	155,400	-	4	1	-	1	-
(16) Madongan River	1	11,800	16,000	4,000 *3	60,000	-	17,500	225,500	-	7	1	-	-	-
(17) Papa River	1	10,700	16,100	1,000 *3	14,500	-	12,400	132,000	-	2	1	-	-	-
(18) Lower Bongo River	-	-	-	17,750	636,000	-	-	-	20	-	-	-	10	-
(19) Upper Bongo River	2	12,000	17,100	19,300	293,000	-	19,300	192,900	-	5	1	2,710(2)	3	-
Total	10	82,700	123,900	135,750 (New dike=120,750) (Heightening=15,000)	3,819,800	1,532,000	87,950	937,540	90	74	5	3,025(3)	117	22

Notes:
*1: Floodwall.
*2: Heightening of existing dike = 10,000 m, and new dike = 950 m.
*3: Heightening of existing dikes only.

Table I.10 Breakdown of Project Cost by Sub-project

Unit : million pesos

Sub-project	Civil Works	Compensation	Administration	Engineering	Physical Cont.	Total
(1) Tangid, Laoag	27.8 (22.8)	1.0 (0.0)	1.4 (1.2)	2.8 (2.8)	3.3 (2.7)	36.3 (29.5)
(2) Suyo, Laoag	11.7 (9.6)	0.0 (0.0)	0.6 (0.5)	1.2 (1.2)	1.3 (1.1)	14.8 (13.3)
(3) Poblacion, Laoag	48.1 (39.4)	0.0 (0.0)	2.4 (2.0)	4.8 (4.8)	5.5 (4.5)	60.8 (50.8)
(4) Camangaan, Laoag	27.3 (22.4)	1.0 (0.0)	1.4 (1.2)	2.7 (2.7)	3.2 (2.7)	35.7 (28.9)
(5) Poblacion, San Nicolas	22.2 (18.2)	0.6 (0.0)	1.1 (0.9)	2.2 (2.2)	2.6 (2.1)	28.8 (23.5)
(6) San Manuel, Sarrat	13.8 (11.3)	3.9 (0.0)	0.9 (0.7)	1.4 (1.4)	2.0 (1.6)	22.0 (15.1)
(7) San Felipe, Sarrat	32.0 (26.2)	0.7 (0.0)	1.6 (1.3)	3.2 (3.2)	3.8 (3.1)	41.3 (33.9)
(8) Sto. Tomas, Sarrat	13.3 (10.9)	0.5 (0.0)	0.7 (0.6)	1.3 (1.3)	1.6 (1.3)	17.4 (14.1)
(9) San Marcos, Sarrat	8.7 (7.1)	0.3 (0.0)	0.5 (0.4)	0.9 (0.9)	1.0 (0.8)	11.4 (9.2)
(10) San Cristobal, Sarrat	25.5 (20.9)	0.3 (0.0)	1.3 (1.1)	2.6 (2.6)	3.0 (2.4)	32.6 (26.9)
(11) Guisit R./Mandaloque, Dingras	161.5 (132.4)	3.8 (0.0)	8.3 (6.8)	16.2 (16.2)	19.0 (15.6)	208.7 (170.9)
(12) Suyo, Dingras	25.3 (20.7)	0.3 (0.0)	1.3 (1.0)	2.5 (2.5)	2.9 (2.4)	32.4 (26.7)
(13) Poblacion, Dingras	31.4 (25.7)	1.0 (0.0)	1.6 (1.3)	3.1 (3.1)	3.7 (3.0)	40.9 (33.3)
(14) Cura/Labugaon River	640.0 (524.8)	0.1 (0.0)	32.0 (26.2)	64.1 (64.1)	73.6 (60.4)	809.7 (675.4)
(15) Solsona River	281.9 (231.2)	0.1 (0.0)	14.1 (11.6)	28.2 (28.2)	32.4 (26.6)	356.8 (297.5)
(16) Madongan River	329.4 (270.1)	0.0 (0.0)	16.5 (13.5)	32.9 (32.9)	37.9 (31.1)	416.7 (347.6)
(17) Papa River	219.8 (180.2)	0.0 (0.0)	11.0 (9.0)	22.0 (22.0)	25.3 (20.7)	278.0 (232.0)
(18) Lower Bongo River	92.6 (75.9)	1.0 (0.0)	4.7 (3.8)	9.3 (9.3)	10.8 (8.8)	118.3 (97.8)
(19) Upper Bongo River	391.6 (321.1)	0.3 (0.0)	19.6 (16.1)	39.1 (39.1)	45.1 (37.0)	495.7 (413.3)
Total	2,403.9 (1,971.2)	14.9 (0.0)	121.0 (99.2)	240.4 (240.4)	278.0 (228.0)	3,058.2 (2,538.8)

Note: 1) Outside of Parentheses: financial cost
2) Inside of Parentheses: economic cost

Table I.11 Breakdown of Average Annual Benefit by Sub-project

(Unit : Million Pesos)

Sub-project	Socio-economic Condition	
	Present	Future (2020)
Tangit, Laoag	5.9	14.0
Suyo, Laoag	1.0	2.5
Poblacion, Laoag	12.2	31.8
Camangaan, Laoag	4.0	9.4
Poblacion, San Nicolas	3.5	8.7
San Manuel, Sarrat	2.1	5.0
San Felipe, Sarrat	0.7	1.6
Sto. Tomas, Sarrat	0.1	0.3
San Marcos, Sarrat	0.1	0.1
San Cristobal, Sarrat	1.3	3.3
Guisit/Mandaloque	6.3	15.2
Suyo, Dingras	4.1	9.8
Poblacion Dingras	5.4	13.4
Cura River	69.9	226.6
Solsona River	44.9	131.7
Madongan River	48.3	133.1
Papa River	20.0	54.1
Lower Bongo River	4.7	11.2
Upper Bongo River	7.8	28.9
Total	242.3	700.7

Note : Benefits are expressed in terms of economic value

Table I.12 Evaluation of Sub-project

Sub-project	Protected Area(ha)	Protected Population	Project Cost (million P)			EIRR (%)		Technical Validity	Emvironmental Adverse Impact
			Sabo Dam	River Imp.	Total	Present	Future		
Tangit, Laoag	600	3,945		36.3	36.3	17.9	27.6	no problem	not significant
Suyo, Laoag	200	1,054		14.8	14.8	7.4	13.6	no problem	not significant
Poblacion, Laoag	130	5,149		60.8	60.8	21.6	34.1	no problem	not significant
Camangaan, Laoag	480	2,039		35.6	35.6	12.5	20.2	no problem	not significant
Poblacion, San Nicolas	230	5,835		28.7	28.7	13.7	22.4	no problem	not significant
San Manuel, Sarrat	550	1,339		22.0	22.0	12.8	20.7	no problem	not significant
San Felipe, Sarrat	100	182		41.3	41.3	*	2.7	no problem	not significant
Sto. Tomas, Sarrat	150	107		17.4	17.4	*	*	no problem	not significant
San Marcos, Sarrat	30	102		11.4	11.4	*	*	problem	not significant
San Cristobal, Sarrat	80	73		32.6	32.6	3.4	8.5	problem	not significant
Guisit/Mandaloque	730	1,058		208.8	208.8	2.1	6.3	problem	not significant
Suyo, Dingras	200	2,317		32.3	32.3	14.0	22.5	no problem	not significant
Poblacion Dingras	550	4,228		40.8	40.8	14.6	23.9	no problem	not significant
Cura River	3,900	11,115	219.7	589.9	809.6	10.7	17.2	no problem	not significant
Solsona River	2,280	7,152	88.9	268.0	356.9	14.4	22.7	no problem	not significant
Madongan River	4,180	8,764	65.7	351.1	416.8	13.6	21.3	no problem	not significant
Papa River	1,950	4,651	65.9	212.2	278.1	8.4	14.4	no problem	not significant
Lower Bongo River	400	480		118.4	118.4	3.5	8.2	problem	not significant
Upper Bongo River	550	1,528	70.5	425.3	495.8	0.7	4.1	problem	not significant
Total	17,290	61,118	510.7	2,547.7	3,058.4	171.3	290.4		

Note : * means negative EIRR

Table I.13 Salient Features of Proposed Sabo Dam

River	Cura		Labugaon		Solsona		Madongan	Papa	Total
Dam Name	Cura No.1	Cura No.2	Labugaon No.1	Labugaon No.2	Solsona No.1	Solsona No.2	Madongan	Papa	
Catchment Area(km^2)	68.2	63.1	100.5	90.9	72.2	68.2	153.8	51.4	
Dam Height(m)	6.5	4.5	10.0	7.0	10.0	10.0	7.0	7.0	
Dam Lenghth(m)	170	70	100	160	30	90	120	210	
Existing River Bed Slope(%)	1.08	1.08	1.15	1.15	2.58	2.58	1.52	2.08	
Design Sedimentation Slope(%)	0.81	0.81	0.86	0.86	1.94	1.94	1.14	1.56	
Design Sedimentation Volume(m^3)	391,000	150,000	1,043,000	511,000	233,000	233,000	2,192,000	707,000	5,460,000

Table I.14 Construction Works by Each Sub-project

(1) Sabo Dam

Sabo Dam	Main Dam Nos. (unit)	Apron Length (m)	Counter Dam Nos. (unit)	Total Concrete Volume (m^3)	Total Excavation (m^3)	Compensation Land (ha)	Compensation House (units)
Cura No.1	1	18	1	14,500	22,200	-	-
Cura No.2	1	20	1	6,300	9,700	-	-
Labugaon No.1	1	30	1	19,200	19,800	-	-
Labugaon No.2	1	21	1	16,350	23,400	-	-
Solsona No.1	1	40	1	9,600	5,700	-	-
Solsona No.2	1	40	1	11,900	5,000	-	-
Madongan	1	26	1	17,300	39,800	-	-
Papa	1	17	1	18,000	22,700	-	-
Total	8	212	8	113,150	148,300	-	-

(2) River Improvement Works

Work Items	Dike Length (m)	Dike Volume (m^3)	Channel Excavation (m^3)	Revetment Length (m)	Revetment Area (m^2)	Toe Protection Length (m)	Toe Protection Volume (m^3)	Spurdike (units)	Sluiceway (units)	Groundsill (units)	Bridge Extension (m^2)(Nos.)	Compensation Land (ha)	Compensation House (units)
(1) Tangid, Laoag	6,450	176,000	-	-	-	-	-	10	2	-	-	10	-
(2) Suyo, Laoag	2,100	73,000	-	-	-	-	-	-	2	-	-	4	-
(3) Poblacion, Laoag	1,500	-	-	-	-	-	-	-	3	-	-	-	-
(4) Camangaan, Laoag	4,000	195,000	-	-	-	-	-	-	3	-	-	8	1
(5) Poblacion, San Nicolas	3,000	140,000	-	-	-	-	-	10	2	-	-	6	-
(6) San Manuel, Sarrat	3,600	86,000	-	-	-	-	-	-	2	-	-	5	20
(7) Suyo, Dingras	3,700	104,000	-	-	-	-	-	-	3	-	-	5	-
(8) Poblacion, Dingras	5,600	205,000	-	-	-	-	-	10	3	-	-	10	-
(9) Cura/Labugaon River	21,900	350,000	1,532,000	22,200	206,500	22,200	35,500	20	4	1	315(1)	1	-
(10) Solsona River	10,950	173,000	-	13,700	155,400	13,700	25,300	-	4	1	-	1	-
(11) Madongan River	4,000	60,000	-	17,500	225,500	17,500	32,800	-	7	1	-	-	-
(12) Papa River	1,000	14,500	-	12,400	132,000	12,400	23,400	-	2	1	-	-	-
Total	67,800	1,576,500	1,532,000	65,800	719,400	65,800	117,000	50	37	4	315(1)	50	21

Table I.15 Breakdown of Project Cost

Work Item	Unit	Quantity	Amount (Million P)
1. CONSTRUCTION COST			1,714.3
1.1 Preparatory Works	l.s.	1	157.7
1.2 Main Works			1,401.4
1.2.1 Sabo Dam	units	8	301.5
1.2.2 River Improvement			1,099.9
(1) Earth Dike	m	6,450	170.8
(2) Flood Wall	m	1,500	36.8
(3) Channel Excavation	m^3	1,532,000	135.1
(4) Revetment	m	65,800	486.3
(5) Toe Protection	m	65,800	156.0
(6) Spurdike	pcs	50	10.0
(7) Sluiceway	pcs	37	51.0
(8) Ground Sill	pcs	4	46.0
(9) Bridge	pcs	1	7.9
1.3 Miscellaneous Works	l.s.	1	155.2
2. COMPENSATION COST			8.0
2.1 Land Acquisition	ha	50	4.9
2.2 House Resettlement	houses	21	3.1
3. ADMINISTRATION COST (5 % of 1. + 2.)	l.s.	1	86.1
4. ENGINEERING SERVICE COST (10 % of 1.)	l.s.	1	171.4
5. PHYSICAL CONTINGENCY COST (10 % of 1., 2., 3. & 4.)	l.s.	1	198.0
Total			2,177.8

Table I.16 Annual Disbursement Schedule of Master Plan

Unit : 1,000 pesos

Work Item	Total	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1. CONSTRUCTION COST	1,714,300	0	315,524	315,524	313,836	234,491	68,307	68,307	66,112	81,726	68,176	64,191	39,313	39,313	39,430
1.1 Preparatory Works	157,664	0	28,791	28,791	28,643	21,317	6,210	6,210	6,010	7,430	6,198	5,836	4,072	4,072	4,084
1.2 Main Works	1,401,418	0	257,495	257,495	256,131	193,795	56,452	56,452	54,638	67,542	56,344	53,050	30,644	30,644	30,736
1.2.1 R/I at Tangid, Laoag	22,980	0	0	0	0	0	11,490	11,490	0	0	0	0	0	0	0
1.2.2 R/I at Suyo, Laoag	9,676	0	0	0	0	0	0	0	9,676	0	0	0	0	0	0
1.2.3 R/I at Poblacion, Laoag	39,760	0	19,880	19,880	0	0	0	0	0	0	0	0	0	0	0
1.2.4 R/I at Camangaan, Laoag	22,580	0	0	0	0	0	0	0	0	22,580	0	0	0	0	0
1.2.5 R/I at Poblacion, San nicolas	18,307	0	0	0	18,307	0	0	0	0	0	0	0	0	0	0
1.2.6 R/I at San Manuel, Sarrat	11,382	0	0	0	0	0	0	0	0	0	11,382	0	0	0	0
1.2.7 R/I at Suyo, Dingras	20,935	0	0	0	0	0	0	0	0	0	0	20,935	0	0	0
1.2.8 R/I at Poblacion, Dingras	25,948	0	0	0	0	25,948	0	0	0	0	0	0	0	0	0
1.2.9 Cura/Labugaon River	534,264	0	107,966	107,966	108,054	78,412	12,553	12,553	12,553	12,553	12,553	8,966	20,025	20,025	20,085
(1) Cura Sabo Dam No.1	38,675	0	12,879	12,879	12,917	0	0	0	0	0	0	0	0	0	0
(2) Cura Sabo Dam No.2	16,808	0	0	0	0	0	0	0	0	0	0	0	5,597	5,597	5,614
(3) Labugaon Sabo Dam No.1	50,075	0	16,675	16,675	16,725	0	0	0	0	0	0	0	0	0	0
(4) Labugaon Sabo Dam No.2	43,327	0	0	0	0	0	0	0	0	0	0	0	14,428	14,428	14,471
(5) R/I	385,379	0	78,412	78,412	78,412	78,412	12,553	12,553	12,553	12,553	12,553	8,966	0	0	0
1.2.10 Solsona River	232,485	0	38,216	38,216	38,242	29,687	9,841	9,841	9,841	9,841	9,841	7,030	10,619	10,619	10,651
(1) Solsona Sabo Dam No.1	25,613	0	8,529	8,529	8,555	0	0	0	0	0	0	0	0	0	0
(2) Solsona Sabo Dam No.2	31,889	0	0	0	0	0	0	0	0	0	0	0	10,619	10,619	10,551
(3) R/I	174,983	0	29,687	29,687	29,687	29,687	9,841	9,841	9,841	9,841	9,841	7,030	0	0	0
1.2.11 Madongan River	276,645	0	53,232	53,232	53,279	37,491	13,897	13,897	13,897	13,897	13,897	9,926	0	0	0
(1) Madongan Sabo Dam No.1	47,271	0	15,741	15,741	15,789	0	0	0	0	0	0	0	0	0	0
(2) R/I	229,374	0	37,491	37,491	37,490	37,491	13,897	13,897	13,897	13,897	13,897	9,926	0	0	0
1.2.12 Papa River	186,456	0	38,201	38,201	38,249	22,257	8,671	8,671	8,671	8,671	8,671	6,193	0	0	0
(1) Papa Sabo Dam	47,880	0	15,944	15,944	15,992	0	0	0	0	0	0	0	0	0	0
(2) R/I	138,576	0	22,257	22,257	22,257	22,257	8,671	8,671	8,671	8,671	8,671	6,193	0	0	0
1.3 Miscellaneous Works	155,218	0	29,238	29,238	29,112	19,379	5,645	5,645	5,464	6,754	5,634	5,305	4,597	4,597	4,610
2. COMPENSATION COST	8,010	801	801	801	801	801	801	801	801	801	801	0	0	0	0
3. ADMINISTRATION COST	86,116	40	15,816	15,816	15,734	11,765	3,455	3,455	3,346	4,126	3,449	3,210	1,966	1,966	1,972
4. ENGINEERING SERVICES COST	171,428	70,765	11,794	11,794	11,794	11,794	6,831	6,831	6,611	8,173	6,818	11,141	2,361	2,361	2,361
5. PHYSICAL CONTINGENCY	197,985	7,161	34,394	34,394	34,222	25,885	7,939	7,939	7,687	9,483	7,924	7,854	4,364	4,364	4,376
Total	2,177,839	78,767	378,329	378,329	376,437	284,736	87,334	87,334	84,557	104,309	87,168	86,396	48,004	48,004	48,139

Table I.17 Economic Cost and Benefit Stream of Project under Present Condition

(Unit : Million Pesos)

Serial Year	Year	Cost: Construction	Cost: O&M	Cost: Total	Benefit: Flood Control	Benefit: Land Loss Prevention	Benefit: Land Restoration	Benefit: Negative Benefit	Benefit: Total	Balance
1	1999	88.9		88.9					0.0	-88.9
2	2000	305.6		305.6				0.0	-0.0	-305.6
3	2001	305.6	0.9	306.5	40.1			0.0	40.0	-266.4
4	2002	303.8	1.9	305.7	80.1			0.0	80.1	-225.6
5	2003	236.4	2.8	239.2	117.6	1.7	1.0	0.0	120.3	-121.6
6	2004	73.2	3.7	76.9	147.6	4.2	2.1	0.1	153.8	76.9
7	2005	73.2	4.0	77.2	157.4	6.6	3.1	0.1	167.0	89.8
8	2006	70.8	4.3	75.1	167.1	9.2	4.2	0.1	180.4	105.3
9	2007	87.5	4.6	92.1	175.0	12.0	5.2	0.1	192.1	100.0
10	2008	73.1	4.9	78.0	185.8	14.9	5.2	0.1	205.9	127.9
11	2009	74.6	5.2	79.8	194.8	18.1	5.2	0.1	218.0	138.2
12	2010	37.8	5.5	43.3	203.8	21.2	5.2	0.1	230.2	186.9
13	2011	37.8	5.5	43.3	208.3	24.7	5.2	0.1	238.2	194.9
14	2012	37.8	5.5	43.3	212.8	28.4	5.2	0.1	246.4	203.1
15	2013		5.5	5.5	217.4	32.3	5.2	0.1	254.8	249.3
16	2014		5.5	5.5	217.4	35.2	5.2	0.1	257.7	252.2
17	2015		5.5	5.5	217.4	38.1	5.2	0.1	260.6	255.2
18	2016		5.5	5.5	217.4	41.1	5.2	0.1	263.6	258.1
19	2017		5.5	5.5	217.4	44.0	5.2	0.1	266.5	261.0
20	2018		5.5	5.5	217.4	53.5	5.2	0.1	276.0	270.6
21	2019		5.5	5.5	217.4	63.9	5.2	0.1	286.4	280.9
22	2020		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
23	2021		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
24	2022		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
25	2023		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
26	2024		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
27	2025		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
28	2026		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
29	2027		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
30	2028		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
31	2029		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
32	2030		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
33	2031		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
34	2032		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
35	2033		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
36	2034		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
37	2035		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
38	2036		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
39	2037		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
40	2038		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
41	2039		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
42	2040		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
43	2041		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
44	2042		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
45	2043		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
46	2044		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
47	2045		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
48	2046		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
49	2047		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
50	2048		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
51	2049		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
52	2050		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
53	2051		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
54	2052		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
55	2053		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
56	2054		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
57	2055		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
58	2056		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
59	2057		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
60	2058		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
61	2059		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
62	2060		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
63	2061		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1
64	2062		5.5	5.5	217.4	75.0	5.2	0.1	297.5	292.1

NPV: -130.1 B/C: 0.87 EIRR: 13.1%

Table I.18 Economic Cost and Benefit Stream of Project under Future Condition

(Unit : Million Pesos)

Serial Year	Year	Cost			Benefit					Balance
		Construction	O&M	Total	Flood Control	Land Loss Prevention	Land Restoration	Negative Benefit	Total	
1	1999	88.9		88.9					0.0	-88.9
2	2000	305.6		305.6				0.0	-0.0	-305.6
3	2001	305.6	0.9	306.5	50.5			0.0	50.5	-256.0
4	2002	303.8	1.9	305.7	105.1			0.0	107.2	-200.7
5	2003	236.4	2.8	239.2	160.0	2.1	1.2	0.0	163.3	-79.1
6	2004	73.2	3.7	76.9	208.7	5.4	2.5	0.1	216.5	139.6
7	2005	73.2	4.0	77.2	231.2	8.8	3.8	0.1	243.8	166.6
8	2006	70.8	4.3	75.1	255.1	12.7	5.3	0.1	273.0	197.9
9	2007	87.5	4.6	92.1	277.6	17.1	6.8	0.1	301.4	209.3
10	2008	73.1	4.9	78.0	306.2	22.1	7.0	0.1	335.2	257.2
11	2009	74.6	5.2	79.8	333.5	27.7	7.3	0.2	368.3	288.5
12	2010	37.8	5.5	43.3	362.6	33.6	7.5	0.2	403.5	360.2
13	2011	37.8	5.5	43.3	381.7	40.4	7.8	0.2	429.6	386.4
14	2012	37.8	5.5	43.3	401.7	47.9	8.0	0.2	457.4	414.1
15	2013		5.5	5.5	422.5	56.2	8.3	0.2	486.8	481.3
16	2014		5.5	5.5	435.2	63.3	8.6	0.2	506.9	501.4
17	2015		5.5	5.5	448.3	70.9	8.8	0.2	527.8	522.4
18	2016		5.5	5.5	461.8	78.9	9.1	0.2	549.6	544.1
19	2017		5.5	5.5	475.6	87.3	9.4	0.2	572.2	566.7
20	2018		5.5	5.5	490.0	109.7	9.7	0.2	609.2	603.8
21	2019		5.5	5.5	504.7	135.3	10.1	0.2	649.8	644.4
22	2020		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
23	2021		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
24	2022		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
25	2023		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
26	2024		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
27	2025		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
28	2026		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
29	2027		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
30	2028		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
31	2029		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
32	2030		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
33	2031		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
34	2032		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
35	2033		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
36	2034		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
37	2035		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
38	2036		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
39	2037		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
40	2038		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
41	2039		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
42	2040		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
43	2041		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
44	2042		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
45	2043		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
46	2044		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
47	2045		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
48	2046		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
49	2047		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
50	2048		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
51	2049		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
52	2050		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
53	2051		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
54	2052		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
55	2053		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
56	2054		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
57	2055		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
58	2056		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
59	2057		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
60	2058		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
61	2059		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
62	2060		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
63	2061		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8
64	2062		5.5	5.5	519.9	164.2	10.4	0.2	694.3	688.8

NPV: 493.0 B/C: 1.50 EIRR : 20.6%

Table I.19 Environmental Interaction Matrix

MAJOR ACTIVITIES (which may cause of Impacts)		ENVIRONMENTAL FACTORS														
		Physico-Chemical				Biological		Geological		Socio-Economic						
Project Stage	Activities	Surface Water	Groundwater	Topography	Air, Noise & Offensive Odor	Terrestrial Species	Aquatic Species	Scientific Interest	Aesthetic Potential	Economic Activities	Land Use	Transportation & Traffics	Historical & Archeological Interest	Health and Social Services	Life Style & Community	Cultural Communities
Pre-Construction	Land Acquisition										-					-
	Relocation or Resettlement										-					-
Construction	Labor Mobilization									+						
	Sabo Dam	-			-	-	--			++	-					
	Reinforcement of Existing Dike				-					+						
	New Dike				-		-			+	-					
	Channel Dredging	-			-		-			+	-					
	Spur Dikes				-		-			+	-					
	Bank Protection				-		-			+	-					
Post-Construction	Sabo Dam	+					-			+++	+++					
	Dikes	+++								+++	+++	++		+	++	
	River Channel	++								+++	+++	+++			++	

Note: + : Positive (Beneficial) Impact - : Negative (Adverse) Impact

Impact Categories :
+ or - : Possible but Minor Impact
++ or -- : Minor to Moderate Impact
+++ or --- : Moderate to Major Impact