5.2 Conceivable Alternative Plan

5.2.1 List of Conceivable Alternative Plan

The conceivable alternative plans as the countermeasure against flood are listed below.

(a) Dredging (Excavation) } River Improvement Plan
(b) Cut-off } River Improvement Plan
(c) Diking } River Improvement Plan
(d) Diversion channel (Floodway)
(e) Dam
(f) Regulating pond
(g) Retarding basin
(h) Polder plan
(i) Reformation of land utilization
(j) Regulation of building type (height)
(k) Preparation of inundation map
(l) Flood forecasting system
(m) Others

5.2.2 Description of Conceivable Alternative Plans

The preliminary selected each alternative is to be described below. The combination plans of each alternative is to be studied in the further stage.

(A) Dredging, Cut-off and Diking (River Improvement Plan)

The three countermeasures have to be considered together as they are the basic countermeasures for the river improvement and it is better to study the improvement synthetically by the combination of dredging, excavation, cut-off and diking.

For selecting alternatives of river improvement plan, the alternatives of flood protection areas are made. If the flood protection areas are decided, the stretches of river improvement plan are automatically decided.

The following two points are taken into consideration for selecting the flood protection areas.

(a) The areas with higher flood damage shown in Tables IV.5-1 and IV.5-2 are to be protected with priority.

(b) The flood runoff in the downstream reach will be excessively increased if the river improvement works with confined dikes in the upper and middle reaches are executed. The cost for flood control in this case is expected to be remarkably large. Therefore, it is considered to arrange the retarding basins in the areas with lower damage potential.

The capacity of flood routing by river stretch is calculated to decide the proposed retarding basin along the river as shown in Table IV.5-3.

The following are the selected conceivable alternatives of flood protection areas.

(a) Alternative 1

Improvement section is the main stream of the Panay river from Panitan to the river mouth. The stretches upstream from Panitan are left unprotected without any protection works.

(b) Alternative 2, 3, 4 and 5

Improvement sections of these four alternatives are different each other. The stretches downstream from Panitan are commonly improved. However, the stretches upstream from Panitan are divided by sections with protection or without protection. Alternative 2 has more stretches unprotected than the other three alternative and the protection areas are limitted in Level-1 areas. Alternative 3 and 4 has more stretches protected than Alternative-1 and the protection areas are extended to Level-2. Alternative-5 has more stretches protected than the other three alternatives and the protection areas are extended to some of Level-3.

(c) Alternative 6

All the stretches in the flood prone area are protected by some flood control works. However, the areas with exceedingly low damage potential and with clearly low effect of flood control works are excluded even in this Alternative 6.

The summary of stretches of each Alternative Plans are described below. The description is to be from downstream end to upstream end. The division of river stretch is shown in Fig. IV.5-5.

<u>Panay river</u>

P1	From the river mouth to the bifurcation of the Lower Panay river and the Pontevedra river
P2	From the bifurcation of the Lower Panay river to the upstream end of Panitan town
P3	From Panitan town to the confluence of the Maayon river
P4	From the confluence of the Maayon river to the tributary near Agranguay village which is about 4 km upstream from the confluence
P5	From the confluence of the Maayon river to the confluence of the Mambusao river
P6	From the confluence of the Mambusao river to the upstream end of Dao town
P7	From the upstream end of Dao town to the narrow portion located about 500 m downstream of Cuartero town
P8	From the downstream of Cuartero town to the confluence of the Badbaran river
P9	From the confluence of the Badbaran river to the proposed damsite of Panay C dam which is located about 1 km upstream from Dumalag town
P10	From the proposed damsite of Panay C dam to the upstream stretches

Maayon river

Y1 From the confluence of the main Panay river to the confluence of the Ilas river

Y2 From the confluence of the Ilas river to the section of about 2.5 km upstream from the Maayon town

Y3 From the section of about 2.5 km upstream from the Maayon town to the upstream stretches

Y4 Ilas river, from the confluence of the Maayon river to Maindang town

Mambusao river

M1 From the confluence of the main Panay river to the confluence of the Balacuan river

M2 From the confluence of the Balacuan river to the middle between Sigma town and Mambusao town

M3 From the middle between Sigma town and Mambusao town to the narrow portion of about 3 km upstream from Mambusao town

M4 From the narrow portion of about 3 km upstream from Mambusao town to the Mambusao weir of NIA

M5 From the Mambusao weir of NIA to the proposed site of Mambusao B dam which is located in the middle of Jagnaya town and Jamindan town

M6 From the proposed site of Mambusao B dam to the upstream stretches including the stretch of Jamindan town

M7 Balacuan river, from the confluence of the Mambusao river to the upstream end which can be connected with the Mambusao river by constructing an about 1 km long canal

Badbaran river

B1 From the confluence of the main Panay stream to the stretch of Tinayian village

B2 From the stretch of Tinayian village to the upstream stretches including Dumalag town

The classification of protection in each stretch is shown in Table IV.5-4.

The locations of protected area and unprotected area of each Alternative plan are shown in Figs. IV.5-6 to IV.5-11.

The detailed explanation and evaluation of each alternative plans are to be made in Section 6.

(B) Diversion Channel (Floodway)

After studying on the topographical maps (1/10,000 and 1/50,000 in scale), the following alternative routes of diversion channel are selected.

(a) Mambusao - Balacuan Floodway (FW-1)

At about 1 km upstream from Mambusao town (bridge), the flood runoff is diverted to a floodway which take a route of existing Balacuan river. The total length of this floodway is about 13 km including the retarding basin of about 2 km long on the way. The floodway will be available to reduce the improvement scale of the Mambusao river between Mambusao town and the confluence with the Balacuan river.

(b) Mambusao - Sapian Floodway (FW-2)

Mambusao diversion channel which divert from Mambusao river at about 1.5 km downstream of Mambusao town (bridge) and takes the northern direction. The channel have to take mountainous or hilly routes on the way and enter to the estuary area of Sapian bay. The total length will be about 8 km.

(c) Panitan Bypass Floodway (FW-3)

At present river condition, a big flood is over flooded at the widely meandering portion located about 2.5 km upstream of Panitan town (bridge) as the capacity of Panitan stretch is limited. The Panitan floodway has a diversion point at the said over topped portion and the outlet point at about 1.8 km downstream of Panitan town. The total length of this floodway is about 2.2 km.

(d) Panitan - Bailan Floodway (FW-4)

Panitan - Bailan diversion channel which diverts from the Panay river at about 2.5 km upstream of Panitan bridge, takes the route to eastern direction and enters to Pilar bay. The total length will be about 9 km.

(e) Cogon - Hamulauon Floodway (FW-5)

Cogon - Hamulauon diversion channel which divert from Pontervedra river at Cogon (village) and take the eastern direction. The channel utilizes the present river (Hamulauon river) at the downstream stretch and pours into Pilar bay. The total length will be about 9 km.

(f) Hamulauon Floodway (FW-6)

At the river mouth of the Pontevedra river, the flow capacity is decreased as the river bed elevation is high due to sedimentation of sand and silt. Additionally, it seems that the construction of high dike is not suitable in consideration of the location (close to the sea), land use (fish pond) and foundation. That is, the remarkably wide channel has to be constructed if the Pontevedra river is used as the main stream of big flood.

On the other hand, the river mouth of the Hamulauon river is not yet hightened by sedimentation and flow capacity is still big enough. This Hamulauon floodway is planned to share the function of floodway with the Pontevedra river. The present river channel has to be reformed by cut-offs, widening and river-bed dredging. The total length is about 6 - 7 km.

The locations of floodway alternatives are shown in Fig. IV.5-12.

(C) Dam

The alternative location of dam are as follows:

(a) Panay A : Most upstream of Panay river. Catchment area is about 210 km^2.

(b) Panay B : Upstream of Panay river but downstream of Panay A site. Catchment area is about 240 km^2.

(c) Panay C : Upstream of Dumalag town. Catchment area is about 510 km^2.

(d) Badbaran A : 260 km^2.

(e) Badbaran B : C.A. = 290 km^2

(f) Mambusao A : C.A. = 70 km^2

(g) Mambusao B : C.A. = 215 km^2

(h) Maayon : C.A. = 140 km^2

The location of each dam is shown in Fig. IV.5-13.

The alternative study on the height of dam and allocation of storage is also necessary. It is recommendable that several combinations of alternative dam heights and storage allocation are to be considered first at each damsite. Then the most feasible height and storage allocation from technical and economic view points shall be selected. For the economic view point, the following factors will be available.

. Reservoir efficiency $= \frac{\text{Construction cost}}{\text{Effective storage}}$

. B-C and B/C

Note: B is the benefit for power generation and flood control

The combination plans of plural dams are to be studied after the study on individual dam plan.

(D) Regulating pond and Retarding basin

Though it seems that there is no suitable areas for the regulating pond and retarding basin in the Panay river basin as far as general view from the topographical map as the almost all the flood plains or low land areas are cultivated especially for paddy. The plain area is limited in the basin and it is more or less not recommendable to reduce the cultivated land.

Therefore, it is not recommended to formulate the regulating pond and retarding basin for the flood control plan except those in the river course, at least at the present level of the basin development. But, there is possibility that the formulation of regulating pond and/or retarding basin becomes one of available flood control plan in the future stage of the basin development.

The possible locations of regulating pond and/or retarding basin are described below. The locations are shown in Fig. IV.5-14.

(a) R-1

Mapang creek: Located in the left bank area between the reach of Panay (B-M) and Panay (upper). The diking length will be comparatively short as the area is surrounded by the hills. The area is approximately 3 km^2 and the ground surface elevation is about 14.5 - 21.0 m.

(b) R-2

Balucuan river: Located in the Balucuan river area (tributary of Mambusao river), the western plain of the confluence of Panay river and Mambusao river. The area is approximately 8 km^2 and the ground surface elevation is about 8.0 - 11.0 m.

It is possible to enlarge the area if necessary.

(c) R-3

Barangay Agranguay: Located in the creek (tributary) entering to Panay river (M-M reach). The area is approximately 5 km^2 and the surface elevation is about 7.2 - 10 m.

(d) R-4

Ilas river: Located in the downstream reach of Ilas river (tributary of Maayon river). The area is approximately 6 km^2 and ground surface elevation is about 6.1 - 9.0 m.

(e) R-5

Barangay binagging: Located in the southern part of Pontevedra river. The area is approximately 4 km^2 and the ground surface elevation is about 1.8 - 3.0 m.

(E) Polder Plan

The preparation of reformation by the regulation of land utilization is to be done first. In this regulation, it is recommended to make clear the residence area with some allowance from the present area of towns or villages for the future development.

If this alternative is realized, at least, the building damage due to flood will be remarkably decreased and the indirect damage is also much decreased.

The construction of dike will be not so expensive. For example if the dike of 5 m high has the crest width of 5 m and the slope of 1:2.5, the construction cost for enclosing a town with the dike of 5 km long is estimated as follows:

$A = 75\ m^2$

$l = 5{,}000$ m

unit cost US\$0.85/m^3 (US\$2.88/m^3)

75 x 5,000 x 0.85 (2.88) ≑ US\$320,000 (US\$1,080,000)

Note: The cost with parenthesis is the case without utilizing the excavated material. The costs for construction of revetment and other works such as pumping facilities are not included in the above estimation.

The conceivable locations for polder construction are the towns of Dao, Cuartero, Mambusao, Sigma, Maayon, and Pontevedra. The towns of Dumalag, Dumarao and Panitan are to be excluded from the Polder plan since the elevation of most areas in these town is relatively higher than the flood water level. The locations of conceivable polder plan are shown in Fig. IV.5-15.

(F) Reformation of Land Utilization

Besides the countermeasures by the modification of flood mentioned above, the reformation of land-utilization should be also considered for the modification of damage susceptibility. The reformation of land utilization is, in other words, a flood plain management or a non-structural measure. The discussion on the flood plain management is to be done in Section 11. Some descriptions for considerable reformation plans are mentioned below.

(a) Shifting of principal towns

All the principal towns such as Pontevedra, Panitan, Dao, Sigma, Mambusao, Cuartero, Dumalag and Dumarao and developing villages along the river. Therefore the main area of these towns has to be removed if the river improvement plan, especially with dikes, is realized.

From the social view, it is not recommendable way to shift the towns already developed as a center of each municipality. It is surely difficult to shift these towns. Additionally, even if the safety from flood is much increased by the shift, their life will become inconvenient.

But from the economical view, there is possibility that the cost of shifting towns is more economical than the estimated damage in many years. In this case the construction of new towns, which should be safe against flood and more comfortable than before, shall be also considered as a alternative.

(b) Regulation of development

If the basin is developed in the future, the run-off coefficient from the basin to river will be gradually increased and the run-off time will become short. Then, the flood peak discharge will be increased to the same scale of rainfall. Therefore, the same regulation of development is required.

(c) Modification of cropping practice

For reducing the damage of crops, the modification of cropping practices will be available. The change of cropping pattern is to be studied in consideration of the seasonal pattern of flood. The improvement of crops against inundation is also to be studied.

(d) Revegitation

In the basin, the area of forest is limited due to the felling trees in the past. In the mountain area the big trees are hardly found and only low shrubs and grasses can be seen. This situation causes the erosion of land and the shortage of rainfall water preservation. The revegitation in the mountain area will be useful not only for the flood control but also for the preservation of natural environment.

(e) Terraced field

The extension of areas for paddy field and crop field is available for the temporary storage of heavy rain. The terrace field on low slope mountain is expected not only for the higher level land use but also for the regulation of flood peak.

(F) Regulation of building type

The heighening of house, especially the height under the floor, is available to reduce the flood damage of house properties including furniture and foods.

But it is difficult to make the regulation of building type in regard to the materials as the most people cannot afford to build their house with the expensive materials.

It will be possible to make guide line which shows the standard type of houses for the safety of property. The standard type shall be different by the district in accordance with the frequency and depth of inundation. At least, preparation of refuges in case of flood are considered to be necessary.

(G) Preparation of inundation map

It will be useful to prepare the inundation map which show the possible inundation depth and frequency.

The inhabitant can make the countermeasure against the flood in accordance with the map.

(H) Flood warning system

It will be available for taking countermeasures before flood peak comes if the flood forecasting system is established. For this system, the establishment of telecommunication network with the reliable observation of rainfall and water level at many points in the basin is required.

(I) Others

The other alternatives such as flood insurance, transfer of knowledge about flood, establishment of countermeasure team in each municipality and etc. are also to be studied together with the major alternatives.

6. Selection of Proposed Protection Area

6.1 River Improvement Structural Plan

The river improvement sections and areas of each alternative plan (Alternatives 1 to 6) are described in Subsection 5.3.2 and the general plans of 6 alternatives are shown in Figs. IV.5-6 to IV.5-11.

The improved river channels are designed to have a sufficient flow capacity of accommodating each target flood; 100-year flood for LP, 25-year flood for MP and 10- or 2-year flood for SP respectively. The channels of protected stretches have a compound section with providing dikes on both banks or one side dike in some stretches, except SP for 2-year flood which has a single river section. The river width between dikes or between a dike and a foot side of mountain is decided to be not changed by the scale of plan except the stretches downstream from Panitan where the width between dikes in SP would be enlarged in MP and LP in consideration of economic advantage, though the section of low flow channel is changed in accordance with the scale of alternative plan. The locations of dikes are decided to take the outside route of present and past river channels in most stretches, though the standard river width is decided by referring to the examples in Japan shown in Fig. IV.6-1. It is considered that the way of river will take previous river routes at the time of flood even if the channel routes are artificially modified by cutoffs and dikes.

The longitudinal profile of the improved river is studied on the basis of the present river profile (attached in Data Book II) and is shown in Fig. IV.6-2.

The capacity of low flow channel is increased by straightening, deepening and widening of the present river channel with shortcutting some meanders, on the condition that the flood water levels in the improved river conditions would not significantly exceed those in the present river conditions. The capacity of low flow channel would be about 2- to 3-year flood, but widening would not exceed twice the existing channel width.

In the stretches of unprotected area, located downstream of protected area, the dikes are not to be constructed but the excavation and dredging is to be carried out in low flow channels for keeping the water level lower than that of the present river condition except the stretch of the Pontevedra river where the dike height is regulated to be lower than 3.5 m in height.

The dike slopes of the standard improved river channels are decided as follows: (The typical diking Section is shown in Fig. IV.6-3.)

(a)	low flow channel	1 : 3.0
(b)	high flow channel	1 : 2.5

Flood discharges and water levels of various return periods are to be referred to Appendix I. Based on this information, the design discharges to be assumed for respective plans are summarized in Table IV.6-1 and Fig. IV.6-4.

6.2 Comparison of Protection Area Alternatives

For the selection of proposed protection area, the economic evaluation of six basic alternative plans formulated in the Subsection 5.3.2 is carried out in case of LP scale in consideration of the following.

(a) As a framework plan for the future, it is necessary to consider the possibility of development with the maximum scale and to cope with the any possible needs for development.

(b) As already mentioned in the foregoing Subsection 5.1.2, more than 90% of the inhabitants in the flood prone area has to be protected and the protection of agricultural areas has to be considered with priority.

(c) However, the above consideration can not be applied if the flood damage potentials (cost, population, area) are exceedingly inferior.

The summary of results, 3 major comparison indices, is shown below.

Plan	Damage REduction - Cost Ratio	% of Agricultural Land Protected	% of Population Protected
Alt. 1	33	25	37
Alt. 2	21	36	49
Alt. 3	20	50	62
Alt. 4	21	73	80
Alt. 5	18	77	88
Alt. 6	16	91	100

The further detailed summary of the results is shown in Table IV.6-2. The construction cost is estimated first by using the cost curves shown in Figs. IV.6-5 to IV.6-8 which are prepared as relation curves between a design discharge and the corresponding construction cost in each river stretch. The results of cost estimate for six alternatives are summarized in Table IV.6-3. The breakdown which shows the results of calculation in every stretch is shown in Tables IV.6-4 to IV.6-9.

Comparing the figures shown in the tables, the following points are found.

(a) It is observed in Fig. IV.6-9 that the cost effectiveness shown in terms of the "Damage Reduction/Cost" ratio makes a bend at Alternative-4. This indicate that even if the protection area is expanded any further from this point, the cost-effectiveness would drop.

(b) The implementation of Alternative-4 would relieve some 80% of the affected population of flood damages. This value is close to the target of 90%. With regard to the remaining 10% of the affected population, non-structural measures could be effectively devised.

(c) Alternative-4 would have some 73% of agricultural land in the flood vulnerable area. Even if the protection is expanded (as in Alternative-5), the incremental area of protected agricultural land is only minor, and thus Alternative-3 is deemed to realize protection to its practical maximum extent.

(d) If the protection was extended further from Alternative-4, the flood discharge in the downstream reaches would enlarge significantly.

(e) In terms of the cost-effectiveness, Altarnative-1 would be rated best, as shown in Fig. IV.6-9. Notwithstanding, the protected population and farmland would be far less than targets, and hence would not be acceptable as the framework of the Long-term Plan.

In the above indices and the descriptions, it is concluded that Alternative-4 is the most attractive plan of protection area. Therefore the further alternative study of not only the combinations with the other structures but also MP and SP is to be carried out based on the condition with the protection areas selected; Alternative-4. In practice, the Flood Control Project should be coordinated in the overall framework of the comprehensive plan, by readily reflecting the development needs of the area.

6.3 Economic Evaluation of Selected River Improvement Plan

Alternative-4 is selected as the most profitable protection area alternative plan as explained in the previous Subsection 6.2. The river improvement plan is to be made on the basis of this Alternative-4 protection areas.

The economic evaluation of the river improvement plan with the protection areas of Alternative-4 is carried out and the results are shown below.

Economic Evaluation of Independent River Improvement Plans (Alt. 4)

Work	Construction Cost (₱ x 10^6)	Present Values/1 (₱ x 10^6) Cost (C)	Benefit (B)	NPV (B - C)	EIRR (%)
All improvement/2 stretches	5,593	2,691	919	-1,772	2.8

Notes: /1 At discount rate 8% p.a.

/2 In this calculation, improvement work was assumed to be applied to the Pontevedra and Hamulauon rivers.

The EIRR of the independent river improvement plan was assessed as 2.8%, which is indicative of its economic unfavourability. Therefore alternative facility plans including floodway and flood control dams will be studied in the subsequent Subsection 5.

The breakdown of economic evaluation of river improvement works is shown in Table IV.6-10.

6.4 Flood Water Level and Discharge

The flood water level and dishcarge at Panitan base point in case of the selected river improvement plan are shown below.

<u>Water Level and Discharge after Improvement (Alt. 4)</u>

(Panitan Base Point)

Probable Flood (Year)	Present Condition		After Improvement	
	Water Level (El. m)	Discharge (m^3/sec)	Water Level (El. m)	Discharge (m^3/sec)
100	10.30	2,670	12.00	4,520
50	9.55	2,270	10.71	3,570
25	8.70	1,830	9.43	2,750
10	7.55	1,370	7.81	1,880
5	6.60	1,040	6.83	1,435
2	5.80	790	5.77	1,040

The flood water level and discharge at the other base points are to be referred to Appendix I.

7. Combination Plan of River Improvement and Floodway

7.1 Proposed Floodway Plans

The floodway plan was examined at the six (6) locations as explained in the Subsection 5.3.2 and shown in Fig. IV.5-12.

The further detailed explanation is given below.

(A) Mambusao - Balacuan Floodway (FW-1)

At about 1 km upstream from Mambusao town (bridge), the flood runoff is diverted to a floodway which takes a route of the existing Balacuan river. The total length of this floodway is about 8.3 km including the retarding basin on the way which has about 2 km long and 4 km^2 in area. The floodway will be availabe to reduce the improvement scale of the Mambusao river between the inlet and the outlet of this floodway. The route of this floodway is shown in Fig. IV.7-1.

The 100-year flood at this point is 2,300 m^3/sec. Taking away the present capacity of the Mambusao river of 300 m^3/sec, the design discharge of the proposed floodway would be 2,000 m^3/sec.

This plan would relieve flood damage in the areas downstream of the diversion point, but it would inevitably inundate the lowlying areas of Balacuan from the beginning of the flood season.

(B) Mambusao - Sapian Floodway Plan (FW-2)

This plan would divert the flood discharge of the Mambusao river at a point 1.5 km downstream of the town of Mambusao and bring it northwards to the Sapian Bay, and thus decrease the flood discharge in the Panay river. The total length of the diversion channel would be 8 km. The channel would run through low paddy fields in the first 1 km, through hilly undulating areas in the next 4 to 4.5 km and through lowlands in fishpond areas in the last 2.5 to 3.0 km. The catchment area at the diversion point is 330 km^2. The capacity of the diversion channel is determined to be 2,000 m^3/sec, by applying the same method as in (A) above. Figure IV.7-2 shows the route of the proposed diversion channel.

(C) Panitan Floodway (FW-3)

At the present river condition, a big flood is overflooded at the widely meandering portion located about 2.5 km upstream of Panitan town (bridge) as the capacity of Panitan stretch is limited though the capacity of this stretch is comparatively big; over 1,000 m^3/sec. The Panitan floodway has a diversion point at the said overtopped portion and pass through the right bank of Panitan town. The outlet point is located about 1.8 km downstream of Panitan bridge. The total length of this floodway is about 2.2 km. The route is shown in Fig. IV.7-3.

With the catchment area at the Panitan town being 1,987 km^2, the 100-year flood discharge was estimated to be 4,600 m^3/sec. While the present capacity of the existing channel is 1,800 m^3/sec, the balance of 2,800 m^3/sec would be the design discharge of the floodway. It should be noted that weathered tuff breccia outcrops on the river bank near the proposed entrance point. The invert of the channel, therefore, should be set above the weathered rock zone.

(D) Panitan - Bailan Floodway Plan (FW-4)

This plan would divert the flood discharge of the Panay river at a point 2.5 km upstream of the Panitan bridge, direct it eastwards to be discharged into the Pilar Bay, and thus decrease the flood discharge into the Pontevedra river. The total length of the channel would be about 11.5 km. The diversion channel would run through low paddy fields in the first 9 km, through a low plateau in the next 0.5 km and in the existing estuary river channel for the last 2.5 km. The route of the floodway channel is shown in Fig. IV.7-4.

The design capacity of the floodway would be 4,100 m^3/sec, which is the balance of the 100-year flood at the Panitan point of 4,600 m^3/sec and the present bankful capacity of 500 m^3/sec.

(E) Cogon - Hamulauon Floodway Plan (FW-5)

This plan would divert the flood discharge of the Pontevedra river at the point about 4 km downstream of the Panay/Pontevedra bifurcation, and direct it eastwards to be flushed into the Hamulauon river. The total length of the channel would be about 9.5 km slightly shorter than the existing river course of the Pontevedra river of 11 km. The route of the floodway channel is shown in Fig. IV.7-5.

The existing Pontevedra river below the diversion point would accommodate the bankful discharge of 500 m^3/sec in the event of a flood, with only partial improvement work provided. Since the 100-year flood is estimated as 4,600 m^3/sec at the diversion point, the design discharge of the proposed floodway is 4,100 m^3/sec.

(F) Hamulauon Floodway Plan (FW-6)

This plan would divert the flood discharge of the Pontevedra river at the present bifurcation of Pontevedra/Hamulauon rivers. It takes the route along the Hamulauon river though the present meandering conditions are improved by cutoff and widening. This floodway flush out the flood to the sea at the river mouth of the Hamulauon river. The total length of the channel would be about 7 km. The routes of the floodway channel is shown in Fig. IV.7-6.

The estuary of the Pontevedra river has been aggravated by siltation, and as a result, the clogged river mouth is lowering the capacity of the river. Land adjacent to the lower Pontevedra river, downstream of the Pontevedra town, is dominated by fishponds, and soil conditions are not suitable for constructing high levees. Therefore the height of levees, if constructed, would be 3 m at a maximum. Because of the constraints of clogged river mouth and limited levee height above, the river channels would be about 1,500 m wide, if the Pontevedra river is ever to be improved. In this case, significant negative effects would be inflicted on the surrounding land use.

By contrast, there has been no serious siltation is at the mouth of the Hamulaoun river. Taking advantage of this, the Hamulauon floodway plan would divert part of the flood flow into a new floodway to be constructed along the Hamulauon river. In this case, the Pontevedra river would accommodate about 1,500 m3/sec of flood discharge and the remaining 3,100 m^3/sec would be flushed by the floodway.

7.2 Evaluation of Floodway Alternatives

The floodway plan is essentially an alternative to the river improvement plan at specific locations. River improvement will still be required in the other areas and in this regard the floodway plan should be formulated in combination with the river improvement work.

There will be a reduction in flood discharge, in the downstream river reaches, if the floodway plan is provided in the upper reach. Taking into account of this aspect, the combined plan of diversion work and river improvement work was formulated for each floodway scheme.

The evaluation of floodway plans is carried out on the following conditions and methods.

(A) Discharge of Floodway

(a) The flood discharge of LP scale; 100 year probable flood, is used.

(b) The design discharge of floodway is to be the remainder of the discharge in the mainstream from the flood discharge.

(c) The discharge of the mainstream is decided to be the capacity of present river channel or the increased capacity in case the mainstream channel is improved. The extent of improvement of mainstream channel is to be considered at each floodway plan.

(B) Evaluation

(a) The comparison between a floodway and the corresponding river improvement is carried out first. The evaluation is done by the construction cost. If the construction of floodway is cheaper than that of the river improvement, it is concluded that the floodway is more advantageous over the corresponding river improvement. But, if it is more expensive, the floodway plan is to be discarded without further evaluation.

(b) Among six floodways, the following two bypass type floodways are concluded to be adopted as a part of flood control plan without further evaluation, if the floodway is more economical than the corresponding river improvement.

- Mambusao - Balacuan Floodway (FW-1)
- Panitan Floodway (FW-3)

(c) However, the remaining four floodways need the further comparison between each floodway, if it is not discarded in the first step.

That is, if any of four floodways are concluded to be advantageous over the each corresponding river improvement, the following comparison is to be carried out in order among the advantageous floodways. A disadvantageous floodway is automatically to be cancelled in the following procedure.

- Hamulauon Floodway (FW-6) vs. Cogon - Hamulauon Floodway (FW-5)
- Panitan - Bailan Floodway (FW-4) vs. a selected one between (FW-6) and (FW-5)
- Mambusao - Sapian Floodway (FW-2) vs. a selected one among (FW-6), (FW-5) and (FW-4)

On the comparison above, the cost for river channel improvement between a upstream floodway and a downstream floodway has to be included in the cost of the downstream side floodway.

The cost of each alternative plan is summarized in Table IV.7-1 and the breakdown of the cost is shown in Table IV.7-2.

Among six floodway plans, the following four plans are discarded on the first step, that is, the comparison between a floodway and the corresponding river improvement.

(a) Mambusao - Balacuan Floodway (FW-1)
(b) Mambusao - Sapian Floodway (FW-2)

(c) Panitan Floodway (FW-3)

(d) Panitan - Bailan Floodway (FW-4)

(e) Hamulauon Floodway (FW-6)

Note: The cost of FW-6 is not so much different from that of the corresponding river improvement.

The economic evaluation is to be carried out for only Cogon - Hamulauon Floodway (FW-5).

7.3 Economic Evaluation of Selected Floodway

The selected Cogon - Hamulauon floodway is to be formulated in the river improvement plan of LP scale. As the economic evaluation of river improvement plan is already shown in the Subsection 6.3, that for the combined plan of the river improvement and the floodway is carried out. The river improvement plans of 1) river stretches P1 and P2 only and 2) all the protection stretches of LP, both inclusive of the floodway FW-5, were subjected to economic evaluation. The results are summarized below:

Economic Evaluation of Floodway Plan FW-5

Item	Construction (₱ x 10^6)	Present Value/1 (₱ x 10^6)			Remarks
		Cost (C)	Benefit (B)	NPV (B - C)	
1) Stretches P1 + P2	1,426	830	310	-520	Downstream of Panitan
2) LP all stretches	4,418	2,573	942	-1,631	EIRR = 3%

Note: /1 At discount rate 8% p.a.

The EIRR of overall river improvement projects for all the stretches of Long-term Plan, inclusive of the floodway plan FW-5, was assessed at 3.0%. This value slightly exceeds the EIRR of the Long-term Plan by river improvements alone, estimated at 2.8%, which is indicative of economic merit of the plan inclusive of the floodway of FW-5. The floodway FW-5 was, therefore, included in the framework of Long-term Master Plan hereafter, and the river improvement project henceforward would always presume inclusion of FW-5.

8. Results of Multipurpose Dam Plan

8.1 Prospective Dam Sites

Referring to the previous studies and also scrutinizing 1 : 50,000 scale topographic map in the present study, the following eight dam sites were identified. Their locations are shown in Fig. IV.5-13.

Panay A site, Panay B site, Panay C site
Badbaran A site, Badbaran B site
Mambusao A site, Mambusao B site
Maayon site

Among the above dam sites, the Panay A site was identified and studied in the Feasibility Study of Jalaur River Multipurpose Project by NIA and Panay C site, Badbaran B site, Mambusao B site and Maayon site are identified and studied by the previous study of Nation-wide Flood Control Plan by MPWH. Other sites, Panay B site, Badbaran A site and Mambusao A site are identified in this Study.

8.2 Preliminary Selection

As the results of preliminary selection by paper planning and surface geological investigation and test drilling, the following four sites are rejected from further study due to the following reasons.

Panay A site:

Though the results of paper planning were premising, geological condition of dam site is not good consisting of not well consolidated conglomerate and a lot of water leakage was recorded in the past drilling. Besides, the security condition at the site is not good so that carrying out the further investigation is difficult.

Badbaran B site:

The site is located in the limestone zone which is highly suspicious to be cavernous type considering from the existence of springs near the site. Since a prospective dam site A was found outside the limestone zone, this site was rejected.

Mambusao A site:

Due to small catchment area of only 73 km^2, hydropower generation is not prospective and geological condition at the dam site is not favorable. Besides, the storage efficiency ($\frac{\text{dam construction cost}}{\text{total storage}}$) is low.

Maayon site:

Due to small catchment area of only 140 km^2 and the comparatively small annual rainfall in the area of about 2,000 mm/year, hydropower generation is not prospective. Besides, the storage efficiency is also not good.

Thus, the Panay B site, Panay C site, Badbaran A site and Mambusao B site are selected for further study. The preliminary study results of prospective dam site are summarized in Table IV.8-1. Their locations are shown in Fig. IV.8-1.

8.3 Planning of Dam and Power Station

The development scales of the selected dams were optimized to take account both of flood control and hydropower generation. Allocation of storage capacity was made on the basis that flood control should be given priority. Of the four sites, Badbaran A and Mambusao B dams were planned for the single purpose of flood control, since inadequate storage could be allowed for power generation.

At the selected prospective dam sites, the following study is carried out for deciding the basic features of dam and power station from the technical and economic viewpoints.

(a) Dam height
(b) Allocation of storage
(c) Power generation

The general features of dam and power station at each dam sites based on the alternative study are summarized in Table IV.8-2.

The principal features of each dam are summarized below.

General Features of Preliminarily Selected Dams

Item	Panay B	Panay C /1	Panay C /2	Badbaran A	Mambusao B
Type of dam	Concrete gravity	Concrete gravity	Concrete gravity	Rockfill	Combined C. gravity & rockfill
Catchment area (km^2)	239	509	509	258	217
Height (m)	52.4	39.1	34.3	30.9	34.7
Floodcontrol storage (10^6 m^3)	33.8	144.8	130.2	38.0	31.5
Water utililization storage (10^6 m^3)	30.5	252.3	127.6	-	-
Installed power (kW)	7,100	11,000	6,800	-	-

Notes: /1 Independent scheme

/2 Combined with the Panay B dam

The flood mitigation effects of the dam plans are summarized in Table IV.8-3.

8.4 Flood Control Effect of Each Dam Plan

A flood flow analysis for downstream reaches was made taking into account flood regulation effects of each dam plan. As the results of analysis, the flood flow discharges and flood water levels at the Panitan base point are shown in Table IV.8-4, and flood peak discharges for 2-, 5-, 10-, 25- and 100-year floods at major base points along the Panay mainstream are summarized in Figure IV.8-2 and flood water levels are illustrated in Fig. IV.8-3.

The figures show the following:

(a) Flood control effect is the biggest in case of the Panay C dam, followed by the Panay B dam, Badbaran dam and Mambusao dam. It is noted that the flood control effect of the Mambusao dam is very small due to a large retardation effect in the downstream reach, though the Mambusao dam would cut the 100-year peak inflow flood of 1,770 m^3/sec to 885 m^3/sec in case of a 10-year flood, the flood control effect at the Panay - Mambusao junction is almost nil. Flood discharge reduction would only be 20 m^3/sec (from 2,720 m^3/sec to 2,700 m^3/sec), due mainly to substantial natural retardation effects in the downstream reach.

(b) The flood control effect in terms of the peak discharge reduction would gradually decrease in the downstream reaches. In case of the Panay B dam, the peak discharge reduction for a 100-year flood would be 180 m^3/sec at the Badbaran junction, while it would further drop to 60 m^3/sec at Panitan. This tendency is common to all other cases.

(c) Decrease in the flood water level is generally greater in the cases of small floods than large ones. In case of the Panay B dam, the decrease in the flood water level at Mambusao junction would be 0.2 m in the case of 100-year, 5-year and 2-year floods are 0.7 m for both cases. This tendency is common to all other cases.

8.5 Construction Cost of Each Dam Plan

The construction cost of each dam plan was estimated on the financial cost basis at the price level of 1984. The estimated cost of each plans are as shown below.

Construction Cost of Each Dam Plan

(Unit: ₱ x 10^6)

	Construction cost
Panay B dam	471.2
Panay C dam/1	1,044.7
Panay C dam/2	834.3
Badbaran dam	353.2
Mambusao dam	438.7

Notes: /1 Independent scheme

/2 Combined with Panay B dam

8.6 Economic Evaluation of Each Dam Plan

For the purpose of economic evaluation of each dam plan, the disbursement of economic cost is assumed as follows:

(a) Construction period of dam and power station is assumed to be 5 years.

(b) Disburse of economic construction cost of dam and power station is assumed to be 10% in the first year, 15% in the second year, 25% in the third year, 30% in the fourth year and 20% in the fifth year.

The annual amount of operation and maintenance cost is assumed to be 2% of the economic construction cost.

On the other hand, for the benefit of the project, flood control benefit and power benefit are accounted. The flood control benefit is assessed in the same way as shown in the previous Section 6.

The power benefit is assessed dividing in capacity benefit and energy benefit. Unit capacity benefit is assumed to be ₱2,340 per kW and unit energy benefit to be ₱1.255 per kWh. Annual power benefit is to be the same in each year during the project life. The way of estimation for power benefit is shown in Appendix V.

The production foregone due to the submerged area is considered as negative benefit. The production foregone is explained and calculated in Appendix V.

Using economic cost and benefit assessed above the economic evaluation is made in the same way as shown in the Appendix IV.

The results are as shown below and the detail of calculations are shown in tables of Appendix V.

Economic Evaluation of Each Dam Plan

Dam Plan	Present Value/1 (₱ x 10^6)			B/C	EIRR (%)
	Cost	Benefit	NPV		
Panay B dam	345	455	110	1.3	10.8
Panay C dam	687	601	-86	0.9	6.8
Panay B + Panay C dam	740	709	-31	1.0	7.6
Badbaran A dam	213	55	-158	0.3	-/2
Mambusao B dam	290	28	-262	0.1	-

Notes: /1 At discount rate of 8% p.a.

/2 - indicates no EIRR value.

As shown in the table above, the economic merits are in the order of Panay B, Panay C, Badbaran A, Mambusao B dams, if the dam plans are to be implemented as the sole element of flood control. With respect to the Badbaran A and Mambusao B dams, since economic indices are very low (EIRRs were even lower than those of the river improvement plans), they were eliminated from further considerations, except the combination of dams.

The basic design of Panay B dam is shown in Fig. IV.8-4. The figures of the other dams are to be referred to Appendix report V.

9. Combination Plan of River Improvement and Dam

9.1 Selection of Combination Plan

The composite flood control plans are the combinations of a dam or dams and river improvement plans. In this Study, four plans were contemplated as given in the table below.

The four plans below include all the combinations of prospective independent plans, while other combinations with less favourable component plans were discarded at this study stage.

Contemplated Alternative Combined Plans

Alternative composite plan	Dam plans				River improvement plan
	Panay B dam	Panay C dam	Badbaran A dam	Mambusao B dam	
DR-1	*				*
DR-2		*/1			*
DR-3	*	*			*
DR-4/2	*	*	*	*	*

Notes:
- * Contemplated plan.
- /1 Panay C independent plans; others are all combined with the construction of Panay B dam.
- /2 A case for reference of the development of all the four dams (though Badbaran A and Mambusao B dams would not be favourable).

The basic design of each dam is shown in Appendix V.

9.2 Flood Control Effect of Combination Plans

The combined plans would have potentiality of bringing flood control effects more effectively than independent implementation of the dam project and river improvement project.

The river improvement plans SP, MP and LP aim at accommodating the 10 to 100-year floods, and if combined with a dam plan, the required height of dykes along the river channel could be lowered for the reduced flow due to retention in the reservoirs, without relaxing protection level in terms of the objective flood.

Flood control effect can be simply evaluated by flood level and discharge at a selected base station. These data at Panitan bifurcation point are given in Table IV.9-1.

9.3 Economic Evaluation of Combination Plan

Regarding the schedule of the combination plan of river improvement and a dam or dams, the following principles are to be applied.

(a) Dam construction is to be started in the same year as that of river improvement.

(b) If two dams are to be constructed, the construction work of the second dam would be started 4 years after commencement of work for the first dam.

(c) The discount rate is at 8% per annum.

The economic evaluation of the combined flood control plans is conducted by using the cost and the benefit estimated for each plan. The results of evaluation are given below.

Economic Evaluation of Combined Plans

Alternative	Construction Cost (₱ x 10^6)	Present Value/1 (₱ x 10^6)			B/C	EIRR (%)
		Cost	Benefit	NPV		
DR-1	5,572	2,352	1,357	-995	0.58	4.5
DR-2	6,188	2,621	1,432	-1,189	0.55	4.2
DR-3	6,514	2,643	1,514	-1,130	0.57	4.4
DR-4	7,211	2,840	1,468	-1,371	0.52	3.8

Note: /1 At discount rate 8% p.a.

10. Combination Plans of Inclusive Structural Measures

10.1 Formulation of Long-term Plan

(1) Selection of Long-term Plan

The results of economic evaluation on facility alternative plans contemplated in Sections 7 and 9 are summarized below:

Economic Evaluation of Facility Plans for Long-term Plan

Alternative	Construction Cost (₱ x 10^6)	NPV/1 (₱ x 10^6)	EIRR (%)
River improvement only/2	5,593	-1,771	2.8
River impr. + floodways/3	4,418	-1,421	3.0
River impr. + floodways/3 + dam			
- Alternative Dr-1/4	5,572	-995	4.5
- Alternative DR-2/5	6,188	-1,189	4.2
- Alternative DR-3/6	6,514	-1,130	4.4
- Alternative DR-4/7	7,211	-1,371	3.8

Notes:
/1 At discount rate 8% p.a.
/2 Protective areas Alternative-4
/3 Cogon - Hamulauon floodway
/4 Panay B dam
/5 Panay C dam
/6 Panay B dam + Panay C dam
/7 Panay B dam + Panay C dam + Badbaran A dam + Mambusao B dam

As shown above, the alternative facility plan DR-1, which includes the construction of Panay B dam, is best rated economically.

Alternative DR-3 (with Panay B dam and Panay C dam) and Alternative DR-2 (with Panay C dam) are the next beneficial alternatives following to Alternative DR-1. Both alternatives have sufficiently competitive NPV and EIRR to those of Alternative DR-1. However, the alternatives including Panay C dam have social problems in regard to the submergence area of about 40 km^2 including Tapaz town. Therefore it is considered that Alternative DR-1 is the best one among the alternatives.

The design discharge distribution in case of DR-1 is shown in Fig. IV.10-1. The standard cross section of LP including the comprehensive projects is shown in Fig. IV.14-4 in Section 14.

Further, the economic evaluation of DR-1, selected LP, is shown in Table IV.10-1 and the cost breakdown is shown in Table IV.10-2.

(2) Implementation of Long-term Plan

The EIRR if Alternative DR-1 is estimated at 4.5%, which is relatively low. Therefore the implementation of the Long-term Plan would not be justifiable under the current economic conditions.

On the other hand, the economic activities in the basin are expected to be developed year by year. Accordingly the damage potential will be gradually increased and the execution of Long-term Plan may turn to be economically feasible at some time in the future. According to the preliminary estimation, the execution time will come around 2020 when the EIRR becomes over 8%.

As a conclusion of implementation for LP, it is reasonable to postpone the execution of flood control plan with LP scale until the damage potential will be enlarged to a certain level in the future. The flood control plans with the scale of MP and SP are to be studied in the following sections.

10.2 Formulation of Mid-term Flood Control Plan

In the preceding Subsection 10.1, an overall framework of the Long-term Flood Control Master Plan (LP) was developed. Within this framework, the economic viability for the Mid-term Plan, which would devise the protection level against a 25-year flood, was assessed.

(1) Evaluation of Mid-term Plan

In the Subsection 5.1, the target of the Mid-term Plan was set at relief of flood damage for about 70% of the presently affected population. The protection priority areas of the Mid-term Plan, selected to achieve this target, were those defined as action areas in Alternative 3 discussed in the preceding Subsection 5.3.2. On the basis of this objective action

(Alternative-3), a comparative study was conducted to confirm whether the facility plan selected in the long-term master plan would be still viable in the Mid-term Plan level protection works. The following three facility plan alternatives were compared:

MP-1 : River improvement alone (incl. Cogon floodway)

MP-2 : River improvement*(incl. Cogon floodway + Panay B dam)

MP-3 : River improvement*(incl. Cogon floodway + Panay B dam - Panay C cam)

* The protection areas of each river improvement are same, however, the capacity of river channel is different due to the reduction of flood discharge by the regulating effect of dam(s).

The results of economic evaluation are summarized in Table IV-10-3, in which the MP-2 plan was evaluated to be most favourable. The facility plans included in the MP-2 are consistent with those proposed in the Long-term Plan.

The results of economic evaluation for the MP-2 plan are detailed by river stretch (sub-area) in Table IV.10-4. On the basis that whole portions of the MP plan is implemented, the overall EIRR is assessed to be 6.7% and, therefore, the implementation of the project would not be justifiable under the present damage potential condition.

A preliminary estimation suggested that the Mid-term Plan would only be economically viable (EIRR to be more than 8%) when the works were commenced around the year 2020 and completed around the year 2030. This lining is almost same as that assessed for the Long-term Plan. This implies that there is no merit of advanced implementation of the Mid-term Plan, aheading the Long-term Plan. It is noted however that this is the case of implementation of the whole portion of the proposed Mid-term Plan and the situation would be different if the selected piece-mill works are implemented. This will be examined in the next subsection.

The breakdown of cost estimate for MP is summarized in TAble IV.10-6.

(2) Evaluation of Piece-Mill Works

Subsection 10.1 revealed that the Long-term Plan level protection work (100-year design flood) would be justificable, for implementation around the year 2020. In this case, the Mid-term Plan level protection work should preferably be completed before 2015; otherwise, the service period of the completed works will be too short.

Assuming that polder plan is implemented at 4 towns (Dao, Cuartero, Sigma and Mambusao) under the Short-term Plan programs (See Subsection 10.3), the economic viability of river improvement works was reassessed by river stretch as given in Table IV.10-5, in which flood damage reduction benefit attributable to the polder plans was excluded. A possibility conceived was that river improvement works in specific stretches might become viable when damage potential in the area increases in future. The same possibility was also considered for some of polder plans other than those, selected in the Short-term Plan.

The viability of these piece-mill works was evaluated by varying the timing of completion from year 2000 to 2015. The results of evaluation are summarized in Table IV.10-7. The table indicates that the following works will be viable for implementation as Mid-term projects.

Piece-mill Projects justifiable as Mid-term Implementation Works

Work	Construction Cost (10^6 Peso)	Timing of Completion
River improvement work		
- Stretches P1 and P2	999	2010
Polder plan		
- Maayon	49	2000
- Jamindan	39	2000
- Dumarao	58	2015

The above timing is still tentative subject to re-examination in combination of the preceeding short-term projects which is described in later Section 10.3. The polder plans at Maayon, Jamidan, and Dumarao are shown in Figs. IV.10-3 to IV.10-5. The polder plans for short-term provisional plans are shown in Figs. IV.10-8 to IV.10-13 attached for the preceeding Section 10.3.

The design flood discharge distribution of MP and the standard river cross section of MP are respectively shown in Figs. IV.10-6 and IV.10-7. The general plan of MP including the comprehensive projects is shown in Fig. IV.14-3 in Section 14.

10.3 Short-term Provisional Flood Control Plan

10.3.1 River Improvement with Polder Plans

Flood damage potential is naturally high in major towns where residents' properties are concentrated. Hence, protection of the major towns and villages should be given priority in the Short-term Provisional Plans. For this purpose, polder dykes were proposed for the facility plan. The polders were designed against a 100-year flood.

There are 12 major towns/villages in the flood vulnerable area with locations as shown in Fig. IV.5-1. Polders were preliminary planned for all the 12 towns/villages above. The construction cost estimates and results of economic evaluation are shown in Table IV.10-8.

The results of economic evaluation showed that the polder plans would have EIRR values of more than 8% at the 6 towns/villages of cuartero, Mambusao, Sigma, Dao, Panitan and Pontevedra. Protection by polders, therefore, of the above 6 towns/villages will be considered to be included in Short-term Provisional Plan, though the further study of polder plans at Pontevedra and Maayon would be carried out in Subsection 10.3.4.

The design flood for the polder plan was assumed to the 100-year probable flood. Besides the embankment of polders, the construction work would include installation of drainage and pumping facilities as the water will be drained either by gravity or pumps depending on water level in the extenrior area. The polder plan for each township is shown in Figs. IV.10-8 to IV.10-13.

10.3.2 River Improvement with Dam Plans

As discussed in Section 5.1, two design protection levels, namely against a 10-year flood (Plan SP-1) and a 2-year flood (SP-2), were contemplated in the Short-term Provisional Plan. Facilities to be constructed for the two alternative plans would be compatible with those conceived within the framework of the Long-term Plan. The stretches for SP are decided to be P1 and P2 the downstream reach from Panitan, after comparison of the following two alternatives based on the economic evaluation.

SP-stretch	Stretches				
	P1	P2	P3	P4	P5
Alternative 1	P	P	U	U	U
Alternative 2	P	P	P/U	U	P

Notes: P: Protected
U: Unprotected
P/U: Partially protected

In estimating the flood control benefit, the proportion attributable to the proposed polder dykes will be taken aside, on assumption that they would be constructed prior to implementation of the plans. Tables IV.10-9 and IV.10-10 summarized the results of economic comparison. The cost breakdown of SP is shown in Table IV.10-11.

10.3.3 Other Plans for Specific Areas

(1) Improvement work of existing Mambusao weir

The existing Mambusao irrigation intake weir is situated about 7.6 km upstream of the Mambusao town. This is a 4.5 m high fixed weir, and the backwater of the weir would obviously raise the flood water levels upstream. This plan would have the existing weir lowered by 2.5 m in height, and would expand the channel capacity by dredging the 2 km stretch both up- and downstream of the weir and hence decrease flood water levels upstream of the weir. A 2.5 m high collapsible rubber dam would be installed on top of the improved weir, to maintain the present pondage level for normal operation.

The results of economic evaluation for this plan is shown in Table IV.10-12. This plan is eliminated from further consideration, since the economic index is not satisfactory.

(2) Widening of bottleneck sections at Cuartero and Dao

According to the investigation of the flood in November 1984 (Undang Flood), the flood flow was retarded by the bottleneck sections at Cuartero and Dao, and the backwater thereof heightened the water levels in the upstream reaches. This plan intends to widen the river channel at these critical sections and thus lower the water levels in the upstream stretches. Nevertheless, this plan would in turn create a defect of increasing the outcoming peak discharge in the lower reaches. The associated effects of lowering the water levels and increasing of peak discharge in lower reaches are summarized below:

Change in Water Level and Discharge by Widening of Cuartero and Dao

Probable Flood	Upstream Water Level (El. m)				Downstream Discharge	
	Cuartero		Dao		Panitan	
	Present	After widening	Present	After widening	Present	After widening
100-year	18.9	15.1	15.8	15.5	2,670	2,980
50-year	17.8	14.2	15.1	14.6	2,270	2,540
25-year	16.6	13.3	14.2	13.7	1,830	2,020
10-year	15.1	12.3	13.2	12.7	1,360	1,470
5-year	13.9	11.6	12.1	11.9	1,040	1,110
1-year	12.8	10.7	11.2	10.9	790	840

Table IV.10-12 presents the results of cost-benefit analysis of this plan. The evaluation indicated that this plan would not necessarily be advantageous.

(3) Expansion of channel capacity at Panitan

The same problem of backwater as in Cuartero and Dao is caused at Panitan section. Nonetheless, the expected disadvantage of channel widening is overwhelming, because of the additional damage which would arise in the areas downstream is high. Hence the river improvement of the downstream reaches, which will be examined in Subsection 10.3.2, would be the prerequisite of this plan.

(4) Elimination of inundation in lowlying areas along Balacuan river

At present, the inundation in the lowlying areas along the Balacuan river is apt to be prolonged, due mainly to insufficient channel capacity in the lower Balacuan river (particularly at the existing Sigma - Cuartero road bridge). In the case of the 1984 flood, the flood flow was retarded in the lowlying areas for about a week after the water level at the Balacuan outlet fell. Recently a new bridge has been under construction in order to widen the river channel at the bridge, and this will be effective in shortening inundation period in the lowlying areas.

Notwithstanding the above, the inundation in the lowlying areas along the Balacuan river would not be eliminated, unless the overflow from the Mambusao river and the backwater of the Panay mainstream were also treated. In this sense, flood protection in these lowlying areas will not be easily dealt with in Short-term Plan. This Study concludes that this plan should be included in the considerations for LP and MP.

10.3.4 Selection of Short-term Provisional Plan

(1) Panitan - Panay area flood control project

Among the five alternative protection projects set forth for the river improvement plan for SP (refer to Tables IV.10-9 and IV.10-10 for their description), SP-1B was rated most favorably in term of its economic index. The areas protected by SP-1B are along the stretches P1 and P2, both downstream of Panitan. These areas, therefore, were selected for the action area of Short-term Plan.

As alternative measures of flood damage mitigation for these areas, the following three cases were conceived:

Case-A: River improvement

The EIRR value of SP-1B was evaluated to be 9.4%. The further consideration was that the implementation of the river improvement work would realize positive conditions prerequisite to irrigation development of the Panitan - Panay area. The two projects above, therefore, should be evaluated as a package. As summarized in Table IV.10-13, the EIRR of the river improvement and irrigation in combination was assessed to be 10.1%.

Case-B: Implementation polder plans at Pontevedra and Panitan

This plan would have the Pontevedra and Panitan towns alone protected by polders, and leave the rest of the areas in the present condition. In this case, the damage reduction associated with SP-1B above was accounted as the penalty of this plan in comparison with Case-A above, since the areas without protective measures would remain susceptible to fl-od damage. The results of comparison are shown in Table IV.10-13.

Case-C: No structural measures enacted

This plan would suspend both of the river improvement and polders, and leave all the areas in the present condition. Because all the areas above would continue to be prone to flood damage, the penalty at the amount of the expected damage reduction of SP-1B would be imposed in comparison, as employed for Case-B above. The results of comparison with Case-A are shown in Table IV.10-13.

As indicated in the comparison index in Table IV.10-13 (NPV), Case-A was assessed to be more economically favourable than any of the others.

The selected projects for Short-term Provisional Plan for flood control (structural measures), based on the considerations made in (1) and (2) above, are summarized in Table IV.10-14.

The design flood discharge distribution of SP and the standard river cross sections of SP are respectively shown in Figs. IV.10-14 and IV.10-15. The general plan of SP including the comprehensive projects is shown in Fig. IV.14-2 in Section 14.

11 Contemplation of Non-structural Measures

11.1 Alternative Plans of Non-structural Measures

In materializing non-structural measures against floods, considerations would have to be given to various socio-economic statistics, regional land uses and detailed records of past floods. In the present Study, preliminary basin-wide assessments could be made, since more refined discussions on the non-structural measures would require much more detailed information. The descriptions for non-structural measures are summarized in Table IV.11-1.

11.2 Flood Plain Management

In the present flood vulnerable area, there are possibilities of progress in land-use development, agricultural production and enhancement of property values at a certain rate of growth. This would mean that the damage potential within the flood vulnerable area will gradually increase. This plan intends to restrain the future growth of damage potential by regulations and administrative guidelines. Specific measures would cover:

- Designation of flood vulnerable area (by ranks of damage frequency and risk grades)
- Management of development within the flood vulnerable area
- Instruction and propagation to residents

This plan is applicable basically to all areas, but would be most effective in areas with high future damage potential.

(A) Assumption of development in flood vulnerable area

(If development regulation and propagation are not enacted)

- Population, property and agricultural production will grow at 1/4 of the rate of non-flooded areas; i.e., the damage potential will grow at the same rate.

(If development regulation and propagation are enacted)

- Damage potential will restrained to the low rate with almost a half of the current growth. The future development is deemed to take place mainly in non-flood areas.

(B) Assessment of benefit

The benefits accruing from the development regulation will be the difference between the two cases above, which would be equivalent to the increase in future damage potential in the flooded areas.

(C) Estimation of cost

(a) Cost of managing development

The salaries of personnel for development regulation and propagation, cost of buildings and equipment and others will be expended throughout the management period. Table IV.11-2 presents the estimated cost.

(b) Compilation of maps for management

Detailed maps (say 1/2,500) of the flood vulnerable areas will need to be compiled for management. The cost of mapping will be expended during the first five years. The estimated cost is shown in Table IV.11-2.

11.3 Structural change to buildings

This measure would include structural change to buildings such as making higher floors, diking around buildings and/or elevating ground by land fill. By devising these measures, most of the property damage could be protected.

These measures would be effective in the areas specified below:

- Areas with relatively few residents, sparsely built up
- Areas with no substantial agricultural damage
- Areas with light flood damage; i.e. shallow and gentle flow inundation area

(a) Assessment of benefit

Reduction in building and property damages in the concerned areas will be assessed as the benefit of this measure. No reduction will be achieved in damage on agricultural land, public facilities, nor indirect damage.

(b) Estimation of cost

Subsidies to promote structural change to a high floor and/or land elevation are accounted as the cost of this measure. The estimated cost is shown in Table IV.11-2.

11.4 Alteration of land use and removal of inhabitants

This plan would have the land use altered, say from paddy field to rubber or oil palm, or have the inhabitants removed out of the inundation areas, for the purpose of reducing the flood damage. Such measures would be effective particularly in the areas described below:

- Areas without intensive land use, particularly of rice cropping (since extensive land use alteration would be difficult in practice)
- Areas inhabited by few people
- Areas prone to fatal damage (need for removal is high)

Since the areas in the Panay river basin is extensively used for rice cropping, enforcing of the alteration of land use would be impractical in view of the regional economy. In addition, despite the inflicted flood damage, the net production of the agricultural land including paddy fields at present is still positive. Taking the above into account, alteration of land use would not appear to be a viable measure. Hence, only relocation of residents will be positively contemplated.

(a) Assessment of benefits

Since this plan would remove the houses and associated structures to non-flooded areas, the reduction in flood damage on the buildings, public facilities and related indirect damage is the benefit of this measure.

(b) Estimation of cost

The cost of this measure would comprise (i) relocation cost of buildings and facilities and (ii) acquisition cost of new land. The estimated cost is shown in Table IV.11-2.

11.5 Evaluation and Selection of Non-structural Measures

The cost-benefit indices for the above three alternative measures were assessed for each of the protection areas. The results are shown in Table IV.11-3 based on which the following would be recommended:

(A) Flood plain management:

The measure was evaluated to be economically viable in several sub-areas, and moreover the basin-wide application of the measure would also be worthy of consideration in view of a positive value of NPV (Net Present Value) for the whole basin. In principle, this measure, once to be implemented, should cover a sufficiently large area to make the measure effective (if the measure is enforced only in limited areas, it will merely result in shifting the development activities to other flood prone areas where no regulation is enforced yet). As the implementation of the measure requires only small capital costs, it would not cause excessive budget burden to the implementing agency even if a wider area is proposed for implementation. These suggests that the measure should be enforced for the whole basin area as a lot, rather than for the limited areas for which positive net benefit was proven in Table IV.11-3.

(B) Structural change of buildings:

This study revealed that the overall attractiveness of this measure would be small, as represented by relatively low economic returns. One of the reasons for this negative conclusion seems that the measure is effective only for small floods with inundation depth of less than 1m and therefore the damage reduction effect is relatively small.

It is noted however that the present evaluation is based on analyses for relatively large study unit areas (23 sub-areas) and the evaluated results represent the average value for these large areas. More detailed evaluation, which should be made for small divided areas, may reveal that the measure may be economically justifiable in some local areas where only shallow flooding is predominant. This should be examined as one of detailed survey items in the subsequent feasibility study.

(C) Relocation of housings:

Table IV.11-3 indicates that this measure would be feasible in two sub-areas; Y1 and M3 (excluding Mambusao town). Accordingly, this study proposes the measure to be implemented in these two areas. Nevertheless, practicality of the plan should be ascertained in the subsequent feasibility study based on detailed inventory survey of buildings in the areas.

The proposed non-structural measures are indicated in the rightmost column of Table IV.11-3.

12 Installation of Flood Forecasting and Warning System

This measure would be effective in the Panay river basin in that some part of flood damages on property and human lives could be eliminated by advance knowledge of the occurrence of floods. Identification of the inception of floods in the upper stretches at an early stage is the most practical and positive way to forecast inundation downstream. It is proposed that staff gauges be installed at the major points in the upper and middle reaches of the river, so that occurrence and depth of flooding can be foreknown by a stage correlation technique. A comprehensive telemeter system shall be forwarded, once the flood run off characteristics and flood level correlations have been firmly established on the basis of several years' records collected by staff gage measurements.

Fig. IV.12-1 presents the disposition of staff gauges, rainfall gauges and telemeters to be installed. The list of proposed equipment is shown in Table IV.12-1.

(a) Assessment of benefits

The benefit that would accrue from a forecasting and warning system is generally difficult to assess without conducting a detailed field survey of effects. Thus only a preliminary assessment was made in this Study. The precedents given below for similar projects were referenced in estimation:

- As an empirical estimation in U.S.A., emergency planning based on a flood warning system was reported to eliminate a minimum of 5% and often 15% of total damage.

- In a study of the Kelantan river of Malaysia, damage reduction corresponding to 25% of removable property, such as furniture and households effects, was assumed to be practicable.

In this Study, the benefit was assessed for trial by whichever the smaller between 5% of total damage and 25% of property damage.

(b) Estimation of cost

The estimated cost is shown in Table IV.12-2.

Based on the estimated cost and benefit, economic evaluation of the flood forecasting and warning system was conducted. The results are shown in Table IV.12-3. With the EIRR of this plan being assessed as 4.7%, the implementation of this measure would not be economically justifiable.

Nevertheless, flood hydrological data will be essential for proper operation of flood control facilities, both structural and non-structural. For this reason, the flood forecasting and warning system is proposed as an integral element of structural/non-structural flood control plans.

13 Formulation of Flood Control Project

The flood control measures worthy of implementation were contemplated in Sections 10 and 11, within the frameworks of Long-, Mid- and Short-term Plans. Details of the specific measures are collectively given in Table IV.13-1, and summarized below:

Proposed Flood Control Projects

Proposed Project	Long-term Plan (LP)	Mid-term Plan (MP)	Short-term Plan (SP)
Design flood	100-year	25-year	10-year
Facility plan			
River improvement work	109.4 km	22.1 km	22.1 km
Dam construction			
- Panay B dam	*	*	*
Polder dykes	-	3 towns	4 towns
Non-structural measure	*	*	*
Flood forec./warning system	*	*	*

Notes: * Contemplated
- Not contemplated

As discussed before, Long-term Plan and Mid-term Plan would not be economically justifiable under present condition (i.e., EIRR less than 8%). Therefore it is appropriate that Short-term Plan which would be economically viable should be implemented first, and later be upgraded to the levels of Mid-term Plan and further to Long-term Plan.

Implementation Stage	Proposed Project
1st Stage Work	Implementation of Short-term Provisional Plan
2nd Stage Work	Upgrading to Mid-term Plan level
3rd Stage Work	Upgrading to Long-term Plan level

This plan of river improvement works for SP (1st Stage Work) is shown in Fig. IV.13-1 and IV.13-2.

14. Program of Flood Control Plan

14.1 Framework of Flood Control Plan

The basin development program consists of not only the flood control plan but also the irrigation development plan, the water supply plan and the hydro-electric power supply plan. The latter three plans are respectively formulated in each Appendix Report and the comprehensive frameworks of these four plans are set in Main Report. In this section, the description is given only for the program of flood control plan.

The frameworks of Long-, Mid- and Short-term Plans were set forth in Section 13. This Study proposes that the flood control project be implemented by stages. The specific projects of each stage are detailed in Table IV.14-1, and summarized below:

Stagewise Implementation of Flood Control Project

Item	1st Stage (Short-term Provisional Plan)	2nd Stage (Extension to Mid-term Plan)	3rd Stage (Extension to Long-term Plan
River improvement			
- Improvement of Pontevedra river	6.1 km	-	-
- Improvement of new sections	16.0 km/1	None	93.4 km
- Enlargement of previously improved sections	-	16.0 km/1	16.0 km/1
Total	22.1 km	16.0 km	109.4 km
Multipurpose dam (flood control & hydropower)			
- Panay B dam	x	-	-
Polder plans	4 towns	Additional 3 towns	-
Non-structural measures (Flood plain management)	x	-	-
Flood forecasting and warning system	x	-	-

Notes: /1 Includ. Cogon floodway

x: Contemplated
-: Assumed to have been implemented in previous stage

Of the three stages of the plan, the 1st Stage should be given priority for implementation, on the grounds of its economic feasibility which is high even at present, and that it would substantially improve the health and livelihood of local residents.

It was recommended, however, that the 2nd and 3rd Stage works should be kept abeyance until the increased potential value of damage increases the economic viability of the plan (i.e. more than 8% of EIRR). Preliminary assessment suggested that Mid- and Long-term Plans would be justifiable if implemented around the year 2015 (work commencement around 2010), and around 2030 (commencement around 2022) respectively.

15.2 Outlines of Proposed Development Project

The following are the outline, purpose and timing of implementation of the proposed development projects. The implementation program of proposed projects including the project for irrigation and water supply is shown in Fig. IV.14-1.

(1) 1st Stage work (Short-term provisional plan)

River improvement

The river improvement for this stage would comprise the following work items:

(A) Cogon-Hamulaoun floodway (9.5 km)

This plan would have a bypass floodway constructed, from 4 km downstream of Panitan to the Hamulaoun river mouth. Flood flow exceeding the bankful capacity of the Pontevedra river of 500 m^3/sec would be diverted by this floodway.

(B) River improvement of the Pontevedra river (6.1 km)

This would provide partial improvement of the Pontevedra river for the stretch from the floodway entrance to the Pontevedra town. The channel section, where the carrying capacity is less than 500 m^3/sec, would be widened and eroded banks would be revetted.

(C) Stretch between Panitan and Cogon floodway entrance (6.5 km)

The low flow capacity of low water channel would be expanded by improvement of the existing river channel. Levees would be constructed on the both banks.

By this improvement work, the areas downstream of the Panitan (including the Panitan - Panay irrigation area) would be relieved of flood damages caused by floods of less than 10-year recurrence. The areas upstream of Panitan would be relieved of flood damages caused by floods, since the flood levels would be lowered by the improvement work. The location of stretches for the channel improvement plans is shown in Fig. IV.14-2.

Multipurpose dam

The Panay B dam would be constructed to reduce the flood flow discharge into the stretches downstream of the dam. The dam is proposed as a multipurpose dam with a power station equipped with 7,100 kW generating facilities. The general plan of the dam is shown in Fig. IV.8-4.

Polder dykes

Polder dykes would be embanked to lighten flood damages caused at 4 towns/villages with high flood damage potentiality (i.e. Dao, Cuartero, Mambusao and Sigma). The locations of the planned polders are shown in Fig. IV.5-15 and the general plans for each location are shown in Fig. IV.10-8 to IV.10-11.

Non-structural measures - flood plain management

(A) Flood plain management

In the areas upstream of Panitan (flood vulnerable area 220 km^2), where flood control projects by structural measures will not be carried out for the time being, regulation of development should be introduced to avoid any increase in the risk of future flood damage. For area downstream of Panitan too (flood vulnerable area 118 km^2), appropriate guidelines for development would be set out since the protection level of the proposed Short-term Plan is only against a 10-year flood.

(B) Relocation of housings

Relocation of housings is preliminarily proposed for two sub-areas of Y1 and M3 (excluding Mambusao town). Actual implementation should however be subject to further detailed survey to be included in the feasibility investigations, in which the practicality of the plan would be examined on the basis of each housing.

Flood forecasting and warning system

Advance information on incipient floods is indispensable for efficient operation of structural and non-structural measures proposed herein. Flood forecasting by a stage-correlation technique is proposed as a provisional step, which will be replaced later by telemeter facilities.

(2) 2nd Stage work (Mid-term plan)

River improvement

In this stage, the bankful capacity of river channels would be increased (design discharge: a 25-year flood) in the stretches downstream of Panitan, which were previously improved under the 1st Stage project.
The location of the river stretches that would be improved is shown in Fig. IV.14-3.

Polder dykes

Polder dykes would be constructed additonally at 3 towns/villages, i.e. Maayon, Jamindan and Dumarao. The locations of the planned polders are shown in Fig. IV.5-15 and the general plans shown in Fig. IV.10-3 to IV.10-5.

(3) 3rd Stage work (Long-term plan)

The work items to be completed in the 3rd Stage would be intended to provide all the flood vulnerable areas with protection, and thus raise the protection level up to the 100-year flood. The protective work would include the following:

(A) Enlargement of bankful capacity of channels improved in 2nd Stage (16.0 km)

This would raise the bankful capacity to accommodate a 100-year flood for the stretches improved in the preceding 2nd Stage work. The work would include the heightening of levees and improvement of appurtenant facilities.

(B) Improvement of upstream reaches of main and tributary rivers (93.4 km)

Improvement work would be initiated in this stage for the river stretches previously left unimproved, i.e. 1) middle and upstream reaches of the Panay, 2) lower stretches of the Maayon and 3) lower stretches of the Mambusao river. With the completion of this stage work, almost all the areas vulnerable to inundation in the Panay basin would have been protected from flood damages (except for parts of retardation basins unavoidably inundated by inland water).

The location of the stretches subjected to improvement in this stage is shown in Fig. IV.14-4.

14.3 Implementation Program

Based on the principles concerning the implementation of specific projects set out in the preceding Subsection 14.2, the "Master Schedule" of the basin-wide development program was formulated, as given in Fig. IV.14-1.

14.4 Cost Estimation and Economic Evaluation of Development Program

14.4.1 Cost Estimates of Development Project

The total cost of the basin-wide development program for flood control plan was estimated at ₱5,816 x 10^6 (1984 base price). Cost breakdowns of the program by specific projects are as given below:

Development Cost Estimates of Specific Projects

(1984 base price)

Project (Stage)	Project Cost (P= x 10^6)	Breakdown by currency /1	
		Foreign currency (US$ x 10^6)	Local currency (₱ x 10^6)
Flood Control Project			
a) River improvement			
- 1st Stage work	589	11.5	383
- 2nd Stage work	440	8.6	286
-3rd Stage work	3,486	67.7	2,266
Sub-total	4,515	87.8	2,935
b) Polder dykes			
- 1st Stage work (4 towns)	231	6.4	116
- 2nd Stage work (3 towns)	146	4.0	75
Sub-total	377	10.4	191
c) Multipurpose dam			
- Panay B dam /2	471	15.4	194
d) Non-structural measures /3	51	-	51
e) Flood forecasting and warning system	84	3.8	15

Notes: /1 Rough estimation. Exchange rate: US$1 = ₱18

/2 Including power generating facilities.

/3 Initial cost only.

The details of project cost breakdowns for river improvement of each stage, for Panay B dam and for polder plans are shown in Table IV.14-2 to IV.14-7.

14.4.2 Economic Evaluation of Specific Projects

(1) Economic evaluation of projects

The economic value of the specific projects are shown below:

Summary of Economic Evaluation of Proposed Projects

Project	EIRR (%)				
	1st Stage		2nd Stage		3rd Stage
Flood Control Project					
(a) River improvement:		9.4		9.8	15.2
(b) Polder dykes:	Dao	12.7	Maayon	9.3	-
	Cuartero	25.7	Jamindan	9.2	
	Sigma	10.5	Dumarao	8.1	
	Mambusao	11.6			
(c) Panay B dam:		11.2			
(d) Non-structural measures:		9.6		-	-
(e) Flood forecasting/ warning system:		4.5		-	-
(f) Overall		11.4		10.8	15.2
Irrigation Development:	Panitan-Panay	11.7		-	-
	Mambusao	12.3		-	-
Roxas City Water Supply Project:		16.9		-	-
(Reference)					
1st Stage River Impr. + Panitan-Panay Irrigation		10.1		-	-

Note: /1 For reference. These projects to be implemented irrespective of economic merits

The evaluation above is based on the following conditions:

(a) The implementation of specific projects were assumed as given in Fig. IV.14-1.

(b) The 2nd and 3rd Stages of the flood control plan were evaluated on the incremental benefit that would accrue in excess of the benefit counted in the previous stage.

In the above evaluation, the EIRR of 3rd stage project shows pretty high value; 15.2%. The reason is mainly due to the following.

(a) The execution of 3rd stage project is extended until the year of 2030. The economic evaluation was performed on the assumption that the benefit (damage potential) rate is to be increased proportionally until the future due to the development of the basin.

(b) After the completion of 3rd stage project, the polders are not necessary any more. Therefore, the benefit produced by polders could be transferred to the benefit of river improvement in the 3rd stage.

Further it should be noted that the river improvement for 1st Stage work has the positive benefit of facilitating development of the Panitan - Panay irrigation project. The two project needs to be evaluated as a package. The EIRR value of river improvement + irrigation was assessed as 10.1%.

(2) Sensitivity analysis

The sensitivity analysis was conducted on the following conditions:

(a) Cost 20% up

(b) Benefit 20% down

The results of the sensitivity analysis are shown in Table IV.14-8.

15. Technical Consideration of Plans

The flood control plan in the scale of LP, MP, and SP was formulated in the foregoing sections, where some alternative plans were proposed for each protection level and each structural measure. The selection of plan was principally done on the basis of economic evaluation by benefit and cost, though the technical problems were also considered when the alternative plans are made. Therefore, it is expected that no serious technical problem is remained in the finally selected plans.

However, it is considered to be better to review the technical points on the plans formulated as final ones especially for the next stage of study. The following are some technical consideration for the flood control plan.

(1) Risk associated with high dykes

In the river improvement plans, proposed structural measures will include embankment of high dykes to accommodate a large flood of 10 to 100-year reccurrences. In this regard, the following items should be given due attention:

(a) The dykes are safe only against floods smaller than the design flood

(b) The flood damage potential in the areas protected by dykes would naturally rise, and therefore, deliberate contemplations should be given in determining the design discharge

(c) On the ground of the uncertainty involved in flood flow analysis and possible future change of flood runoff characteristics resulted from intensification of land use, it should be noted that the probable flood discharge would be subject to change and not be a fixed value

In constructing high dykes, therefore, the following propositions will have to be made to allow room for future counteractions:

(a) Heightening of dykes and/or widening of river channel by backward disposition of dykes. They might be difficult, however, from the social viewpoint and due to costly land acquisition.

(b) Maintaining room for future construction of retardation basins and dams in the upstream reaches. If channel improvement in the upper reaches is to be implemented, deliverate considerations will have to be made on possible effects on flood discharge concentration in the lower reaches.

As a rule, if high dykes are to be constructed, accommodating a flood larger than the design discharge must be evaded by all means. In compliance with this, there might be cases where measures given above be necessiated in future.

(2) Measures against inland water

The catchment area of the secondary tributaries except for the Ilas and Balacuan rivers is small as aforementioned and hence inland water can be drained by means of sluices. Because all the river improvement alternatives did not adopt drainage by pumping, inundation of part of the inland area will be unavoidable. A detailed study of the inundated area based on maps scaled to 1/2,500 or so will be made in subsequent feasibility studies.

(3) Dam planning

The construction of Panay B dam is proposed in the finally selected plan. The remaining three dams, namely, the Panay C, Badbaran A and Mambusao B dams, are not attractive in terms of feasibility. It is probable that the need for their construction may arise in future once the flood runoff from the upper Panay, Badbaran and Mambusao rivers increases due to the change of land use which causes the increase of runoff coefficient from sub-basins and land use level in the downstream area becomes high. Therefore the construction of these dams has to be taken into account provisionally in a long-term plan.

(4) Diversion planning

The study of diversion floodway channel plans performed in forgoing Section 7 concluded that the plans are less favorable from the aspect of economic evaluation except Cogon-Hamulauon floodway. However, the diversion plan seem to be worthy of further consideration if the flood discharge will be much increased due to the development of upper and middle basins and the any difficulty of river channel improvement is occurred or if the conditions on flood control planning taken at this study is remarkably changed in the future.

(5) Detour of improved river course

In the present river improvement planning, the channel has to traverse a part of some municipality towns such as Mambusao, Sigma, Dao and Panitan.

But, it is expected to have difficulty to let the inhabitants move to the other areas. Therefore, the consideration of detouring routes would be required in the further study stage.

(6) Land Aquisition

The 2nd and 3rd Stage Flood Control Projects contemplate to widen the river width, for which the acquisition of large land areas along the proposed river channel would be required. Although the enforcement of a strict land use regulation is presumably impractical from the social viewpoint, it will still be recommendable to provide appropriate guidance not to intensify land uses in the concerned areas. This will be made possible by repeated delivery of information and warnings on flood risks to people in the area.

(7) Maintenance of Unprotective Stretch

In the river improvement alternatives, unprotected area located downstream of a protected area have no dike(s) as the areas are used for a retarding basin during flood. Though the present river channel is improved by excavation and dredging upto the same capacity as that in the low-water channel of upstream protected area.

In this case, it is considered that the flood flow coming out of the upstream protected stretch suddenly spread widely in the downstream unprotected stretch and suddenly narrow at the entrance to the downstream protected stretch. That is, the direction and velocity of stream flow are changeable due to chains of protected stretch and unprotected stretch. Then, the remarkable erosion, scouring, and sedimentation will be expected to happen in the unprotected stretches including the part of upstream and downstream protected areas. Therefore, the occasional inspection and the maintenance are necessary to be carried out.

(8) Effectiveness of Retarding Basin

According to the flood runoff analysis by a storage function method, the unprotected areas (stretches) showed effective functions as a retarding basin which reduce the peak flood discharge in the downstream stretches. However, in the stage of feasibility study, it is suggested to study further about the effectiveness of unprotected areas, in regard to the elongation of flooding period and the lowering extent of peak water level.

(9) Land Use in High Water Channel Area

The flood of which discharge is more than the capacity of low water channel in the protected stretch and river channel in the unprotected stretch, does not happen frequently, say once 2-3 years. In this case, it is expected that the inhabitants cultivate the unprotected areas. It is suggested to study further about the regulation and management of land use in these areas.

(10) Consideration for Tidal Waves

At the time of "Undang" typhoon, the people in the estuary area suffered serious damages including the death of more than a hundred people by the high tidal waves caused by the low atmospheric and strong wind of the typhoon. The tidal wave reached to about 5 km from the seaside. The wave was higher than 3 m in the seaside but be lowered gradually to the inland. The protection against the tidal waves is different matter from that against the river flood. However, it is suggested to study about the protection of tidal waves and the influence of tidal waves to the flood control plan in the stage of feasibility study.

(11) Reduction of unprotected area

Some areas of flood plain are left unprotected in the flood control plan. This means that the unprotected areas are hardly developed in the future due to the expected recurrence of flood. In the Panay river basin, the flat land area is limited as the mountaneous area covers almost 70% of the basin. Therefore, it is expected in the further stage of study to reduce the unprotected land as narrow as possible for the possible development of the basin.

(12) Necessity of review on this study

It is necessary to review the results of flood control plans formulated in this study report before designing the structures due to the following reasons.

(a) The social and economic situations as the background of the study are always changeable. Therefore, the review can be done on the basis of more reliable new data.

(b) The economic evaluation was carried out on the basis of some assumptions estimated by a economist or a engineer. It is necessary to confirm the adequacy of the assumptions.

(c) The study on this report was carried out with comparatively detailed analyses as a stage of master plan. However, the range of study item was so broad. Therefore, it seems to be quite available to concentrate the study items to some limited range based on the comparative study performed in this report. The accuracy and the extent of detail will be increased by the further stage of study including the review.

(13) Some discrepancies of map

For the study of flood control plan, the maps of 1/10,000 in scale were used. The maps were very useful for the study. However, it was found that there are some doubts to have discrepancies and insufficiencies on the maps especially for the following points.

(a) The names of locations are not sufficient. For example, the names of some large villages, some mountains, and some large tributaries/creeks are not shown on the map. In addition, some names seem to be incorrect.

(b) The elevations read from the photographs taken from an airplane seem to have quite remarkable errors though it was not confirmed yet. Especially, the elevations in the estuary area and in the western mountain (Tapaz) area are doubtful.

It is considered that such insufficiencies were caused mainly by the shortage of survey time, the bad weather and the reading limit for aerophotographs of 1/20,000 scale.

It is suggested to confirm the accuracy of figures and descriptions of the map in the early time of the next study stage.

(14) Additional river cross sections

For the study of flood control paln, the river cross sections with the intervals of 3-5 km were used. They were one of basic data for the hydrological analysis as well as river improvement plan and they are fully used for the study on this stage (Master plan). However, it is suggested to perform the additional survey in the early time of the next study stage for improving the following points.

(a) The interval of cross section seems to be too long. At some river stretches, the interval is longer than 7-8 km.

(b) The directions of some cross sections are too much inclined from the right angle with the river course.

(c) The range of cross section survey did not cover all the stretches of flood vulnerable area, especially in the upstream portions.

(d) The cross section survey did not perform for some important tributaries and branch river such as the Balacuan river, the Ilas river, and the Hamulauon river.

(15) Flow capacity of stretches downstream of Panitan (1st Stage)

The stretches downstream of Panitan (including Cogon floodway) are designed against a 10-year probable flood. Because the flood control plan of the Pontevedra river includes the construction of levees, there will remain a risk of the breakage of levees in the event of floods larger than the 10-year probable flood. To counter such eventuality the following measures shall be taken:

- Under ordinary conditions, the inflow into the Pontevedra river would be kept below the bankful capacity of the Pontevedra river. In the event of emergency, however, it was assumed that the steam-flow in excess of the design capacity of the Cogon floodway will be emitted to the Pontevedra. This would mean that the Pontevedra area will continue to be susceptible to flooding to a certain extent.

- Maintenance of levees shall be duly made and any deformation of levees caused by excessive settlement shall be mended.

- The flood forecasting and warning system shall be established as described in Section 12, in order to quicken preventive measures.

Even if a 100-year probable flood causes inundation, water depth will be nearly the same as the depth before the river improvement. This Study assumes the freeboard of dykes to be 1.0 to 1.2 m. If the flow is confined in the channel to dyke top level, the channel could discharge a 30-year probable flood, although this is not the presumption for designing.

(16) Flooding condition of the middle reach of the Panay river (1st Stage)

After the completion of 1st Stage Project, the middle reach of the Panay river (the reach up to the confluence with the Mambusao river) is relieved of flood damage caused by floods of smaller than the 10-year probable flood. On the other hand, levees downstream of Panitan are to be connected with highland banks, this closing off the downstream areas.

Hence, if the flow capacity of the improved stretches downstream of Panitan is not sufficient, flooding the middle reaches of the Panay river might worsen in future. In this context, flood water levels at the Panay/Pontevedra bifurcation were compared and the results are given below:

Estimated Flood Water Level at Panitan (Upstream End of Dyking)

Probable flood (year)	Present Condition		After SP Execution	
	Flood discharge (m^3/sec)	Flood water level (El. m)	Flood discharge (m^3/sec)	Flood water level (El. m)
2	790	5.8	1,040	5.8
10	1,370	7.6	1,880	7.8
25	1,830	8.7	2,750	9.4
50	2,270	9.6	3,570	10.7
100	2,670	10.3	4,520	12.0

As seen above, the improvement work will cause no adverse effects, but will have a beneficial effects by lowering water levels in the upper area.

(17) Stretch at Panitan (1st Stage)

River improvement work at Panitan stretch for the 1st Stage Project would be confined to improvement of the existing river channel. This plan would require removal of part of the settlements removed out of the right bank area of the river. Consequently, an alternative plan was formulated to provide a floodway constructed on the saddle section of the right bank, and thus shift the planned river channel off the settlement area of the right bank. Preliminary assessment indicated, however, that the alternative plan is not likely to be viable. The details of the fllodway plan should be further examined however at the feasibility study phase.

(18) Polder plan at Sigma (1st Stage)

Widening of river channel at the right bank of the Sigma town is planned for 3rd Stage Project, which would need relocation of houses. Therefore polder dykes are proposed only for the left bank area.

(19) Confluence with the Maayon river (2nd and 3rd Stages)

The catchment area of the Maayon river is 367 km^2 at the confluence with the Panay river, which is relatively large. In the left bank area in the downstream reach, there are extensive paddy fields laid in low elevation. These fields are in flood prone areas subject to backwater from the Panay mainstream. Because of its large catchment, this area receives a large flood runoff (1060 m^3/sec at the 100-year probable flood) and, therefore, the installation of gates to prevent backwater from the Panay river will not be effective as a flood control measure for the confluence area.

To free this lowland area from flood damage, it is proposed that the 3rd Stage Project should include the construction of 16-km-long back dykes along the Maayon river and the Ilas river, a secondary tributary merging into the Maayon river at its left bank. This area is unlikely to be relieved of flood damages until 3rd Stage Project is implemented, which would deny the possibility of intensive land-resources development of the area for the time being.

(20) Confluence with the Balacuan river (a tributary of the Mambusao river) (2nd and 3rd Stages)

The catchment area of the Balacuan river is about 50 km^2 at the confluence with the Mambusao river. Paddy fields are extensively developed in the downstream area which is also prone to flood damages. The 100-year flood water level at the confluence reaches El. 15.5 m. Paddy fields lying at elevations lower than the 100-year flood water level amount to about 2,200 ha which correspond to about 60% of all the paddy fields in the area. The lowest land in the area is at El. 8 - 8.5 m and about 800 ha which is used as natural flood retardation ponds and devoid of any particular land use.

Since lowland form a basin, the construction of back dykes for flood control seems impracticable. Therefore the proposed plan in 3rd Stage Project is to install gates at the confluence with Balacuan river for preventing the intrusion of backwater from the Mambusao river. However, this would mean that paddy fields in the lowland will be subject to periodic inundation from inland water even after the 3rd Stage Project and thus further land-resources development of the lowland area would not be recommendable.

It might become feasible in some year to install pumping equipment for draina-e at the gate, though this was not contemplated for 3rd Stage Project.

(21) Measures against inland water (2nd and 3rd Stages)

The catchment area of the tributaries except for the Maayon and Balacuan rivers is small as mentioned earlier hence inland water can be drained by means of sluices, although some inundation by inland water will be unavoidable. In further studies, it is recommended that a detailed study of the inundated area based on maps at a scale of 1/2,500.

(22) Future land use

Future land use in the flood plain will be largely dependent upon whether the flood control project is enacted or not, and if it will be enacted, what specific measures will be taken. Land use in particular areas will be considered in feasibility studies which will follow, but this Study made preliminary recommendations on the land use of the following three categories of areas:

(a) Areas where the flood control project will be carried out by structural measures

(b) Areas where no flood control project will be carried out for the time being

(c) Areas to be preserved as future channel bed susceptible to occasional flooding

The areas of the above three categories are shown in Fig. IV.15-1, and the recommendations concerning the land use in the specific areas are presented in Table IV.15-1.

In the above categories, acquisition of land will have to be conducted for the item (c) above. Although the enforcement of strict land use regulation is presumably impractical from a social viewpoint, it is recommended that appropriate guidance should be provided to curb intensification of land use in the areas concerned. This should be possible by repeated delivery of information and warnings on flood risks to people in the area. It is also recommended that all river-related facilities, such as bridges, water intakes, etc., to be built in future should be planned taking into account future river improvement works.

(23) Hydrological observation

A difficulty experienced in carrying out this Study was the limited availability of basic data and information, particularly in respect of flood discharge, flood level and storm rainfall records. In order to provide sufficient data for subsequent studies and design of the Project, it is emphasized that the following observation should be continued henceforward:

- Observation of rainfall at stations newly established during this Study, where new installation of automatic recorders is recommended to facilitate detailed observation of storm rainfall (in place of manual-reading gauge presently installed).

- Measurement of water level, discharge and sediment load at the existing stream gauge station; 3 automatic gauges and 4 staff gauge stations.

(24) Detailed surveys on non-structural measures

Present study on non-structural measures (See Section 11) remains at a preliminary study level (master plan study level) in view of limited data used and relatively large study area divisions (23 sub-areas) assumed in the study. The subsequent feasibility study should be based on more detailed surveys including inventory surveys of land uses properties in each sub-divided areas and interviews with local people, from which upgraded study outputs could be worked out. Moreover, the feasibility study will examine the practical methods of enforcement of the proposed non-structural measures including the recommendation of legislations.

(25) More detailed study for river improvement in middle reach

For the 1st (SP) and 2nd (MP) stage projects, the river improvement works are planned only for the stretches downstream Panitan. That is, the upstream stretches (middle reach of the Panay river) are left without any improvement due to the economic comparison which shows the inferiority of river improvement in the middle reach in the scale of SP and MP due to the higher damage potetical in the downstream stretches. However, it is proposed that the more detailed evaluation should be performed with more detailed data including the river cross sections with short intervals in the future stage of study.

(26) Effect of flood control by 1st stage project on discharge and water level

At the 1st stage project, the following works are executed in regard to the flood control.

- Construction of Panay B dam
- Construction of Polder at 4 towns
- River improvement at stretches downstream of Panitan (including Cogon floodway)

Among above three work items, the construction of polder dike is not effective for reducing the flood water level though the polders can protect the towns against the flood damage. On the other hand, Panay B dam is effective to reduce the flood water level, however, the reduction rate become smaller at the downstream stretches. The effect of Panay B dam on flood discharge and water level is summarized below.

Effect of Panay B Dam

On Flood Discharge and Water Level

Upper: Discharge m^3/sec
Lower: Water level El. m

Location (Base Point)	10 yr Flood			25 yr Flood			100 yr Flood		
	Present	W/Dam	Effect	Present	W/Dam	Effect	Present	W/Dam	Effect
Panay C dam	853	746	-107	1,282	1,105	-177	2,153	1,858	-295
(BP-1)	26.78	26.31	-0.47	28.42	27.78	-0.64	31.09	30.26	-0.83
Dumalag	868	760	-108	1,305	1,125	-180	2,189	1,890	-299
(BP-2)	23.23	22.86	-0.37	24.54	24.03	-0.51	26.67	26.01	-0.66
Conf. w/Badbaran R.	843	761	-82	1,240	1,099	-141	2,048	1,807	-241
(BP-3)	19.89	19.66	-0.23	20.93	20.59	-0.34	22.56	22.12	-0.43
Cuartero	1,104	1,064	-40	1,554	1,480	-74	2,383	2,257	-126
(BP-7)	15.92	15.76	-0.16	17.52	17.28	-0.24	19.91	19.58	-0.33
Conf. w/Mambusao R.	1,117	1,076	-41	1,567	1,494	-73	2,382	2,258	-124
(BP-8)	13.74	13.63	-0.11	14.85	14.68	-0.17	16.46	16.24	-0.22
Conf. w/Maayon R.	1,290	1,264	-26	1,803	1,750	-53	2,684	2,595	-89
(BP-13)	10.40	10.34	-0.06	11.44	11.34	-0.10	12.84	12.72	-0.12
Panitan	1,365	1,340	-25	1,832	1,789	-43	2,668	2,612	-56
(BP-17)	7.55	7.53	-0.02	8.66	8.57	-0.09	10.29	10.19	-0.10

Note; Regulation effect of Panay B dam

	10 yr flood	25 yr flood	100 yr flood
Inflow	602	1,013	1,995
Outflow	351	557	1,047

As seen above, the reduction of water level in the middle reach, where the polders are planned to be constructed, is not so sufficient as the polder dike can be eliminated. For example, the reduction of water level at Cuartero and Dao in case of 100 year flood is respectively only 33 cm and 22 cm.

The river improvement at the stretches downstream of Panitan is also effective to reduce the water level at the upstream stretches of Panitan but only for the small flood, as the upstream stretches remain at present condition.

The effect of first stage flood control plan on discharge and water level is shown in Fig. IV.15-1.

(27) Effect of flood control by 3rd stage project on discharge and water level

At the 3rd stage project, the river improvement is executed upto the stretch upstream of the confluence of the Panay river and the Badbaran river. The effect of 3rd stage flood control project on flood discharge and water level is summarized below.

Effect of 3rd Stage Flood Control
Project on Flood Discharge and Water Level

Unit: Q: m^3/sec
W.L.; El. m

Base Point and Location	Present		River Improvement only		R.I. with Dam	
	Q	WL	Q	WL	Q	WL
1. Panay C dam	2,153	31.09	2,153	31.09	1,860	30.26
2. Dumalag	2,189	26.67	2,189	26.67	1,890	26.01
3. Conf. w/Bad. R.	2,048	22.56	2,244	22.57	1,940	22.01
7. Cuartero	2,383	19.91	3,330	19.28	3,090	18.95
8. Dao	2,382	16.46	3,346	18.40	3,110	18.02
13. Conf. w/Maayon R.	2,684	12.84	4,457	13.48	4,230	13.24
17. Panitan	2,668	10.29	4,524	11.99	4,380	11.82

Note: Along Main Stream of the Panay river

The table above shows the following features.

(a) Flood discharge at the present condition is not increased at the downstream stretches due to the inundation effect of flood plain.

(b) Flood discharge after the river improvement is remarkably increased at the downstream stretches as the inundation effect is not so much. For example, 2,668 m^3/S is increased to 4,524 m^3/S at Panitan. Therefore, the water level at the downstream stretches is also raised though the raising rate is not so high as the increase rate of discharge due to the river improvement effect. For example, El. 10.29 m is raised to El. 11.99 m at Panitan.

(c) The Panay B dam has effect to decrease the discharge as well as the water level though the rate is not remarkable especially at the downstream stretches as shown below.

Flood Reduction Effect of Panay B dam
on LP River Improvement

Location	Q (m^3/se)	W.L. (m)
Dumalag (BP-2)	299	0.66 m
Cuartero (BP-7)	240	0.33 m
Panitan (BP-17)	144	0.17 m

The effect of Third stage flood control works on peak discharge and peak water level is shown in Fig. IV.15-2 where the effects of Papay B dam and river improvement are respectively shown in the same figure to see the effect of each works clearly.