Economic Evaluation of Floodway Plan FW-5

| Item | Construction Cost (₱ 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 in 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.

### 5.2.3 Multipurpose Dam Plan

(1) Identification of prospective dam sites

The following eight dam sites were identified, through desk study of the 1 : 50,000 topographic maps, and by reference to previous studies. The locations of dam sites are shown in Figure 5.2-8, namely:

- Panay A site, Panay B site, Panay C site (Upper Panay river)
- Badbaran A site, Badbaran B site (Badbaran river)
- Mambusao A site, Mambusao B site (Mambusao river)
- Maayon site (Maayon river)

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

(2) Preliminary selection

Reconnaissances and surface geological investigations were carried out at these dam sites, and preliminary planning of dams and hydropower generation was made on the basis of 1 : 10,000 topographic maps, using estimated runoff data for each dam site.

The results of the investigation and studies are summarized in Table 5.2-3. Based on the above information, the following four sites were ruled out from further study.

| | | |
|---|---|---|
| Panay A site | : | Though the results of the preliminary planning were promising , the geology of the dam site is not favourable; the site consists of poorly consolidated conglomerates while extraordinary water leakage was recorded in past drillings. |
| Badbaran B site | : | The site is situated in a limestone zone. The rock appears to be cavernous and springs were found near the site. (N.B.: Badbaran A dam site in an upstream reach was found to be outside the limestone zone.) |
| Mambusao A site | : | The catchment area is small (73 $km^2$) and geology at the dam site is not favourable. Moreover, cost index value per storage (dam construction cost/total storage) is low. |
| Maayon site | : | The catchment area is relatively small (140 $km^2$). The cost index value is not good, either. |

Hence Panay B site, Panay C site, Badbaran A site and Mambusao B site were selected for further study. The location of four dams is shown in Figure 5.2-8.

(3) Development plan of dams preliminarily selected

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.

The general features of the selected dam plans are shown in Table 5.2-4 and 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 |
| Flood control storage ($10^6$ $m^3$) | 33.8 | 144.8 | 130.2 | 38.0 | 31.5 |
| Water utilization 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 regulating capacity of the dam plans is summarized in Table 5.2-5.

(4) Flood control effect of dam plans

A flood flow analysis for downstream reaches was made taking into account flood regulation effects of each dam plan. From this, the flood flow discharges and flood water levels at the Panitan base point are shown in Table 5.2-6, 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 5.2-9 and flood water levels are illustrated in Figure 5.2-10.

The figures suggested the following:

i) The flood control effect of the Panay C dam would be largest, followed by the Panay B dam, Badbaran and Mambusao dams. It is noteworthy that the flood control effect of the Mambusao dam is very small; though the Mambusao dam would cut the peak inflow flood of 1,770 $m^3$/sec to 885 $m^3$/sec in case of a 100-year flood, the flood control effect at the Panay - Mambusao junction would be 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.

ii) 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.

iii) Decrease in the flood water level is not much different in the cases of small floods and 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 a 2-year floods. This tendency is common to all other cases.

(5) Construction cost of dam plans

The construction costs of the dam plans were estimated on a financial cost basis at the price levels of 1984. The estimated costs of the 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

(6) Economic evaluation of each dam plan

The construction period of the dam and power station was assumed to be 5 years as stated earlier. Disbursements of the construction cost would 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 the operation and maintenance cost is assumed to be 2% of the economic construction cost.

The benefits of the project comprise the flood control benefits and power benefits. The flood control benefits were assessed by the method described in Subsection 5.1.3. The power benefits were assessed by the two components; capacity benefit and energy benefit. The unit capacity benefit was assumed to be ₱2,340 per kW and unit evergy benefit ₱1.255 per kWh. The method applied to the benefit estimate is shown in Section 7.2 of Appendix V compiled in supporting Report II.

Economic evaluation was made from the costs and benefits estimated above. The results are summarized below:

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 in the previous page, 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 alone individually. With respect to the Badbaran A and Mambusao B dams, since economic indices were very low (EIRRs were even lower than those of the river improvement + floodway plans), they were eliminated from further considerations.

### 5.2.4 Combination of River Improvement and Dam Plans

#### (1) Alternative composite 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 dam plans and river improvement plans, while other combinations with less favourable component plans were discarded at this Study stage.

<u>Contemplated Alternative Combined Plans</u>

| 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 were not assessed favourable).

(2) Flood control effect of composite flood control plans

The composite plans of dams and river improvement would be potentially more effective for flood control than the independent implementation of a dam and river improvement projects. If combined with dam plans, the required height of dykes along the river channel could be lowered because of the reduced flood flow by retention in the reservoirs, without relaxing the target protection level.

The flood control effect can be simply evaluated by the flood level and discharge at the base stations. These data at the Panitan station are given in Table 5.2-7. Figures 5.2-11 to 5.2-12 illustrate the flood discharge and water levels at several points along the mainstream of the Panay river.

(3) Economic evaluation of composite dam/river improvement plans

Regarding the schedule of development of the component projects, the following principles were applied. If two dams are to be constructed, the construction work on the second dam would be started 4 years after commencement of work on the first dam. If a river improvement plan is combined with a dam plan, the construction work for the river improvement was assumed to start 3 years after commencement of work on the dam.

The economic evaluations of the composite flood control plans were conducted by using the cost and benefit estimated for each plan. The results of the 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 | 4,234 | 2,352 | 1,357 | -995 | 0.58 | 4.5 |
| DR-2 | 5,223 | 2,621 | 1,432 | -1,189 | 0.55 | 4.2 |
| DR-3 | 5,418 | 2,643 | 1,514 | -1,130 | 0.57 | 4.4 |
| DR-4 | 5,837 | 2,840 | 1,468 | -1,371 | 0.52 | 3.8 |

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

### 5.2.5 Formulation of Long-term Plan

(1) Selection of Long-term Plan

The results of economic evaluation on facility alternative plans contemplated in Subsections 5.2.2 to 5.2.4 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 | 5,593 | -1,771 | 2.8 |
| River impr. + floodways/2 | 4,418 | -1,421 | 3.0 |
| River impr. + floodways + dams/3 | | | |
| - Alternative DR-1 | 4,234 | -995 | 4.5 |
| - Alternative DR-2 | 5,223 | -1,189 | 4.2 |
| - Alternative DR-3 | 5,418 | -1,130 | 4.4 |
| - Alternative DR-4 | 5,837 | -1,371 | 3.8 |

Notes: /1 At discount rate 8% p.a.
/2 Including floodway plan FW-5.
/3 Including power facilities.

As shown above, the alternative facility plan DR-1, which includes the construction of Panay B dam, is best rated in terms of NPV (though negative) and EIRR. Subsequently, the facility plan DR-3, which includes construction of Panay B and Panay C dams, was almost compatible, although it would not be conceived as equally desirable as DR-1, because of its associated social problem (submergence of 40 $km^2$ area, including Tapaz town). This Study, therefore, proposes alternative DR-1 within the framework of the Long-term Plan. Cost-benefit indices by proposed protection areas are summarized in Table 5.2-8. The diagram of flood flow distribution with DR-1 implemented is presented in Figure 5.2-13.

(2) Implementation of Long-term Plan

The EIRR of 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.

As future economic activity in the river basin increases, the cost of flood damage will naturally rise but implementation of the Long-term Plan will have to wait until the economic condition in the river basin will be ready to justify the plan. According to a preliminary estimation made in this Study, the earliest year for work commencement that would justify the plan, i.e. EIRR of more than 8%, will be around the year 2020.

This Study thus concludes that the Long-term Plan, which would include a large-scale construction work, should be commenced only when the flood damage potential has risen to a level that would justify the implementation of the Plan. The following subsections will present the considerations as to what short-term measures should be enacted.

## 5.3 Formulation of Mid-term Flood Control Project

In the preceding Section 5.2, an overall framework of the Long-term Flood Control Master Plan (LP) was developed. The economic viability of the Mid-term Plan, which would provide protection level against a 25-year flood, was then assessed within this same framework.

### 5.3.1 Evaluation of Mid-term Plan

In Subsection 4.2.2 of Chapter IV, the target of the Mid-term Plan was set at relief of flood damage for about 70% of the population presently susceptible to flood damage. 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 4.2.3. On the basis of this objective action area (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:

| Alternative Plan | Proposed Facility | Design Discharge at Panitan |
|---|---|---|
| MP-1 | River improvement alone* | 2,750 $m^3/s$ |
| MP-2 | River improvement* + Panay B dam | 2,670 $m^3/s$ |
| MP-3 | River improvement* + Panay B dam + Panay C dam | 2,270 $m^3/s$ |

The results of economic evaluation are summarized in Table 5.3-1, in which the MP-2 plan was evaluated to be most favorable. 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 5.3-2. 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.

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*Incl. Cogon floodway

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 timing 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.

### 5.3.2 Evaluation of Piece-Mill Works

Subsection 5.2.5 revealed that the long-term plan level protection work (100-year design flood) would be justifiable 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 5.4.4), the economic viability of river improvement works was reassessed by river stretch as given in Table 5.3-3, 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 those piece-mill works was evaluated by varying the timing of completion from year 2000 to 2015. The results of evaluation are summarized in Table 5.3-4. 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 Section 10.2 of Chapter X.

## 5.4 Short-term Provisional Flood Control Plan

### 5.4.1 Polder Plan

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 Plan. 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 Figure 5.4-1. Polders were planned for all these 12 towns/villages. The construction cost estimates and results of economic evaluation are shown in Table 5.4-1.

The results of economic evaluation showed that the polder plans would have EIRR values of more than 8% at the 6 towns/villages of Pontevedra, Panitan, Dao, Cuartero, Sigma and Mambusao. Protection by polders, therefore, of the above 6 towns/villages are worthy of consideration in Short-term Provisional Plan. Subsection 5.4.4 will further discuss this specifically.

### 5.4.2 River Improvement - Dam Composite Plan

As discussed in Subsection 4.2.1 (2), 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. In estimating the flood control benefits, the proportion attributable to the proposed polder dykes will be taken aside, as discussed in Subsection 5.4.1 above, on assumption that they would be constructed prior to implementation of the plans. Tables 5.4-2 and 5.4-3 summarize the results of economic comparison.

### 5.4.3 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 flood water levels upstream. This plan would have the existing weir lowered to 2.5 m in height, and would expand the channel capacity (up to the 10-year flood) 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 5.4-4. 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 (refer to the longitudinal section of flood water levels shown in Figure 3.5-3). This plan is intended to widen the river channel at these critical sections, and thus lower the water levels in the upstream reaches. Nevertheless, this plan would in turn create a defect by 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 ($m^3/sec$) | |
|---|---|---|---|---|---|---|
| | 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 | 2,670 | 2,540 |
| 25-year | 16.6 | 13.3 | 14.2 | 13.7 | 1,830 | 2,020 |
| 10-year | 15.1 | 12.4 | 13.2 | 12.7 | 1,360 | 1,470 |
| 5-year | 13.9 | 11.6 | 12.1 | 11.9 | 1,040 | 1,110 |
| 2-year | 12.8 | 10.7 | 11.3 | 10.9 | 790 | 840 |

Table 5.4-4 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. Nevertheless, the expected disadvantage of channel widening is overwhelming, because of the additional damage which would arise in the areas downstream. Hence the river improvement of the downstream reaches, which was examined in Subsection 5.4.2, would be the prerequisite of this plan.

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

At present 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.

### 5.4.4 Selection of Short-term Provisional Plan

Among the five alternative protection projects set forth for the river improvement plan for SP (refer to Tables 5.4-2 and 5.4-3 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%. A further consideration was that the implementation of its 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 5.4-5, 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 flood damage. The results of comparison are shown in Table 5.4-6.

Case-C : Non-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 5.4-5.

As indicated in the comparison index in Table 5.4-5 (NPV), Case-A was assessed to be more economically favorable than any of the others.

The selected projects for Short-term Provisional Plan for flood control (structural measures), based on the above considerations, are summarized in Table 5.4-6.

## 5.5 Contemplation of Non-structural Measures

In materializing non-structural measures against floods, consideration would have to be given to various socio-economic statistics, regional land uses and detailed records of past floods. In the present study, only preliminary basin-wide assessments could be made, since more refined discussion on the non-structural measures would require much more detailed information.

### 5.5.1 Alternative Plans of Non-structural Measures

(1) 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 growth will be constrained to the half of the above. Most of the future development is deemed to take place 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

i) 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 5.5-1 presents the estimated cost.

ii) 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 three years. The estimated cost is shown in Table 5.5-1.

(2) Structural changes to buildings

This measure would include structural changes to buildings such as making higher floors, dyking around buildings and/or elevating ground by land fill, where raising of structures and fill was assumed to be about 1 m high. By devising such measures, the property damage could be relieved in case of shallow flooding less than 1 m in depth.

These measures would be effective in the areas described below:

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

(a) Assessment of benefits

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 changes to a high floor and/or elevation of ground by land fill are accounted as the cost of this measure. The estimated cost is shown in Table 5.5-1.

(3) 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 would be high in such cases)

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 5.5-1.

### 5.5.2 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 5.5-2, 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 burder 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 5.5-2.

(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 1 m and therefore, the damage reduction effect is relatively small.

It is noted however that the present evaluation is based on analysis 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 5.2-2 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 5.5-2.

## 5.6 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 would 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 as a first-stage program 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 predicted by a stage correlation technique. This will be followed by the installation of a comprehensive telemeter system, once the flood runoff characteristics and flood level correlations have been firmly established on the basis of several years' records collected by staff gauge measurements.

Figure 5.6-1 Presents the disposition of staff gauges, rainfall gauges and telemeters to be installed.

(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 5.6-1.

Economic evaluation of the flood forecasting and warning system was made on the basis of the estimated cost and benefits. The results are shown in Table 5.6-2. 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.

## 5.7 Formulation of the Flood Control Project

The flood control measures worthy of implementation have been considered in Sections 5.2 through 5.6, within the frameworks of Long-, Mid- and Short-term Plans. Details of the specific measures are consolidated in Table 5.7-1, and summarized below:

Proposed Flood Control Projects of Long-, Mid- and Short-term Plans

| 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 | 115.5 km | 22.1 km | 22.1 km |
| Dam construction | | | |
| - Panay B dam | * | * | * |
| Polder dykes | - | 7 towns | 4 towns |
| Non-structural measures | * | * | * |
| 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 |

Details of stagewise implementation program will be given in Chapter X.

# CHAPTER VI. AGRICULTURAL AND IRRIGATION DEVELOPMENT PLAN

## 6.1 Prospective Development Plan

### 6.1.1 Development Concept

The basic concept for agricultural and irrigation development in the Panay River basin would be to expand rice production by improving the unit yield of paddy production by efficient and productive use of land and by expanding the area of irrigated land. Consideration is given to the following items:

(a) Consistency with the government development plan,
(b) Rice marketing to outer islands,
(c) Increase of farmer's income,
(d) Profitability of rice, and
(e) Increase of employment opportunity.

The strategy for agricultural and irrigation development is thus formulated to increase rice production as follows:

(a) To introduce improved irrigation farming practice,

(b) To provide appropriate agricultural extension and supporting services,

(c) To develop the existing irrigator's groups into a functional and viable organization,

(d) To provide irrigation facilities to supply stable perennial irrigation water to the potential irrigation area,

(e) To improve and rehabilitate the existing irrigation systems to raise productivity and cropping intensity,

(f) To integrate the existing PIS which are dispersed along the Panay river,

(g) To provide adequate drainage facilities to reduce damage associated with inadequate drainage and floods, and

(h) To introduce a more effective operation and maintenance system as well as a water management system after completion of the scheme.

### 6.1.2 Selection of Irrigation Scheme Area

In order to select the irrigation scheme areas, the potential irrigable areas were first delineated in the river basin as shown in Figure 6.1-1, taking into consideration the soils, topography, land suitability class and present land use.

The potential irrigable areas were next classified into NIS, CIS and PIS from consideration of the total area, present irrigation conditions, availability of water and possible intake sites for each potential area.

The potential irrigable areas and classification of the irrigation schemes thus identified are summarized as follows:

Potential Irrigation Area in Basin

| Location | | Potential Irribable Area (ha) | Classification of Scheme | Existing Irrigation Area (ha) |
|---|---|---|---|---|
| (1) | Tapaz | 500 | CIS | 190 |
| (2) | Dumalag | 500 | CIS | 250 |
| (3) | Dao-Panitan | 1,500 | PIS | 790 |
| (4) | Panitan-Panay | 3,400 | NIS | 1,590 |
| (5) | Lemery | 700 | CIS | 250 |
| (6) | Dumarao | 550 | CIS | 90 |
| (7) | Cuartero | 650 | CIS | 30 |
| (8) | Jagnaya | 400 | CIS | 90 |
| (9) | Mambusao | 2,500 | NIS | 1,640 |
| (10) | Ilas | 1,000 | CIS | 720 |
| | Total | 11,700 | | 5,640 |

Out of the above potential areas, the Panitan-Panay area and the Mambusao area were selected as the candidate projects for NIS development, since both areas already possess existing irrigation service areas of more than 1,000 ha. After planning the irrigation canal layout, the Panitan-Panay scheme area was ultimately determined as 3,250 ha and the Mambusao area as 2,145 ha.

## 6.2 Present Conditions in Proposed Irrigation Scheme Areas

### 6.2.1 Physical Status

(1) Panitan - Panay area

The Panitan - Panay irrigation area encompasses a gross study area of 6,000 ha. The study area is on an alluvial plain along the lower reaches of the Panay river.

The soil in the study area is mainly alluvial, suitable for rice cropping, and covering an areas of 4,650 ha or 78% of the study area. Land suitability for agricultural development is high, particularly in areas with alluvial soils, as shown in Figure 6.2-1.

Taking topographic conditions into account and eliminating areas to be occupied by flood control works, a total area of 3,250 ha is proposed for development as NIS. In this proposed irrigation area, 1,600 ha have already been developed as PISs, which has become outdated and malfunctional, and compounded with problems of improper distribution and salinity of irrigation water and high cost of O & M. Thus the proposed irrigation scheme would integrate the existing PISs as part of the proposed NIS.

(2) Mambusao area

The Mambusao area extends on both sides of the Mambusao river, a tributary of the Panay, and has a gross area of 4,000 ha. The area consists of alluvial plain, natural levees, depressions, swamps and hills. The area slopes gently eastward, and is drained by creeks and small rivers.

The soils are mainly alluvial and fertile, covering some 3,200 ha or 80% of the study area. Land suitability of the area for agricultural development is high, as shown in Figure 6.2-2.

In the Mambusao area, a total area of 2,145 ha is proposed for development. This includes the existing run-of-the-river Mambusao RIS (1,440 ha) and potential irrigation areas in the outer areas or elevated places. The proposed irrigation plan would comprise the rehabilitation of the existing intake facilities and canals, and implementation of extension works.

### 6.2.2 Present Land Use

Present land use in the Panitan - Panay area was determined mainly by interpretation of available aerial photographs. The lowlands in the Paniten - Panay area have been developed for rice cultivation close to the potential maximum extent, with irrigation water supply in some paddy fields. The paddy area is estimated to be about 5,100 ha, corresponding to 85% of the study area of 6,000 ha.

In the Mambusao area, the plains and valleys are mainly devoted to rice cultivation twice a year under both irrigated and rainfed conditions. The areal extent of paddy area is estimated to be about 3,400 ha, corresponding to 85% of the study area of 4,000 ha.

### 6.2.3 Agricultural Population

The population of the Panitan - Panay area is estimated to be approximately 37,700 persons, accounting for about 8% of the basin population of about 448,000. The agricultural population in the areea is estimated to be about 26,000 persons.

The total population of the Mambusao area is estimated to be approximately 21,000 persons, accounting for about 4% of the total basin population. The agricultural population within the rural area is computed to be about 11,200 persons.

### 6.2.4 Agricultural Production

The cropping patterns prevailing in these irrigation areas are different. In the Panitan - Panay area, triple cropping of paddy is made on some parts of the irrigated paddy areas. In the Mambusao area, the double cropping of paddy is practiced in most areas. The cropping patterns prevailing in these two areas are illustrated in Figure 6.2-3.

Paddy cultivation by the direct seeding method is widely practiced in both wet and dry seasons. All the family labor is devoted to rice farming. Animal power, mainly of buffaloes and oxen, is extensively used for land preparation. The use of farm machinery and equipment is not so common.

High yielding varienties are used, the main varieties being IR-36, IR-50 and IR-52 which are short matured varieties with growth periods of 105 to 115 days. Paddy seeds are saved from the last harvest or supplied from the Capiz Seed Producers Association. Land preparation, ploughing and harrowing are carried out before transplanting using animal power. After preparation works, direct seeding or transplanting is practiced. Fertilizer is commonly applied in two split doses at the rate of 100 kg of urea and 150 kg of phosphorous ($N_{16}$-$P_{20}$-KO) per ha. Harvesting is generally done by using sickles.

In order to investigate the present yield and production of paddy, a yield survey was carried out on the farm level. According to the results of this survey and analysis, present yields of paddy were estimated to be 3.2 tons per ha for irrigated paddy and 2.8 tons per ha for rainfed paddy in both areas. Present paddy production is about 13,500 tons in the Panitan-Panay area and about 10,200 tons in the Mambusao area.

Buffaloes and oxen play an important role in farming operations and transportation as motive power and as a source of meat supply. Livestock and poultry products are consumed at home or sold to meet special expenses.

### 6.2.5 Marketing and Prices

After consumption in households, surplus paddy is sold to the National Food Authority (NFA) through NFA's buying stations and NFA's procurement teams. Paddy collected by NFA is transported to other provinces after milling or re-drying in NFA's own facilities or private mills under contract to NFA.

Paddy prices generally are controlled by the Government through NFA. In September 1984, the buying price of paddy was set at ₱2.65 per kg. The prices of milled rice were set at ₱4.65 per kg at the selling point with a ceiling of ₱4.85 per kg.

### 6.2.6 Farm Budget

In order to determine present economic conditions on the farm, typical paddy farmers were selected among the beneficiaries in the both Panitan-Panay area and Mambusao area namely, 1.5 ha with 7 family members and 2.2 ha with 8 family members. The typical farmer's income and expenditure are summarized as follows:

Present Farmer's Income and Expenditure

(Unit: Peso)

| Item | Panitan-Panay | Mambusao |
|---|---|---|
| A. Farmer's Income | (1.5 ha) | (2.2 ha) |
| 1. Crop | 8,830 | 11,440 |
| 2. Livestock | 2,500 | 2,600 |
| 3. Others Wages | 4,500 | 4,500 |
| 4. Extra | 200 | 200 |
| Total Income | 16,030 | 19,540 |
| B. Farmer's Expenditure | | |
| 1. Tax and Duty | 600 | 840 |
| 2. Living Expenses | 14,740 | 17,840 |
| Total Expenditure | 15,340 | 18,680 |
| C. Capacity to Pay (A - B) | (+)690 | (+)860 |

The farmer's income and expenditure on a 1.5 ha sized paddy field in the Panitan-Panay area are ₱16,030 and ₱15,340. Therefore the Capacity to Pay is plus ₱690. In case of a 2.2 ha sized paddy farmers in the Mambusao area, the total income is ₱19,540 and the total expenditure is ₱18,680. The Capacity to Pay comes to plus ₱860.

## 6.3 Plan Formulation of Proposed Irrigation Schemes

### 6.3.1 Anticipated Yield and Production

In due consideration of the basic development concept as described in Subsection 6.1.1, paddy is selected as the main crop for cultivation. For some portions in the Panitan-Panay area, mung beans are recommended as a supplementary crop for diversification of production. The proposed cropping patterns are illustrated in Figure 6.3-1.

In formulating the proposed cropping pattern, a fallow period of one month is taken into allowed for as the period for maintenance of the irrigation canal system. In the Mambusao area, double cropping of paddy is proposed with medium-term varieties such as IR-38 and IR-54. In the Panitan-Panay area, triple cropping of paddy is proposed with short-term varieties like IR-36 and IR-50.

After scrutinizing the results of the paddy yield survey conducted by the Study Term, anticipated target yields of paddy were set at 5.0 tons per ha for both wet and dry season paddy under the "with the project" condition. This target is rather conservative and is realizable through the introduction of proper farming practices. With the adoption of new farming methods, it is anticipated that the productivity of paddy field would increase nearly two-fold. The yield which is calculated from the number of ripened grains per square meter will, after the completion of the Project, reach about 30,000 nos. as compared with the present 17,000 nos.

### 6.3.2 Irrigation Water Requirement

The unit irrigation diversion requirements were calculated on a monthly basis for a 7-year period from 1976 to 1982 for the Mambusao area and for a 34-year period from 1950 to 1983 for the Panitan-Panay area, based on the monthly rainfall data. For the Mambusao area, two alternative cropping patterns were examined in order to obtain a better matching cropping calendar in view of the availability of natural riverflow. Case-1 shows a cropping calendar with the wet season paddy taken in the same period as conventionally practiced, while Case-2 shows the wet paddy delayed half a month. The examined cropping patterns for the Mambusao and Panitan-Panay irrigation areas, including the two alternatives above for the Mambusao, are shown in Figure 6.3-2. The results of the unit irrigation diversion requirement estimation are shown in Tables 6.3-1 to 6.3.3.

In order to examine the availability of the river discharge for irrigation water use under run-of-the-river condition, a comparison was made month by month between the monthly drought discharge with 80% dependability at the proposed intaked sites and the irrigation water demand during the five months in which shortage of irrigation water would occur.

Available River Discharge and Irrigation Demand

(Unit: $m^3$/sec)

| Month | Panitan-Panay | | Mambusao | | |
|---|---|---|---|---|---|
| | Drought Discharge | Irrigation Demand | Drought Discharge | Irrigation Demand | |
| | | | | Case-1 | Case-2 |
| Feb. | 26.5 | 1.14 | 3.0 | 2.51 | 2.51 |
| Mar. | 20.1 | 2.21 | 1.8 | 0.66 | 0.66 |
| Apr. | 12.8 | 2.57 | 0.6 | 0 | 0 |
| May | 16.4 | 4.75 | 0.8 | 2.10 | 0.64 |
| Jun. | 40.1 | 3.22 | 3.6 | 1.97 | 2.60 |

From the above table, the Panitan-Panay area will have a stable irrigation water supply even in a drought year. For the Mambusao area, the river can supply irrigation water only for Case-2 without any exploitation of additional water resources. The cropping calendar of Case-2 was therefore adopted for the Mambusao area.

The irrigation water demand of the proposed Mambusao and Panitan-Panay NIS areas and those of other potential areas for CIS development were estimated on the basis of the probable irrigation diversion requirement in a standard year with drought conditions once in 5 years. The estimated results are shown in Table 6.3-4.

### 6.3.3 Drainage Requirement

The proposed irrigation scheme areas mainly lie on the alluvial plains along the Panay River and its tributaries. If the lands are not well drained, productivity will not rise even after the implementation of well-designed irrigation facilities.

The drainage requirement was calculated so as to drain the 3-day probable rainfall with a 5-year return period within 3 days after allowing for retention of 100 mm rainfall on the paddy fields. The calculated drainage requirement is 13.1 lit/s/ha or 113 mm/day.

### 6.3.4 Alternative Study on Intake System for the Panitan-Panay Area

The proposed irrigable area of 3,250 ha in the Panitan-Panay area is located on the aluvial plains along the lower reaches of the Panay River. By a gravity irrigation system, a total of 1,250 ha can be provided with irrigation water supply, whereas by a pump system the total area of 3,250 ha can be supplied. Table 6.3-5 shows the general features of the two alternatives. Figure 6.3-3 presents the general plan of the irrigation areas for the two alternatives. Figures 6.3-4 and 6.3-5 show the general layout of the pump station and headwork, respectively.

In order to select the proposed intake system, a comparison of the annual equivalent cost of the intake facilities per ha was made as shown in Table 6.3-6. From these results, the pump system may be seen to be more economical and attractive than the gravity system in terms of the annual equivalent cost per ha. Apart from this economic advantage, the pump system can command the whole irrigable area of 3,250 ha and achieve equitable distribution of the Government investment to the farmers. Therefore the pump system is proposed as the intake system for the Panitan-Panay area.

### 6.3.5 Planning of Project Facilities

The basis for determining the facility requirements was that enough facilities be provided in the most effective and economical manner for optimum development of farming operations.

The salient features of facilities required for the Panitan-Panay and Mambusao schemes are summarized in Tables 6.3-7 and 6.3-8. The general layouts for both areas are illustrated in Figures 6.3-6 and 6.3-7.

## 6.4 Cost Estimate

The construction cost comprises direct construction cost, indirect costs such as cost for O & M, land acquisition cost and administration cost of the executive agency and physical contigencies. These costs are estimated based on 1984 price levels. The cost estimates for both areas are detailed in Tables 10.3-5, and summarized as follows:

Construction Cost of Irrigation Schemes

(Unit: ₱x $10^3$)

| Item | Total | Foreign | Local |
|---|---|---|---|
| Panitan - Panay Area (Overall) | | | |
| Direct Construction Cost | 118,080 | 69,860 | 49,230 |
| Indirect Cost | 40,860 | 24,750 | 16,110 |
| Sub-Total | 158,940 | 93,600 | 65,340 |
| Physical Contingency | 23,850 | 14,040 | 9,810 |
| Total | 182,790 | 107,640 | 75,150 |
| Panitan - Panay Area (P-1 Pump) | | | |
| Direct Construction Cost | 31,880 | 20,270 | 11,610 |
| Indirect Cost | 14,810 | 8,890 | 5,920 |
| Sub-Total | 46,690 | 29,160 | 17,530 |
| Physical Contingency | 7,000 | 4,370 | 2,630 |
| Total | 53,690 | 33,530 | 20,160 |
| Panitan - Panay Area (P-2 Pump) | | | |
| Direct Construction Cost | 86,200 | 48,580 | 37,620 |
| Indirect Cost | 30,830 | 19,960 | 10,870 |
| Sub-Total | 117,030 | 68,540 | 48,490 |
| Physical Contingency | 17,480 | 10,210 | 7,270 |
| Total | 134,510 | 78,750 | 55,760 |
| Mambusao Area | | | |
| Direct Construction Cost | 48,618 | 24,156 | 24,462 |
| Indirect Cost | 20,430 | 13,410 | 7,020 |
| Sub-Total | 69,048 | 37,566 | 31,482 |
| Physical Contingency | 10,350 | 5,634 | 4,716 |
| Total | 79,398 | 43,200 | 36,198 |

The annual operation and maintenance costs are composed of the salaries of the project staffs, material and labor costs for repair and maintenance of project facilities and running cost of the project. The O & M costs for both areas are as given below:

Operation and Maintenace Costs

| Area | Annual O & M Cost ($₱ \times 10^3$) | (₱/ha) |
|---|---|---|
| Panitan-Panay (Overall) | 6,021 | 1,852 |
| Panitan-Panay (P-1 Pump) | 1,868 | 1,990 |
| Panitan-Panay (P-2 Pump) | 4,219 | 1,832 |
| Mambusao | 1,400 | 650 |

Some of the project facilities, especially mechanical and electrical works having shorter useful life than civil works, require replacement at a certain interval within 50 years of the project life. The replacement cost and useful life are summarized as follows:

Useful Life and Replacement Cost

| Item | Useful life (year) | Cost ($₱ \times 10^3$) | | |
|---|---|---|---|---|
| Panitan-Panay Area | | Overall | P-1 Pump | P-2 Pump |
| Pump and other works | 25 | 19,940 | 9,540 | 10,550 |
| Gates for canals | 25 | 1,040 | 310 | 740 |
| O & M equipment | 10 | 6,500 | 6,480 | 6,260 |
| Mambusao Area | | | | |
| Gates for canals | 25 | | 830 | |
| O & M equipment | 10 | | 6,260 | |

6.5 Evaluation

6.5.1 Economic Evaluation

(1) Project economic cost

The economic viability was preliminarily evaluated in terms of the economic internal rate of return (EIRR). Economic costs were estimated by deducting the land acquisition cost from the construction cost estimated in Section 6.4 and by multiplying the standard conversion factor of 0.82 by the financial cost of the local currency portion. The estimated economic costs are summarised as follows:

Estimated Economic Cost of Irrigation Schemes

| Item | Cost (₱ x $10^3$) | | |
|---|---|---|---|
| Panitan-Panay Area | Overall | P-1 Pump | P-2 Pump |
| 1. Direct Construction Cost | 109,224 | 29,790 | 79,434 |
| 2. O & M Facilities | 9,252 | 6,012 | 7,380 |
| 3. Engineering Services | 22,770 | 6,138 | 16,614 |
| 4. Administration Cost | 4,842 | 1,314 | 3,528 |
| 5. Physical Contingency | 22,086 | 6,534 | 16,164 |
| Total | 168,174 | 49,788 | 123,120 |
| Mambusao Area | | | |
| 1. Direct Construction Cost | | 44,215 | |
| 2. O & M Facilities | | 7,576 | |
| 3. Engineering Services | | 9,370 | |
| 4. Administration | | 1,993 | |
| 5. Physical Contingency | | 9,501 | |
| Total | | 72,455 | |

(2) Project benefits

Economic benefits to be reaped in both areas were estimated in the basis of the import substitution price of paddy. Economic farm gate prices of farm products and farm inputs were calculated on the basis of the projected international market prices as forecast by the World Bank in the long-term range for the period of 1983 to 1995. In this study, the forecast 1994 prices were used in the estimation of the economic benefits.

The project benefit is defined as the increment of net production values with and without the project. The net production values of typical farmers with and without the project are estimated at the full development stage as shown in Tables 6.5-1 and 6.5-2. The residual floor damage that would be inflicted by floods exceeding the protection level of flood control plans are counted as the residual negative benefit. The total incremental benefits of the project under different protection levels are summarized as follows:

Incremental Benefit Accrued from Irrigation Development

| Item | | Panitan-Panay Area | | | Mambusao Area |
|---|---|---|---|---|---|
| | | Overall | P-1 Pump | P-2 Pump | |
| Typical Farm Size | (ha) | 1.5 | 1.5 | 1.5 | 2.2 |
| Net Irrigation Area | (ha) | 3,250 | 940 | 2,310 | 2,145 |
| Net Production Values: Without project /1 | | | | | |
| Typical farm | (Peso) | 23,958 | 23,958 | 23,958 | 34,610 |
| Total | (₱ x $10^3$) | 55,620 | 16,092 | 39,528 | 35,360 |
| Net Production Values: With project /1 | | | | | |
| Typical farm | (Peso) | 42,498 | 42,498 | 42,498 | 58,766 |
| Total | (₱ x $10^3$) | 98,658 | 28,530 | 70,128 | 60,030 |
| Residual damage by protection level (₱ x $10^3$) | | | | | |
| No protection | | 13,824 | 3,996 | 9,828 | 7,128 |
| 2-year flood | | 10,800 | 3,132 | 7,668 | 5,418 |
| 10-year flood | | 3,546 | 1,026 | 2,520 | 1,638 |
| 25-year flood | | 1,440 | 414 | 1,026 | 630 |
| 100-year flood | | 0 | 0 | 0 | 0 |
| Incremental benefit by protection level (₱ x $10^3$) | | | | | |
| No protection | | 29,214 | 8,442 | 20,772 | 17,542 |
| 2-year flood | | 32,238 | 9,306 | 22,932 | 19,252 |
| 10-year flood | | 34,492 | 11,412 | 28,080 | 23,032 |
| 25-year flood | | 41,598 | 12,024 | 29,574 | 24,040 |
| 100-year flood | | 43,038 | 12,438 | 30,600 | 24,670 |

Note: /1 Net production value derived from paddy only.

(3) Economic evaluation

The economic internal rate of return (EIRR) was calculated on the basis of the benefit assessment above for the respective schemes. EIRR for the Panitan-Panay area under the flood control plan of a 10-year protection level (Short-term Flood Control Plan) is expected to be 11.7%, 11.4% and 11.8% for overall, P-1 pump and P-2 pump respectively and that for the Mambusao area under no flood protection work to be 12.3%. These EIRR values will further be improved when the flood control plans of higher levels are implemented successively. EIRR of both projects under several flood protection levels are summarized below.

Comparison of EIRR by Risk Level

(Unit: %)

| Protection Level | Panitan-Panay Area | | | Mambusao Area |
|---|---|---|---|---|
| | Overall | P-1 Pump | P-2 Pump | |
| No protection | 7.9 | 7.4 | 8.0 | 12.3 |
| 2-year flood | 9.1 | 8.6 | 9.1 | 13.7 |
| 10-year flood | 11.7 | 11.4 | 11.8 | 16.6 |
| 25-year flood | 12.4 | 12.2 | 12.6 | 17.4 |
| 100-year flood | 12.8 | 12.7 | 13.1 | 17.8 |

Based on the above results, both development plans are economically feasible. They should be promoted for realization, incorporating flood control measures of a reasonably high protection level.

6.5.2 Farm Budget Analysis

A farm budget analysis was made to assess the incremental Capacity to Pay on the farm level. Farm budgets without and with the project were estimated on the basis of rural market prices at 1984 levels. The results are shown in Table 6.5-3 and summarized as follows:

Farm Budget with and without Project

(Unit: Peso)

| Item | Without | With/1 | Increment |
|---|---|---|---|
| Panitan-Panay Area (Net: 1.4 ha) | | | |
| Farm Income | 17,100 | 30,880 | 13,780 |
| Farmer's Expenditure | 15,410 | 16,890 | 1,480 |
| Capacity to Pay | 1,690 | 13,990 | 12,300 |
| Mambusao Area (Net: 2.1 ha) | | | |
| Farm Income | 21,520 | 37,180 | 15,660 |
| Farmer's Expenditure | 18,700 | 20,750 | 2,050 |
| Capacity to Pay | 2,820 | 16,430 | 13,610 |

Note: /1 100-year flood protection

From the results of the above analysis, the Capacity to Pay of the benefited farmers in both scheme areas will increase markedly with implementation of irrigation schemes. The Capacity to Pay of the farmers in each scheme area will be sufficient to cover the irrigation fee and the estimated O & M cost for both areas; 1,852 Peso/ha for the Panitan - Panay area and 650 Peso/ha for the Mambusao area.

If only 10-year flood protection work is provided for Panitan-Panay area and no protection work provided for Mambusao area, the farmer's capacity to pay will decrease to Peso 13,640 in Panitan-Panay area and Peso 13,760 in Mumbusao area respectively. However, these figures indicate that the farmer's budgetary balance is still good even in these flood protection conditions.

# CHAPTER VII. WATER SUPPLY PLAN

## 7.1 Projection of Public Water Demand in the Basin

### 7.1.1 Development Criteria

In 1982, the Government of the Philippines prepared a detailed Master Plan for water supply development the rural areas of the country 1/. The Master Plan provided for dependable water supply based on three different service levels, defined by the criteria given below:

(A) Level I : A protected well or spring as a source, with no distribution system. Generally suitable for sparsely inhabited rural areas, with the furthest user not more than 250 m from the well/spring. Service available for around 15-50 households.

(B) Level II : A Level I system provided with a communal faucet system of single pipe. Suitable for rural areas with relatively dense population, with the furthest user not more than 25 m from the faucet. Each faucet covering 4-6 households.

(C) Level III: A piped system with individual house connections, suitable for densely inhabited urban areas.

In the Master Plan, the Government adopted a policy to provide dependable water supply urgently and economically. Since the implementation of the proposed plan is slightly behind schedule due to economic recession of the nation, a modified target of the supply condition improvement is assumed for the Panay river basin, as given below:

(A) Immediate (by the end of 1990)

(a) All barangays will have at least one system of Level I service.

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1/ The Government of the Philippines, "Rural Water Supply and Sanitation Master Plan", December 1982.

(b) All existing non-operational public wells will be rehabilitated, repaired or replaced.

(c) About 50% of the urban areas and 10% of the rural barangays will have at least one system of Level II service.

(d) About 25% of the urban areas will have Level III service.

(B) Intermediate (by the end of 1995)

(a) About 30% of the rural barangays will have at least one system of Level II system.

(b) The incremental demand for repair and rehabilitation of wells will be satisfied.

(c) All clusters with 50 households or more will have at least one system of Level I service.

(d) All urban areas will have at least one system of Level II service.

(C) Long-range

(a) By the end of 2000, about 50% of all barangays will have at least one system of Level II service.

(b) By the end of 2010, 70% of households clusters will have at least one system of Level II service.

(c) By the end of 2005, all urban areas will have Level III service.

Based on the above scenarios, the following targets are set in terms of population served by public water supply systems. In rural areas, however, some isolated households would not be economically served by public water supply systems. The unserved percentage is expected to be not less than 15% as shown below.

| Area | Service Level | Service Coverage in Percent | | | | |
|---|---|---|---|---|---|---|
| | | 1990 | 2000 | 2010 | 2020 | 2030 |
| Urban | Level I | 50 | 0 | 0 | 0 | 0 |
| | Level II | 25 | 25 | 0 | 0 | 0 |
| | Level III | 25 | 75 | 100 | 100 | 100 |
| Rural | Level I | 36 | 47 | 52 | 47 | 42 |
| | Level II | 0 | 28 | 33 | 38 | 43 |
| | Unserved | 64 | 25 | 15 | 15 | 15 |

### 7.1.2 Water Demand Projection

In general, people served by higher level waterworks such as Level III consume more water than those served by lower level water supply systems. In the Master Plan, therefore, the following criteria were adopted in terms of per capita water consumption: 30 lpcd for Level I; 60-75 lpcd for Level II; and 100 lpcd for Level III.

Table 7.1-1 shows the projection of public water requirement in urban areas of each municipality in the basin up to the year 2030. The total public water requirement in 2030 will be 25,460 $m^3$/day.

## 7.2 Water Supply Facility of Roxas City

### 7.2.1 General

At present, the Roxas City Water District (ROX-WD) provides water supply to Roxas city. ROX-WD was established in 1976 and is the owner of the entire water supply system.

In the Philippines, the Local Water Utilities Administration (LWUA) is an agency which controls water supply works of municipalities and cities with the population of more than 20,000. In 1976, the Feasibility Study for Water Supply of Second Ten Urban Areas was prepared by LWUA and Camp Dresser/McKee International Inc. (CDM), a U.S.A. consultant, in which the improvement work of the water supply system in Roxas city was among the proposed plans.

Based on this F/S, the water supply system of ROX-WD has been improved. A new water treatment plant with a capacity of 7,880 $m^3$/day was constructed, and additional pipelines were laid from the plant to the city. The related facilities such as distribution pipes, transmission pipes and pump facilities were also improved.

Notwithstanding these improvement, ROX-WD still has two serious problems in its water supply system at present. One is salt water intrusion to the water intake site on the Lower Panay river at the time of high tides during the dry season (January - April). The other is a large amount of leakage from distribution pipes.

The purpose of the study contained in this chapter is to identify and recommend the proper method to solve the problems of ROX-WD water supply system.

### 7.2.2 Existing Water Supply Facilities

Location of the existing facilities are shown in Figure 7.2-1.

At present, ROX-WD has two water sources; storage at the Catao reservoir and steamflow of the Lower Panay river. The Catao reservoir is located about 8 km southwest of Roxas city. The streamflow captured from the 85 ha catchment is diverted to the water treatment facility at Arkabalo by gravity. The supply, however, is heavily dependent on the natural inflow to the reservoir.

The Arkabalo intake on the Lower Panay river is located about 4 km south of the city. The streamflow is led to a sump through the intake, and is pumped up to the treatment facility located on a hilltop, elevated 60 m above the sea level. The pumping station at Arkabalo is equipped with two units of pumps, each rated at 2,725 $m^3$/day at 70 m total head and two 60 HP diesel engines as the prime movers. The combined actual production of the two pumps is 4,220 $m^3$/day,

The water treatment facilities were constructed in 1983, with the service capacity of 7,880 $m^3$/day.

## 7.3 Problems in Existing System

### 7.3.1 Salinity of Drinking Water

The Lower Panay river is the main supply source of the ROX-WD system. During the dry season (especially from January to April), however, saline water intrudes upstream beyond the Arkabalo intake. Besides, the supply of water from the Catao reservoir decreases[1/] in the dry months, and consequently the required water volume has to be supplied mainly from the Lower Panay river. In these circumstance, saline water is supplied

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1/: The minimum rainfall during the dry season is 47 mm per month. With a drainage of 85 ha, the run-off from the catchment area ranges from the minimum 533 $m^3$/day to the maximum of 932 $m^3$/day.

during such period of the year. Problems caused by the saline water supply are;

(a) Most of households in Roxas city, including those receiving water from ROX-WD, depend for their drinking water on stored rainwater. Since the stored rainwater frequently runs out in the dry season, and if the water from the water supply system becomes saline at the same time, people are forced to use unsterilized well water for drinking.

(b) Due to highly saline water being pumped up to the water supply system, the corrosion of machinery is conspicuous, causing an increase in maintenance cost. Especially, the pumps must have their parts replaced though only 7 years after installation.

### 7.3.2 Leakage in Distribution System

Another serious problem in the water supply network of ROX-WD is the leakage of water from the distribution system.

Since 26% of the existing distribution pipes have been used for more than 55 years, leakage through the pipes causes considerable loss, especially at night when water use decreases and water pressure in the pipes rises. In order to reduce the leakage, ROX-WD has switched its operation from full time supply to limited hours supply from May 1984. The supply time is from 6:00 a.m. to 1:00 p.m. and from 5:00 p.m. to 8:00 p.m., 11 hours in total. In the F/S plan, replacement of old pipes was proposed, but this has not progressed for up to the present. As a countermeasure against leakage, it is recommended the limited hours supply should continue as an immediate measure during progressive renewal of the pipes.

## 7.4 Basic Layout of Improvement Plan

### 7.4.1 Water Demand of the System

In the previous F/S, the average daily water demand was projected to be about 4,500 $m^3$/day in 1984, which turned out to be considerably over-estimated compared with the actual present value of 2,800 $m^3$/day. Therefore the water demand projection was revised in the Study for the improvement plan as shown below.

<u>Projected Water Demand</u>

| Item/Year | (Unit) | 1985 | 1990 | 1995 |
|---|---|---|---|---|
| Per Capita Water Consumption | lpcd | 100 | 100 | 100 |
| Served Population | | 10,000 | 14,380 | 26,430 |
| Domestic use | $m^3$/day | 1,000 | 1,438 | 2,643 |
| Commercial/Industrial | $m^3$/day | 700 | 811 | 941 |
| Government and Public use, waste/leakage and Plant use | $m^3$/day | 1,133 | 1,499 | 2,389 |
| Average daily demand | $m^3$/day | 2,833 | 3,748 | 5,973 |
| Maximum daily demand 1/ | $m^3$/day | 3,683 | 4,872 | 7,765 |

### 7.4.2 Proposed Capacity of Improvement Plan

According to the master plan, the design criteria for determining capacities of main facilities were as follows:

(a) Planning horizon : 5 or 10 years

(b) Pumping hours : 8 or 16 hours

(c) Storage capacity : 1/4 of maximum daily demand

In the present improvement plan, the target year was set at 1995, assuming a planning horizon of 10 years. Based on the assumed maximum daily demand in 1995 of 7,765 $m^3$/day, the capacity of each facilities were decided as follows:

1/: 1.3 times average daily water demand

Pumping station

The daily pumping time has been as 16 hours in order to keep the capacity of pumping facilities as small as possible. From this, the necessary capacity was calculated to be 11,650 $m^3$/day. Since the capacity of the existing pumping facility at Lower Panay is 4,220 $m^3$/day, the capacity will have to be increased.

Water treatment facilities

The present capacity of water treatment facilities is 7,880 $m^3$/day which is larger than the required capacity of 7,765 m3/day. There is therefore no necessity to increase the capacity.

Storage tank

The necessary capacity of the storage tank to supply the maximum daily demand of 7,765 $m^3$/day, is 1,940 $m^3$. This required capacity is smaller than the present storage tank capacity of 2,840 $m^3$, and there is therefore no neccessity to increase its capacity.

## 7.5 Comparison of Alternative Source Facilities

In this section, the condition of salt water intrusion into the Lower Panay river will be examined first. Secondly, alternative sources and intake facilities with provisions against saline water intrusion will be set out. Finally, the comparison of the alternatives will be made and a plan will be selected for recommendation.

### 7.5.1 Salt Water Intrusion to Lower Panay River

The Lower Panay river is about 32 km long and tidal effects reaches from the branch point from the Main Panay river to its mouth. At the branch point of the Lower Panay river, the sediment from the Main Panay river forms a sand bank which restricts the flow of freshwater from the Main Panay river to the Lower Panay river in favour of the Pontevedra river which is the extension of the main Panay river.

Intrusion of salinity is greatest at high tides during dry season when the river discharge is small and reduced also by abstraction for irrigation (up to 1.8 $m^3$/sec). As there is almost no inflow of freshwater passing through the Lower Panay river at the time, the salt water prism intrudes upstream and beyond the pumping station of ROX-WD.

### 7.5.2 Alternative Source Facilities

If the Lower Panay river is to be the water source, measure have to be taken against intrusion of salinity in addition to installation of further pumping units to increase supply. Alternatively, if the Main Panay river is to be the water source, a new pumping station must be constructed on the Main Panay river togather with a pipeline from the source to the treatment plant.

The following three alternative plans were therefore examined to select the final plan:

<u>Alternative 1</u> (refer to Figure 7.5-1)

In this plan, water from the Main Panay river would be diverted into the Lower Panay river by constructing a diversion weir on the Main Panay river. Irrigation water (about 1.8 $m^3$/sec) presently pumped from the Lower Panay, would be supplied from this weir, and increased streamflow would eliminate salt water intrusion at the pumping station. As the diversion weir, a rubber dam is proposed on grounds of relatively low cost, about 1 km upstream from the present diversion point. The lower Panay river would then be connected with the Main Panay by a shortcut channel, and at the entrance of the channel, an intake gate would be installed. An additional pumping station with a capacity of 7,450 $m^3$/day and a pipeline to the existing treatment plant, 300 mm in diameter and about 1.4 km in length, would have to be constructed.

Alternative 2 (refer to Figure 7.5-2)

Under this plan a new pumping station, with a capacity of 11,650 $m^3$/day, would be constructed on the bank of the Main Panay river together with a pipeline of 450 mm in diameter and about 10 km in length between the new intake and the existing treatment plant.

Alternative 3 (refer to Figure 7.5-3)

Under this plan, the riverbed of the upstream portion of the Lower Panay river would be excavated to El. -1.0 m to take about 2.0 $m^3$/sec from the Main Panay river to meet irrigation and water supply requiremants. The intake would be constructed on the Main Panay about 1 km upstream from the present diversion point. The Lower Panay and Main Panay would be connected by a shortcut channel, and an intake gate would be installed at the intake. In order to ensure the flow capacity of the Lower Panay river at low-water, some riverbed dredging will be required at various places between the intake and the pumping station. Figure 7.5-4 shows the profile of the Lower Panay river.

A tidal gate would also be constructed on the Lower Panay about 6 km downstream from the existing pumping station, to prevent salt water intrusion, together with additional pumping station, with a capacity of 7,450 $m^3$/day, and a pipeline, 300 mm in diameter and about 1.4 km in length, to deliver water to the treatment plant.

### 7.5.3 Cost Estimation of Alternative Plans

Construction costs of the three alternative plans were estimated at 1984 price levels as summarized below.

Construction Cost of Alternative Water Supply Plans

| Plan | Construction Cost (₱ x $10^6$) |
|---|---|
| Alternative 1 | 87.53 |
| Alternative 2 | 49.41 |
| Alternative 3 | 55.95 |

As seen in the above, Alternative 2 is assessed to be the least cost plan. However, other technical factors should also be considered in selecting the optimum plan.

## 7.6 Economic Evaluation of Improvement Work of ROX-WD

### 7.6.1 Preconditions for Economic Analysis

In this study an economic applaisal was made of three alternative plans for the ROX-WD improvement plan. The following critera were adopted:

1) The evaluation horizon is 20 years after the completion of the improvement facilities.
2) Construction cost used for the analysis would be disbursed in one year.
3) New connection and replacement costs would be disbursed in one year before new demands occur.
4) The costs of existing water supply facilities are not included in the analysis because they are considered as "sunk cost".
5) The salvage value of the facilities is regarded as a part of the benefits. It is regarded as an additional benefit at the end of the evaluation horizon.

### 7.6.2 Estimate of Benefits

The benefits of the improvement work would accrue from the following:

(a) Land enhancement benefits:
- increase in land values in the service area owing to the implementation of the water supply project

(b) Health benefits:
- reduction in lost time of income/salary earners
- reduction in economic costs due to premature deaths of people afflicted by water-borne diseases
- reduction of medical expenses for persons afflicted by water-borne diseases

(c) Reduction in fire damage

(d) Beneficial value of water

- an incremental value of water due to improved water supply (consumer satisfaction benefit)

(e) Irrigation

- the increase of water by the intake will prevent saline water intrusion and makes it possible to fully operate irrigation areas in the Lower Panay area. This benefit is included for a period up till the proposed Panitan - Panay irrigation scheme is put in service.

These benefits were evaluated in monetary terms as summarized below. The details of the estimate are given in Appendix VIII.

Benefits Accrued from Water Supply Improvement Work
(Economic Price Basis - 1984 Prices)

(Unit: Thousand ₱)

| Item | Estimated Benefit (20-year total) | | |
|---|---|---|---|
| | Alternative-1 | Alternative-2 | Alternative-3 |
| (a) Land enhancement benefits | 27,460 | 27,460 | 27,460 |
| (b) Salvage value | 28,125 | 28,125 | 28,125 |
| (c) Health benefits | 5,013 | 5,013 | 5,013 |
| (d) Reduction in fire damage | 1,026 | 1,026 | 1,026 |
| (e) Beneficial value of water | 133,109 | 133,109 | 133,109 |
| (f) Irrigation benefits | 36,753 | - | 36,753 |
| Total | 231,486 | 194,733 | 231,486 |

The annual benefit stream over a 20 year evaluation horizon is constructed on the basis of the economic benefit estimation.

7.6.3 Economic Costs

(1) Project costs

The economic construction cost of the improvement plan amounts to ₱83.3 million, ₱46.7 million and ₱52.7 million for Alternatives 1, 2 and 3 respectively.

(2) New connection and replacement costs

After the completion of the proposed water supply facilities, the water district will get new customers in the service area. Over the next 10 years, the incremental service population is estimated to reach 16,830. New connection costs are estimated to be ₱265 per capita. The connection costs cover the costs of measuring meters to be replaced at 15-year interval

(3) Salvage value (Residual value)

The calculated salvage value is based on the residual service life of the proposed water supply facilities and new connection equipment at the end of the evaluation horizon. The salvage value amounts to ₱28.1 million.

(4) Operation and maintenance costs

Operation and maintenance costs include costs for personnel, power supply, chemicals and other maintenance costs of the proposed plan.

7.6.4 Evaluation

Economic evaluation was attempted to compare the relative merits of three alternative plans. The results of this evaluation are summarized below.

Results of Economic Evaluation

| Alternative Plan | Construction Cost (₱ x $10^6$) | Present Value/1 (₱ x $10^6$) | | | B/C | EIRR (%) |
|---|---|---|---|---|---|---|
| | | Cost | Benefit | NPV | | |
| Alternative 1 | 83.3 | 96.6 | 100.5 | 3.9 | 1.04 | 8.7 |
| Alternative 2 | 46.7 | 69.1 | 79.2 | 10.1 | 1.15 | 10.8 |
| Alternative 3 | 52.7 | 67.3 | 100.5 | 33.3 | 1.49 | 16.9 |

Note: /1 Discount rate assumed: 8% p.a.

The above indicates that Alternative 3 is economically the most viable plan. Thus, this Study recommends implementation of the improvement work of ROX-WD system according to the plan and designs proposed in Alternative 3. Preliminary designs of major structures are shown in Figures 7.5-5 to 7.5-8.

Thus the net present value and B/C of the improvement work at a discount rate of 8% are ₱33.3 million and 1.49 respectively. The EIRR would be 16.9% which means that the project should be economically highly efficient.

## 7.7 Financial Evaluation of Improvement Work of ROX-WD

### 7.7.1 Preconditions of Financial Analysis

The financial appraisal of the Alternative-3 of the ROX-WD improvement plans is made by recommending water rate estimated for incremental costs and benefits under assumed loan conditions as stated later.

In the financial analysis, the following criteria and assumptions were adopted;

(a) Evaluation horizon is to be 50 years after the completion of the improvement works. Depreciation period is to be 50 years for intake facilities, concrete structures and pipe line and 25 years for gate and pump facilities.

(b) Initial investment cost used for the analysis is to be disbursed in one year. Replacement cost is to be also disbursed in one year after expiration of the depreciation period.

(c) The costs of existing water supply facilities are not to be included in the analysis. They are considered as "Sunk cost".

(d) Annual costs are to comprize depreciation cost of investment stock cost for replacement, interest to the investment, and operation/maintenance cost.

(e) Water revenue is to be estimated on the basis of salable water supplied by the newly improved facilities. The salable water which can contribute to the revenue is to be derived from 60% of the total water supply by the improved facilities in consideration of water leakage in the distribution system.

(f) Water demand is to be increased annually until 1995 in accordance with the projected water demand after completion of the project.

### 7.7.2 Loan Condition

Since loan conditions of the project can not be settled at this moment, it is tentatively assumed to be the following three cases.

(a) Case 1:
Both the foreign and local currency portions of the initial investment cost would be financed by a grant base. The replacement cost disbursed after expiration of the depreciation period is prepared under the stock condition of an annual interest rate of 8%.

(b) Case 2:
The local currency portion of the initial investment cost would be financed by a grant base and the foreign currency portion of the initial investment and the replacement cost would be financed by foreign funds under the loan conditions of an annual interest rate of 3.5% and a repayment period of 30 years including 7 years grace period.

(c) Case 3:
Funds would be financed as same as Case 2 under the loan conditions of an annual interest rate of 10.25% and a repayment period of 25 years including 5 years grace period. Moreover, commitment charge would be required as an annual interest rate of 0.25% for the initial investment cost.

### 7.7.3 Results of Analysis

The financial analysis of the above 3 cases are carried out and the results which show the required water rate are summarized below.

Water Rate

| Year* (Period) | Water rate (Peso/$m^3$) | | | | | |
|---|---|---|---|---|---|---|
| | Case 1 | | Case 2 | | Case 3 | |
| | A** | B*** | A | B | A | B |
| 1 - 5 | 2.92 | 2.92 | 8.64 | 8.64 | 14.38 | 14.38 |
| 6 - 10 | 2.68 | 2.52 | 7.35 | 6.47 | 11.50 | 9.51 |
| 11 - 15 | 2.54 | 2.35 | 6.41 | 5.17 | 9.38 | 6.61 |
| 16 - 20 | 2.48 | 2.35 | 5.92 | 4.78 | 8.19 | 5.45 |
| 21 - 25 | 2.53 | 2.35 | 5.56 | 4.38 | 7.29 | 4.29 |
| 26 - 30 | 2.50 | 2.35 | 5.38 | 4.61 | 6.98 | 5.66 |
| 31 - 35 | 2.48 | 2.35 | 5.26 | 4.60 | 6.81 | 5.87 |
| 36 - 40 | 2.46 | 2.35 | 5.16 | 4.53 | 6.60 | 5.31 |
| 41 - 45 | 2.45 | 2.35 | 5.06 | 4.33 | 6.38 | 4.74 |
| 46 - 50 | 2.44 | 2.35 | 4.96 | 4.14 | 6.14 | 4.17 |

* Year after starting service

** Water rate average up to the end of each period

*** Water rate average of every 5 years

As seen above, the required water rate is naturally different by the loan conditions and the period taken for the consideration. It is suggested that LWUA or ROX-WD office would conduct the overall financial analysis for the whole facilities referring to the analysis in this report.

# CHAPTER VIII. HYDROPOWER DEVELOPMENT PLAN

## 8.1 Power Supply Network and Demand Forecast

### 8.1.1 General Condition of Power Supply on Panay Island

The electric power supply on Panay Island is entrusted primarily to NPC, the National Power Corporation, for generation and transmission services, and to local power cooperatives for distribution services, as stated in Subsection 3.8.1.

Electric power supply in Capiz province is still primitive. The household connections number 26,621 out of 74,289 potential users in 1983,with an electrification rate of 36%. In the same year, the annual energy supply amounted to 27,100 MWh, or 1 MWh per connected household. Due to large transmission and distribution losses (40% in 1983), actual energy sales amounted to 15,473 MWh, of which 7,243 MWh, or 47% were for residential uses, 2,828 MWh (18%) for commercial uses, and 2,900 MWh (19%) for industrial uses. The average consumption level for residential use is relatively low, amounting to only about 272 KWh annually per connected household.

### 8.1.2 Existing Power Facilities

(1) Generation facilities

Generation facilities for Panay Island are owned by NPC and PECO. The facilities of NPC consist of four units of diesel generators at Dingle, Iloilo (called the Panay Diesel Power Plant I: PDPP I), two diesel generators at Panitan, Capiz (the Panay Diesel Power Plant II: PDPP II), and four gas turbines at La Paz, Iloilo (Power Barge Plant 2: PBP-2). A Power Barge Plant was nearly commissioned in 1984, by rehabilitating the original units erected in the Cebu Island. The total installed capacity of the NPC-owned facilities is 72,200 kW and the facilities owned by PECO totals 19,750 kW in installed capacity. The generating facilities of PECO are outdated and inefficient.

The total installed capacity of the Panay Grid comes to 91,950 kW. The total supply capability (station capacity) of the whole facilities is estimated to be 72,120 kW.

(2) Transmission and distribution facilities

NPC is the implementing agency with responsibility for setting up transmission grids (138 kV and above) in the Panay Island. It has a 138 kV main grid connecting the substations in Panitan and Sta. Barbara via PDPP II (Dingle). All the six power cooperatives are supplied from this main grid through self-owned 69 kV spur lines. The power transmission lines on Panay Island form an interconnected grid for power supply.

The distribution networks are owned by the power cooperatives whose supply areas cover 80% of Panay Island.

The electricity situation in the Panay Grid is however unstable with frequent supply interruptions and load sheddings. The generation capability is insufficient, even since the Power Barge came into operation in 1984, and in 1983 about 38% of outages were attributable to generation troubles. Load sheddings due to insufficient supply capability accounted for 27% of supply interruptions in the same year. With the introduction of the Power Barge Plant in 1984, the supply situation is assumed to have improved to some extent. Even with this, there still is ample room for further enhancement in supply capability in this area, that would bring about more dependable and efficient power generation in the Panay Grid.

8.1.3 Power Demand Forecast

NPC prepared power demand projections in 1984, including those for the Panay Grid, to establish a comprehensive program for development of power facilities. NPC also worked out sales target projections for Panay Grid in 1983. The latter assumed a growth rate of about 10% p.a. for electricity demand, while the former assumed a growth at a slightly lower rate. This Study used mainly the demand projections made in 1984 on the grounds that they were more conservative, though minor modification and extrapolation were made by correlation analysis. Both demand projections are shown in Table 8.1-1.

NPC Plans to interconnect the Panay Grid with the Negros Grid by 1989 by installing a 130 kV submarine cable. This will enable the power demands of the two islands to be integrated. The demand forecast of the Negros Grid was made by NPC in 1983 as part of the review of the feasibility study of the interconnection project.

## 8.2 Plan Formulation of Hydropower Development Project

### 8.2.1 Panay B Multipurpose Dam

The Panay B dam site is located on the upper part of the Panay River about 4 km upstream of Tapaz town. The catchment area at the dam site is 239 $km^2$, with an average streamflow of 14.3 $m^3$/sec, or an annual runoff of $451 x 10^6 m^3$. The topography at the site, particularly that of the right bank, restricts the prospective dam crest below El. 74.5 m. The foundation rock at the dam site is andestic volcanic breccia, overlying massive andesite. Foundation rocks are hard, consolidated and watertight.

The Panay B dam is proposed as a 52.4 m high gravity type dam, which would impound a reservoir of $96 x 10^6 m^3$ total storage capacity. An operation head of 27 to 35 m would be made available by a short waterway embedded in the dam body. A surface type power station is provisionally proposed on the left bank.

Simulation of reservoir operation was conducted on the basis of 23 years of estimated runoff data. It was confirmed that the above proposed reservoir would provide a 90% dependable discharge of 6.8 $m^3$/sec, or 56% of the annual average. With a plant maximum discharge of 27.2 $m^3$/sec, the installed capacity would be 7,100 kW. The annual energy generation would be 31.4 GWh.

The power generated at the Panay B power station would primarily be for transmition to the Panitan substation where it would be connected to the existing 138 kV trunk lines. For this purpose, a new 46 km long transmission line of 69 kV would be required between the power station and the Panitan substation via Cuartero.

## 8.3 Implementation Program for Hydropower Plan

### 8.3.1 Load and Supply Balance in Panay Grid

The power demand of the Panay Grid is expected to double, from 41 MW in 1984 to 84 MW by 1996, in 12 years. On the supply side, the dependable output of the Panay Grid will grow from the present 41 MW to 75 MW by 1989, by the commissioning of a 7.3 MW diesel plant at Dingle in 1984 and a 32 MW unit at Power Barge Station in 1985.

The scheduled interconnection with the Negros Grid will enable the swapping of power from/to the Negros Grid. A preliminary study on the power demand and supply has revealed that the Negros System would be capable of importing constant surplus power of 50 MW and allocating 40 MW for swapping to the Panay Grid.

The demand and supply balance of power in the Panay Grid is shown in Figure 8.3-1, based on the assumptions made above. The balance implies that the Panay Grid will need a new power source in 1995, even if the interconnection is realized. If the surplus power that the Negros Grid would supply is smaller than the above estimation, the time of commissioning would have to be earlier.

### 8.3.2 Recommended Plan

Based on the foregoing analysis, it is considered that commissioning of the Panay B dam would be desirable in 1995, in view of the power supply and demand balance. Economic evaluation of the Panay B dam was made in Subsection 5.2.3 (6) from which the EIRR value was assessed at 11.0%. Multipurpose development for flood control and hydropower generation at the Panay B dam was hence judged to be economically justifiable. In this regard early commencement of a study at F/S level is recommended.

# CHAPTER IX. ENVIRONMENTAL STUDY

## 9.1 Water Quality

The water of the Panay River is usually turbid and in yellowish in colour in the middle and lower reaches. If heavy rainfall continues for a few days, the river turns dark brown. The temperature of the water is around 26.5 to 31.8°C according to measurements by the Study Team. Assessment of water quality was based on samples taken and analysed from the five river stretches.

Although turbid, the quality of the water is acceptable for irrigation, municipal and industrial purposes. At the proposed Panay B site, in particular, since the watershed is mostly covered with scrub and forest, the inflow of organic material would be small and the possibility of eutrofication in the proposed reservoir is remote.

Salt water intrusion is of special importance in the Lower Panay River basin. During the dry season (January to April), the flow in the Panay River is very low and only a small portion of this reaches the Lower Panay. In addition, as up to 1.8 $m^3$/sec is taken for irrigation use, the Lower Panay is virtually non-flushing during the dry season.

At high tide the salt water prism reaches up to and sometimes beyond the pumping station of Roxas Water District. This contaminates the water supply of the town and district.

## 9.2 Soil Erosion

### 9.2.1 Sedimentation and Soil Erosion

The watershed of the Panay River is widely covered with highly weathered igneous rock units. The upper watershed of the Panay River up to an elevation of 400 to 500 meters is covered with corn, bean and cassava fields or with shrub. Natural vegetation in the watershed is sparse, with forests existing only at elevations of 600 meters and above. Therefore, the watershed is mostly erosion-prone.

The speed of erosion was measured from sediment loads transported in the streamflow, as part of the meteo-hydrological investigations. As a result, the annual denudation rate of the watershed was assessed to be 1.44 mm. This indicates that the denudation due to erosion of soil is relatively fast in the Panay River basin.

Soil conservation is thus a long-term necessity of great importance. For the purpose of establishing a comprehensive assessment on the need for soil conservation, a comparative study was made of the four sub-basins, corresponding to the dam sites of Panay B, C, Badbaran and Mambusao, using the land suitability maps and land use maps. First, an Erosion Hazard Classification Map was prepared, as shown in Figure 9.2-1 on the basis of the criteria formerly established for the "Land Capability Classification Guide", by the Bureau of Soils in 1976. In parallel with the above, the composition of land uses in the sub-basins were read on the land use maps as shown in Figure 9.2-2. Accordingly, the necessity for soil conservation was assessed in terms of the percentages of erosion hazard classification and present land use. The results of the erosion hazard classification and present land use are presented in Tables 9.2-1 and 9.2-2, respectively.

As the overall assessment, the sub-basins are deemed to be prone to erosion, judging from the criteria prepared by the Bureau of Soils. Reforestation of scrub areas is clearly desirable for soil conservation of the sub-basins and preservation of the existing forests should be given a policy consideration.

### 9.2.2 Shifting of River Channel

Straightening of river channels sometimes causes degradation in its upper reaches and aggradation in its lower reaches. In the Panay River, however, the slope of the river bed is gentle, about 1/4,000, and therefore the problem of degradation and aggradation in the shortcut channel is unlikely to take place.

### 9.2.3 Landslide

Interpretation of aerial photographs and geological observation revealed that landslides are scarce in the basin area.

## 9.3 Fish and Wild Life

The study of the fish population in the rivers of the basin was made on the basis of existing documents 1/, interviews with specialists of SEAFDEC 2/, with officials and with local residents in the towns of Dumalag, Dumarao, Dao, Sigma, Mambusao and Panitan. According to SEAFDEC specialists, no unique species of fresh-water fish exist in the Panay Island. In this regard, no serious problems are anticipated on account of the proposed storage development.

There is very little use made of riverine fish for home consumption and no problems are foreseen. The creation of reservoirs may even have a positive benefit, as the confined water body with a large surface area would enable the development of new fish culture. Plankton feeders, such as Tilapia, Common Carp and Chinese Carp would be suitable freshwater fish to begin with.

No information was obtainable on the wildlife of the Panay river basin. The areas along the middle and lower reaches of the Panay River are open and flat, with no conspicuous animal life. The storage development plan is not expected to have any major impacts on wildlife in the Panay River basin.

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Note 1/ Source : Feasibility Study of the Amnay Multipurpose Project, Sablayan, Occidental Mindoro

2/ SEAFDEC: The Southeast Asian Fisheries Development Center

## 9.4 Riverine Transportation

There is no regular river transportation on the Panay River, except near the estuary of the Pontevedra River and in the San Anton River. When the river water level is high, a power boat can travel from the estuary up to the towns of Cuartero and Dumalag, though no regular service is available. There are some river crossings by ferry boats at such towns as Dumarao across the Badbaran, Hagnaya across the Mambusao, and Panay across the Panay River.

The only through-the-river transport is conveyance of bamboo stems in rafts. The bamboo stems are rafted from the largest producing areas of Tapaz and Dumalag to Roxas city, through the main stretches of the Panay. Production of bamboo is an important industry to local residents, underlain by extensive demands as house materials. Riverine transportation provides a low cost means of haulage. If a storage is developed at the Panay C site, rafting of bamboo stems will be interrupted, and alternative means of transportation will have to be devised.

## 9.5 Public Health

According to the City Health Office of Roxas city, local residents are prone to a parasitic disease, locally called "lugay". This disease is reported to be common in the Philippines. Its infection process is attributed to insanitary drinking water and infected food.

There are no reports of endemic disease such as schistosomiasis transmitted through tremadodes or nematodes living on fish or snail. Also no reports have been issued by the Provincial Health Office concerning epidemic diseases such as malaria, dengue and H fever, infected through virus or bacteria-bearing insects such as flies and chigger. The occurrence of such epidemic diseases has yet to be investigated.

The sanitary conditions in the river basin are bound to be improved, if the water supply plan is implemented. Adequate potable water would minimize, if not totally prevent, the infection by waterborne diseases.

CHAPTER X. BASIN DEVELOPMENT PROGRAMS

## 10.1 Summation of Development Plans

### 10.1.1 Comprehensive Framework of Development Program

The plans mentioned below have been found worthy of development in the preceeding Chapters V to VIII. They consist of the following four plans:

(1) Flood control plans

The frameworks of Long-, Mid- and Short-term Plans were set out in Chapter V. This Study proposes that the flood control project be implemented by stages. The specific projects of each stage are detailed in Table 10.1-1, and summarized below:

Stagewise Implementation of Flood Contral 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 | None | 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, - : Assumed to have been implemented in previous stage
x : Contemplated

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 in abeyance until the increased potential value of damage increases the economic viability of the plan (i.e., EIRR more than 80%). Preliminary assessment suggests 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.

(2) Irrigation plans

- Panitan - Panay Irrigation Project : 3,250 ha
- Mambusao Irrigation Project : 2,145 ha

(3) Water supply plan

- Roxas City Water Supply Project : 7,450 $m^3$/day

(4) Hydropower generation plans

- Panay B dam : 7,100 kW

10.1.2 Outlines of Proposed Development Project

The following are the outline, purpose and timing of implementation of the proposed development projects.

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

<u>River improvement</u>

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

(a) Cogon bypass 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 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 the river 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 Panitan town (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 also be relieved of flood damages to some extent, since the flood levels would be lowered by the improvement work. The location of stretches for the channel improvement plans is shown in Figure 10.1-1.

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 Figure 10.1-2.

Polder dykes

Polder dykes would be embanked to lighten flood damages caused at 4 towns/villages with high flood damage potentiality (i.e. Dáo, Cuartero, Mambusao and Sigma. The locations of the planned polders are shown in Figure 5.4-1 and the general plans for each location are shown in Figures 10.1-3 to 10.1-6.

Non-structural measures

(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 risks of future flood damage. For areas 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 Figure 10.1-7.

Polder dykes

Polder dykes would be constructed additionally at 3 towns/villages, i.e. Maayon, Jamindan and Dumarao. The locations of the planned polders are shown in Figure 5.4-1 and the general plans shown in Figures 10.1-8 to 10.1-10.

(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 levels 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 the 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 Figure 10.1-11.

(4) Irrigation plan

(a) Panitan - Panay Irrigation Project

This plan would bring a total area of 3,250 ha under irrigation, by integrating the existing sporadic PIS's into one. The target yield was set at 5.0 ton/ha (paddy). For its location, refer to Figure 6.1-1.

A constraint inherent to the proposed development area is that the area is prone to flooding. Therefore some kinds of flood control measures should precede the implementation of the irrigation project. The Panitan - Panay Irrigation Project would have satisfactory economic viability (EIRR 11.7%), if protective measures that counter the 10-year flood as the protection level is enacted, as described in Subsection 6.5.1. The project is thus scheduled to start only after the 1st Stage Flood Control Project is completed.

(b) Mambusao Irrigation Project

This project would aim to rehabilitate existing irrigation facilities and to expand arable areas along the lower reach of the Mambusao river (for its location, refer to Figure 6.1-1). The project covers an area of 2,145 ha in total.

Like the Panitan - Panay irrigation area covered by item (a) above, this irrigation project is located in a flood-prone area. However, an evaluation revealed that the project would be feasible without providing specific measure for flood protection (EIRR 12.3%). Therefore the irrigation project would precede to flood control works (river improvement) which will be realized later under the 3rd stage project.

(5) Roxas city water supply plan

The Roxas city municipal and industrial water supply project proposed herewith, has the following two objectives:

(a) The existing water supply facility has the problem of aggravated water quality due to contamination of the existing water intake by sea water. The primary objective of this project is, therefore, to solve this problem, by diverting the streamflow of the main Panay river.

(b) The second objective is to enlarge the supply capacity of existing facilities. The required water supply capacity in 1995 is projected to be 11,650 $m^3$/day, while the present supply capacity is 4,200 $m^3$/day. The proposed intake and transmission facilities would make available an additional 7,450 $m^3$ of water a day.

Due to the urgency of item (a) it should be given priority for its early implementation.

(6) Hydropower generation plan

The Panay B dam, which is proposed as part of the 1st Stage work of the flood control project, could be completed in 1994 at the earliest. As discussed in Subsection 8.3.1, the power supply and demand balance indicated that the Panay Grid would be faced with a shortage in supply capability around 1995, as illustrated in Figure 8.3-1. Therefore the commissioning of the Panay B power station in time for that date would be justifiable. The electric power generated at the Panay B power station would be transmitted to the Panitan substation (138/69 kV) and thus feed the Panay Grid.

## 10.2 Implementation Program

Based on the principles concerning for implementation of specific projects set out in the preceeding Subsection 10.1.2, the "Master Schedule" of the basin-wide development program was formulated, as given in Figure 10.2-1.

## 10.3 Cost Estimation and Economic Evaluation of Development Program

### 10.3.1 Cost Estimates of Development Project

The total cost of the basin-wide development program 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 (₱x$10^6$) | Breakdown by Currency /1: Foreign currenty (US$x$10^6$) | Breakdown by Currency /1: 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 | 52 | - | 52 |
| e) Flood forecasting and warning system | 84 | 3.8 | 15 |
| Irrigation Development Project | | | |
| - Panitan-Panay Project | 183 | 6.0 | 75 |
| - Mambusao plan | 79 | 2.4 | 36 |
| Sub-total | 262 | 8.4 | 111 |
| Roxas City Water Supply Project | 56 | 2.1 | 18.1 |

Notes: /1 Rough estimation. Exchange rate: US$1 = ₱18
/2 Including power generating facilities
/3 Initial cost only

The details of project cost breakdowns are shown in Tables 10.3-1 to 10.3-8, and Table 5.6-1.

### 10.3.2 Economic Evaluation of Specific Projects

(1) Economic evaluation of projects

An economic assessment of specific projects is detailed in Table 10.3-9 and summarized 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: | | 9.6/1 | | - | - |
| (e) Flood forecasting/warning sistem: | | 4.5/1 | | - | - |
| (f) Overall | | 11.4 | | 9.8 | 15.2 |
| Irrigation Development: Panitan-Panay | | 11.7 | | - | - |
| Mambusao | | 12.3 | | - | - |
| Roxas City Water Supply Project: | | 16.9 | | - | - |
| (Reference) | | | | | |
| 1st Stage River Improvement + 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 Figure 10.2-1.

(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, except for a specific consideration given in (c) below.

(c) Polder facilities will be of no further use and therefore the benefits thereof will terminate in 2030 when the 3rd stage river improvement project is completed. The benefits thenceforward are counted in the 3rd stage river improvement project, which constitutes a major reason for a high EIRR of the 3rd stage project (15.2%). The overall EIRR of the river improvement projects, inclusive of 1st stage through 3rd stage works, is evaluated to be 9.7%. If polder benefit is considered not to be transferred to the 3rd stage river improvement project, the EIRR of the 3rd stage project will be 11.3%.

It should be noted that the river improvement for 1st Stage works 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 for the following conditions:

(a) Cost 20% up
(b) Benefit 20% down

The results of the sensitivity analysis are shown in Table 10.3-10.

## 10.4 Technical Considerations for Control Plan

### 10.4.1 First Stage Project

(1) Flow capacity of stretches downstream of Panitan

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 breaching of levees in the event of floods larger than the 10-year probable flood. To counter such eventuality the following measures should be taken:

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

- Levees should be well maintained and any deformation caused by uneven settlement should be made good. Provisions for flood fighting including organization of the team and preparation of materials should also be made.

- The flood forecasting and warning system should be established as described in Chapter V, in order to quicken precautionary measures and reduce risks of damage.

(2) Flooding condition of the middle reach of the Panay river

After the completion of 1st Stage Project, levees downstream of Panitan would be connected with highland banks, thus closing off the downstream areas. Hence, if the flow capacity of the improved stretches downstream of the Panitan is insufficient, flooding in the middle reaches of the Panay river might worsen in future. In this context, flood water levels at the Panay/Panitan base station were compared and the results are given below:

Estimated Flood Water Level at Panitan

(Upstream End of Dyking)

| Probable flood (year) | Present condition | | After improvement | |
|---|---|---|---|---|
| | Flood discharge ($m^3/sec$) | Flood water level (El. m) | Flood discharge ($m^3/sec$) | Flood water level (El. m) |
| 2 | 790 | 5.8 | 790 | 5.8 |
| 10 | 1,370 | 7.6 | 1,340 | 7.5 |
| 25 | 1,830 | 8.7 | 1,790 | 8.6 |
| 50 | 2,270 | 9.6 | 2,200 | 9.4 |
| 100 | 2,670 | 10.3 | 2,610 | 10.2 |

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.

(3) Local improvement work in upstream reaches

The present study concluded that the 1st stage river improvement would be limited to river stretches downstream of Panitan town (Case SP-1B. See Subsection 5.4.4) and the extension of improvement work in further upstream reaches (Case SP-1A: Partial improvement up to Mambusao junction) would not necessarily be attractive. Nevertheless, there may be a possibility that some local improvement works in upstream reaches, such as shortcutting at meanders and widening of bottleneck sections, may bring on a beneficial effect of increasing the flow capacity thereat, thus quickening the recede of the upstream flood water. Instead, it will result in an increased runoff in the downstream areas. The relative merit of such local improvement works should be examined in subsequent feasibility study stage as a part of the proposed downstream improvement work. The study should be based on detailed river cross section survey data to be taken at a reasonably short interval.

(4) Stretch at Panitan

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 from 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 (Floodway plan FW-3: See Subsection 5.2.2) is not likely to be viable. The details of the floodway plan should be further examined however at the feasibility study phase.

(5) Polder plan at Sigma (Fig. 10.1-5)

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

(6) 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 is 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 Curtero 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. 10.4-1.

### 10.4.2 Second and Third Stage Projects

#### (1) Risk associated with high levees

In 2nd and 3rd Stage Projects, proposed structural measures will include construction of high dykes to accommodate a large flood of 25- or 100-year recurrence. In this regard, the following items should be given due attention:

- The levees will be safe only against flood levels lower than the design flood level

- The flood damage potential in areas protected by levees would naturally rise, and, therefore, careful consideration should be given in determining the design discharges

- On grounds of the uncertainty involved in flood flow analysis and possible future change in flood runoff characteristics resulting 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 levees, therefore, provision will have to be made that will allow room for future counteractions:

(a) Heightening of levees and/or widening of river channel by backward disposition of levees: This might be difficult 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, deliberate consideration will have to be made of possible effects on flood discharge concentration in the lower reaches.

As a rule, if high levees are to be constructed, accommodating a flood larger than the design discharge must be avoided at all costs.

(2) Confluence with the Maayon river

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 at low elevation. These fields are in flood prone areas subject to backwaters from the Panay mainstream. Because of its large catchment, this area receives a large flood runoff (1,000$m^3$/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.

(3) Confluence with the Balacuan river (a tributary of the Mambusao river)

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 about 800 ha at El. 8 - 8.5 m which are used as natural flood retardation basins and devoid of any particular land use.

Since the lowlands form a basin, the construction of back dykes for flood control would be 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 drainage at the gate, though this was not contemplated for 3rd Stage Project.

(4) Measures against inland water

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 will be made of the inundated area based on maps at a scale of 1/2,500.

(5) 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 |
| Panay C Dam (BP-1) | 2,153 | 31.09 | 2,153 | 31.09 | 1,860 | 30.26 |
| Dumalag (BP-2) | 2,189 | 26.67 | 2,189 | 26.67 | 1,890 | 26.01 |
| Conf. w/Badbaran R. (BP-3) | 2,048 | 22.56 | 2,244 | 22.57 | 1,940 | 22.01 |
| Cuartero (BP-7) | 2,383 | 19.91 | 3,330 | 19.28 | 3,090 | 18.95 |
| Conf. w/Mambusao R. (BP-8) | 2,382 | 16.46 | 3,346 | 18.40 | 3,110 | 18.02 |
| Conf. w/Maayon R. (BP-13) | 2,684 | 12.84 | 4,457 | 13.48 | 4,230 | 13.24 |
| Panitan (BP-17) | 2,668 | 10.29 | 4,524 | 11.99 | 4,380 | 11.82 |

Note: Along Main Stream of the Panay river

The talbe 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 | 0.66m |
| Cuartero(BP-7) | 240 | 0.33m |
| Panitan (BP017) | 144 | 0.17m |

The effect of (Third Stage) flood control works on peak discharge and peak water level is shown in Fig. 10.4-2 where the effects of Panay B dam and river improvement are respectively shown in the same figure to see the effect of each works clearly.

## 10.5 Fish Culture and Groundwater Development

### 10.5.1 Fish Culture

In the Panay river basin, fishponds already occupy a total area of 10,560 ha and only 1,850 ha of natural forests of mangrove and nipa remain in the lowlying swamp and marshes along the coast. From the standpoint of eco-system conservation, further expansion of fishponds is not desirable. Improvement of fish culture, therefore, should be sought by enhancing the productivity in existing areas. Enhancement of unit yields would be achievable by installation of hatcheries and rearing tanks for production of fry and by introduction of appropriate methods of breading and capturing fish.

It was reported that the culture of prawns would be about 1.3 times more profitable than the culture of milkfish. The fishponds for milkfish culture extend over about 7,750 ha, and if they were converted to prawn farms, incremental production would be about 13 x $10^6$.

There are presently five methods of commercial production of the prawns; i.e. (i) fry collection at shore waters or mangrove areas, (ii) artificial fry production in the hatcheries, (iii) inshore fisheries by fish corrals, baby trawlers and other fishing gear, (iv) offshore fisheries by commercial trawlers, and (v) prawn cultivation in brackishwater ponds. The last seems to be the most promising industry, supported mainly by artificial fry production, and in the near future may be the most widely used method of the production. In the next stage, a more detail study should be carried to examine the merits of these five methods, including a study on any changes of the present aqua eco-system after implementation of flood control works scheduled in the area.

10.5.2 Groundwater Exploration

A preliminary survey was conducted during this Study to assess groundwater potential in the Panay river basin through review of existing data, inventory surveys of existing wells, and measurement of electric conductivity of water samples collected from the wells and the rivers.

As a result, it was found that the potential for groundwater exploitation in the Panay river basin was not promising due to poor aquifers in the area and the low quality of groundwater in the existing wells.

This does not deny the possibility of groundwater development to a small or moderate scale in local areas. These potentials could be identified on an individual project basis based on further investigation. The investigation should be based on a detailed in-situ sub-surface exploration including electrical prospecting, core drilling, etc.

Judging from geological and topographic conditions, potential areas will be limited to flat plains along the main Panay river, Mambusao, Badbaran, Maayon and Pontevedra rivers in reaches downstream from Dumalag, Dumarao, Maayon and Jamindan respectively. Exploitable aquifers would not be expected in the area downstream of Pontevedra because of saline contamination.

## CHAPTER XI. RECOMMENDATION OF FURTHER ACTIONS

In previous chapters, the Study has identified attractive projects for development in the Panay river basin, with a list of selected projects worthy of implementation. Along with the findings of the Study, several additional recommendations are made in this Chapter, concerning project implementation.

(1) Immediate implementation of priority projects

(a) The most urgent projects in terms of both economic viability and the meeting of social needs will be (i) Flood Control Project - 1st Stage (incl. Panay B dam and polder plans) and (ii) Roxas-WD Water Supply Project. The next steps for realization of these two projects should be started immediately, namely:

| | | |
|---|---|---|
| - Flood Control Project | : | Feasibility Study on 1st Stage Project |
| - Roxas-WD Water Supply Project | : | Detailed design including overall review of the present study |

(b) It is recommended to proceed with the feasibility study of the Mambusao Irrigation Project at an early period. The feasibility study of the Panitan-Panay Irrigation Project should also be commenced so that the project can be completed immediately after the completion of the Flood Control Project.

(2) Implementation of Mid- and Long-term Flood Control Plans

This Study indicates that the 2nd and 3rd Stage Flood Control Projects will be necessary in future when the benefits assessed in current value will give a rate of return above 8%. Based on this criterion, the implementation was tentatively proposed in the years 2005 and 2022 for the 2nd and 3rd Stage Projects respectively. This schedule, however, should be reviewed if more importance is placed by Government onto social factors (such as stabilization of livelihood of local inhabitants) and/or regional development. Although 2nd and 3rd Stage Projects are proposed for the distant future, the implementation schedule should be kept under review.

(3) Panay C, Badbaran A and Mambusao B dams

The present study revealed that the development of dam schemes would be justifiable only at Panay B site. Panay C dam was not included in the proposed development plan, partly because of its relatively low economic index, and partly because of problems associated with inevitable submergence of a 40 $km^2$ area including Tapaz town. The other two dams, Badbaran A dam and Mambusao B dam, were excluded from the proposed plan in terms of economic viability. If the flood runoff characteristics should change in future as a result of activities in the upper area and/or if the damage potential should increase due to economic development in the lower areas, then the case for these dams should be reviewed. It is recommended therefore that the possibility of constructing these dams should not be completely ruled out but be kept under review.

(4) 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 Figure 11-1, and the recommendations concerning the land use in the specific areas are presented in Table 11-1.

In the above categories, acquisition of land will have to be conducted for the item (c) above. Although the enforcement of strict land use regulations 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.

(5) Hydrological observations

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, storm rainfall and sediment records. In order to provide sufficient data for subsequent studies and design of the Project, it is emphasized that the following observations should be continued:

- 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 gauges presently installed).

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

- Measurement of sediments at the representative locations

(6) Detailed surveys on non-structural measures

Present study on non-structural measures (See Section 5.5 of Chapter V) 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.

(7) Economic evaluation of power supply

A preliminary economic evaluation included in this master plan study was based on alternative thermal plant costs. The output of this study should be further refined in the forthcoming feasibility study, in which the optimization study would take into account the least cost solution of power development program of the Panay Grid.

(8) Reservoir sediments

The present study assumes the sediment yield to be 1,400 $m^3/km^2$/year in the upper reaches in terms of denudation rate, which was derived from the observation records in the Jalaur river located in Panay island. In view of the importance of heavy siltation in the limited reservoir storage capacity, the estimated figure should be further confirmed in the subsequent studies.

(9) Guidelines for revervoir operation

In this master plan study, a simplified operation of the reservoir was proposed by providing independent storage allocation each for flood control and hydropower. In the next-phase study, more sophisticated reservoir operation can be proposed in order to make the scheme more beneficial.

(10) Deterioration in efficiency of existing plant

The present study takes into account only the retirement of old diesel plants in planning the system development. However, other than the transmission and distribution loses, deterioration in the efficiency of the existing plants should be considered. It is suggested that this matter will be clarified in the feasibility study based on more detailed inventory survey of the existing plants.

(11) Water demand projection

In regard to projections for future water demand, an increase of per capita consumption is expected after completion of the project. It is suggested that a sophisticated analysis on this matter is examined in the next-phase detailed study.

(12) Reforestation

The present area of forest in comparison with that of shrub is very limited. The conservation of present forest and the reforestation seem to be necessary for the environmental conservation, flood control due to the storage function of rainfall, and the forest industry development. The reforestation plan in the Panay river basin has to be made in consideration of the nation-wide reforestation plan. It is suggested to investigate the present forest condition in detail and to formulate basic reforestation plan in the future stage of study.

(13) Schedule of feasibility study for irrigation project

In the present schedule for feasibility study of irrigation project, the study for Mambusao area is scheduled to start about 1 year earlier than that for Panitan-Panay area. However, it is suggested to consider to undertake the study of both areas at the same time for administrative convenience and economics of scale.

(14) Flood risk map

As one of non-structural measures, the preparation of flood risk map is required. Though the comparatively detailed survey for Undang flood was carried out during the additional investigation in June 1985, the further detailed survey is suggested to be carried out in the next stage for the preparation of flood risk map which would be available not for the reduction of flood damage but also for the proper land use.

(15) Long-term observation of river behavior

The characteristics of river behavior is different at each river. Therefore, the long-term observation of river behavior, including the river bed change, meandering and hydrological observation, is suggested to be done for future flood control study. Especially, it is necessary to know the behavior of natural river like the Panay river.

(16) Cost allocation of water supply project

In the present study, the cost of water supply project is allocated only for the water supply project, nevertheless the subsidiary benefit is expected for irrigation due to the increment of fresh water. Therefore, it is suggested to consider the necessity of cost allocation for saving the cost of water supply project. However, it is noted that the benefit for irrigation can not be included after the proposed Panitan-Panay irrigation scheme is put in service.

(17) Phased execution of water supply project

In the present implementation schedule of water supply project, the project is executed without phase. However, the phased execution can be also considered in case the preparation of project budget has difficulties. The phased execution is suggested to be studied in the next stage of study, if required. For example, the following phase seems to be reasonable.

(a) Construction of tidal barrier

(b) Excavation/Dredging of the lower Panay river including the cut-off channel and construction of intake gate at the entrance to the lower Panay river

(c) Construction of additional pumping facilities

(18) Detailed investigation for non-structural measures

The study for non-structural measures in this report is still limitted in the range of preliminary study due to the shortage of date and the study in each area of 23 river stretches. In the next stage of study, it is necessary to carry out the detailed investigation including that of property and consciousness of inhabitants. Additionally, the study for definit management of non-structural measures considering the law is also necessary for feasibility study.