2.1.4 Development Strategy

The basic idea of development component applied into the area is outlined in the master plan study. In the context of the master plan, development plan is formulated by considering where and for what purpose the above mentioned measures will be taken to cope with the development constraints mentioned in 2.1.1.

The scale of infrastructure measures will be determined based on the physical factors related to timing, extent and degree of flood protection and irrigation, and the agricultural factors related to prospective land use and farming patterns. Non-infrastructure measures will be undertaken based on the progress of government support programs and possibility of farmers' participation. However, implementation capability of the concerned government offices is uncertain and limited. Development programs should therefore be approached with caution. If financial capability to run the proposed development plan is also limited, strategic implementation scheme should be undertaken.

Under such considerations, an idea of stage development will be proposed in the area. In the stage development, both measures will be optimized within each stage. Development scheme for each stage will be completed with comparative development advantages and certain level of production benefits. Under such considerations, three (3) alternative development stages are proposed as follows (see Figure 2.1).

Stage-1

Considering that the Phtea lake area was selected as a priority area for agriculture development plan harmonized with fishery, the F/S study may deal with agricultural development with fishery. Development attention, therefore, puts on the lowland agricultural area, the fishery area and the rainfed or shallow flooded area close to the lowland. Development plan harmonized with fishery will be stressed at this stage with provision of basic facilities. Rehabilitation of reservoirs will allow full irrigation in the lowland areas and provision of new roads/dikes that will serve as flood protection and water conservation dikes. Water conservation weir will support the establishment of stable fishing ground. Construction/rehabilitation in this stage is the minimum requirement to attain the target.

Stage-2

The lowland area is linked with the higher elevation area by the colmatage canals. Further development of the lowland area is needed to control flood intrusion from Mekong river. To shift from single cropping to double cropping, a period of flood protection is required to allow harvesting work under dry field condition. This stage is proposed by adding control gate at the entrance of the colmatage canal to stage-1. With installation of new gates and construction of dikes/farm roads in stage-1, flood intrusion will be protected to some extent in the shallower inundated area. This will enable the extension of intensive farming. Degree of inundation in the recession farming area will be the same as in the present condition.

Stage-3

Full development will result to full flood protection and water control. Forming enclosed dikes with control gates is one effective way to control flood intrusion. Blocked area with dikes

could be developed. This stage is the extreme development model derived from an idea of enclosed dikes that is made by adding some structures to that of stage-2. Road network will be developed with construction of new roads and connection with district roads. This will finally form a circumferential road. With the completion of road network, the whole area is considered as one enclosed area. To enable the deeply inundated farming area to introduce double cropping, flood intrusion should be controlled to some extent. For this purpose, installation of control gate is planned along the present district road. This stage will show an advanced development picture where all physical constraints are eliminated, although it requires much investment. Since this development idea would create a big impact in the area, it should be preceded with caution and be accomplished in line with the medium and long term development scheme of the area.

Although non-infrastructure measures differ by expected agricultural pattern for each stage, operation and maintenance of the facilities are the minimum requirement needed for successful implementation of the proposed projects. Operation and maintenance supporting office should be established in stage-1 to set up some operation and maintenance groups. Supporting services' activities will be strengthened according to various levels of farming practices and farmers' participation in the stage development.

2.2 Land Use Plan

2.2.1 Basic Concept

Both factors of fluctuation of floodwater and land elevation restrict the physical availability of land on the ground or under inundation. The land use situation always changes according to floodwater level. In this study, the flood control/protection plan along the Mekong is not considered. This would therefore mean that the Study Area would still receive the effect of floodwater. As a consequence, the present land use situation will not change drastically.

Floodwater usually covers most of the Study Area at the peak of flood. According to the hydrological analysis, the peak water levels of 1/2 and 1/10 return period in the Study Area, Phnom Penh, are EL. 9.33 and EL. 10.47 m, respectively. The land below EL. 9.0 m occupies more than 85% of the Study Area. Hence, majority of the Study Area is covered with floodwater once every two-years.

Considering the above-mentioned conditions, the construction/rehabilitation of agricultural infrastructures such as farm roads, reservoir dikes and canals are planned. These infrastructures will not change the basic land use category because its primary function is the control of timing of flood intrusion into the areas concerned and not the full prevention of flood.

Taking these matters into consideration, the basic concept of agricultural land use is derived as follows;

- The basic land use conditions will not be changed drastically because floodwater comes yearly even after the provision of agricultural infrastructures planned in the study.
- With the construction/rehabilitation of agricultural infrastructure, flooding condition itself would not be changed. However, length of flooding period would somewhat be controlled

because farm roads will also function as flood protection/retention dikes. (It is also possible to infuse flood water into farmland that are late for harvesting and to retain floodwater longer.) Therefore, flood damages of crops will be reduced for rainfed paddy, upland crops and orchard areas.

- The development of new farmland is limited only in the waste/grass/bush land.
- The vegetation of reservoir/inundated forests will be conserved as these areas have important multi-purpose functions such as, supply firewood for rural people fish habitat and hatchery, not only at present but also in the future.

2.2.2 Land Classification and Potential Area

(1) Land Classification

Since this study aims to enhance agricultural production, land classification will be applied to farmland occupying 58% of the whole area.

From the viewpoint of rainfed paddy in the Study Area, EL. 8.0 and 9.0 m become distinctive levels. As mentioned previously, the peak water levels of 1/2 and 1/10 return period are EL. 9.33 and EL. 10.47 m, respectively. Usually, height of wet season paddy is from 0.8 to 1.2 m (1994 Research Report, "Section 2. Rice Varietal Improvement," CIAP). If the height is about one (1) m, the paddy field below EL. 8.0 m is likely to flood over and receive flood damage once every two-years, statistically. This paddy field area is classified as frequent flood damage zone. In the same way, the rainfed paddy field above EL. 9.0 m is likely to receive flood damage only once every ten-years. This paddy field area is classified as scarce flood damage zone (see Tables 2.1 and 2.2).

The same method is applied to the irrigation paddy and upland crops and orchard areas. Generally, irrigation paddy can be harvested before floodwater comes, so it is rarely affected by flood damage. On the other hand, upland crops are sometimes affected by flood damage because they are located in lowlands. The cropping seasons of most crops start in accordance with rainfall, mostly in May. In this case, the fields of upland crops and orchard below EL. 9.0 m are classified as frequent flood damage zone and the fields above EL. 10.0 m are classified as scarce flood damage zone (see Tables 2.1 and 2.2).

As to the recession paddy fields, there are no differences of water availability based on land elevation because the recession of floodwater gradually starts from highland to lowland with only time lag of cropping between the high and low fields. Usually, receding floodwater is used for initial paddy growth. After the completion of floodwater recession, it needs supplementary irrigation to get good harvest.

If the reservoir dikes are rehabilitated, the volume of stored water increase would be sufficient to irrigate the recession paddy area. There may be local irrigation water shortage caused by inadequate water distribution from reservoirs to fields, especially for farms far from the reservoirs. However, the stored water volume will be secured as a whole. Consequently, in the recession paddy area, there will be no big differences related to field location/elevation.

If farm road conditions will be improved and timing of flood intrusion into the recession paddy

area will be delayed in the future, upland crops could be cultivated to some extent before flooding. In this case, the non-flooding period becomes an important factor to land use. In the Study Area, the cropping period of wet season upland crops generally starts in May/June and ends before flooding. If the flood comes in September, 3 to 4 months of cropping period is secured for crop growth. However, if it comes in August, cropping period becomes shorter, only 2 to 3 months. According to the length of available cropping period, the recession paddy area is classified into three sub-categories (see Tables 2.2 and 2.3).

(2) Potential Area

In the center of the Study Area, dry season recession paddy consists of 1,600 ha. According to the field survey, not all fields for recession paddy are cultivated yearly. Some of the fields remain fallow or planted with mat grass. Early type of mat grass can be harvested within two (2) months after transplanting so water requirement is less than that of recession paddy. Some farmers plant mat grass if they can not secure enough irrigation water for paddy. The area for mat grass is estimated at 20-30% of the recession paddy area.

On the other hand, there are large areas of rainfed paddy, mostly distributed in the eastern part of the Study Area. With the occurrence of severe flooding in the previous year (peak water level - 9.92 m at Phnom Penh, October 3, 1996), many rainfed paddy fields were affected by serious flood damage not only in the Study Area but also in other areas. During the field survey, many dead straws were observed in the field. Despite the serious damage, some fallow fields here and there were observed. The ratio of fallow area is supposed to be about 30% of total.

Besides the two (2) types of fallow paddy fields, some parts of the waste/grass/bush land can possibly be included as potential area for agricultural development, if sufficient water is available. This land category is commonly distributed to the areas between EL. 6.0 to 8.0 m. These areas are usually inundated for about 2 to 4 months according to the hydrological analysis. Since only few reservoirs located above EL. 7.0 m can be provided with irrigation water by gravity, these lands can not be used as recession paddy fields. Some areas in Vihearsour are used as seedbeds for recession paddy. Wet season upland crops are cultivated in some areas affected by moderate floods. However, farming of wet season upland crops is unsuitable in areas affected by floodwater for about 4 months, because growth periods can not be taken long enough before flooding without irrigation system.

Considering the land classification, land use areas by each development stage are clarified. With the completion of stage-1 development, agricultural production will increase in two major paddy areas. Also, flood damage will be reduced in the rainfed paddy, upland crops and orchard areas. With the completion of stage-2 and -3, irrigation paddy and upland crops' areas and the recession paddy area, respectively will increase (see Table 2.4).

2.3 Farming Harmonized with Fisheries

2.3.1 Proposed Cropping System

In the Study Area, there are three major cropping systems according to agricultural land use categories; (1) recession paddy area, (2) rainfed paddy area and (3) irrigation paddy and upland

crops' area. However, the three (3) systems will not change even after the completion of the development plan. The general characteristics of each cropping system and the projected agricultural effects are presented below (see Table 2.5).

(1) Recession Paddy Area

The main crop for this area is recession paddy widely observed in the center of the Study Area. Usually, the cropping period from transplanting to harvesting is about three (3) months because IR varieties are commonly planted. However, transplanting season varies from October to February based on the recession of floodwater. Harvesting season also varies from January to May. Without flood control and irrigation systems, cultivation of upland crops on recession paddy area is very limited.

Besides recession paddy, mat grass is presently cultivated as a substitutive crop for paddy in case of shortage of irrigation water. The planted area for mat grass will decrease after the reservoirs are rehabilitated.

With the rehabilitation of reservoirs in stage-1 development, sufficient water for irrigation is expected. As a consequence, the recession paddy planted area will be expanded through the increment of cropping intensity.

Moreover, with the construction of flood control gates at stage-3 development, it is possible to control flood intrusion into the recession paddy area. Accordingly, upland crop cultivation with natural rainfall before flooding will be expanded to some extent.

(2) Rainfed Paddy Area

The main crop is rainfed paddy widely cultivated in the eastern part of the Study Area. Usually, the period from transplanting to harvesting ranges from 4 to 5 months because several local varieties with different growth duration are commonly planted. Transplanting season generally starts in July or August after the completion of land preparation. Harvesting season is in November or December.

Upland crops can not be cultivated widely because of the difficulty to secure irrigation water during the dry season due to its relatively high elevation. The cultivation of upland crops on rainfed paddy area is just limited to small-scale basis, around houses, and not expected to be expanded to larger-scale.

With the construction/rehabilitation of farm roads/dike in stage-1 development, it is possible to reduce flood damage. Also, the construction/rehabilitation of canal systems of stage-1 development will enable planted areas to be increased through the increment of cropping intensity. Consequently, the production of rainfed paddy will also increase.

(3) Irrigation Paddy and Upland Crops Area

Upland crops such as maize, sesame, vegetables, etc. are mainly cultivated on the natural levee of the Mekong and along the colmatage canals. Usually, the cropping season starts in May or June when rain begins. If it is not flooded, double or triple cropping is possible. In this case,

final harvesting season is in February or March.

Besides upland crops, irrigation paddy is also practiced on the levee of the Mekong. However, even with the provision of infrastructure facilities on irrigation paddy, the effect is limited because cultivation area is relatively higher. Moreover, it is not commonly practiced because of the need to pump irrigation water from the Mekong. Only farmers with movable pumps practiced this type of farming activity.

With the construction/rehabilitation of farm roads/dike at stage-1 development, it is possible to reduce flood damage of upland crops by controlling flood intrusion into the area. It is also supposed to expand the planted area through the increment of cropping intensity with the construction/rehabilitation of colmatage canals in the stage-2 development. Therefore, production of upland crops will increase.

2.3.2 Farming Practice

Data and information of present farming practice by crop are collected from the Rural Socio-economic Survey. Same as the agricultural land use conditions, farming practices of major crops are not changed drastically with the development plan.

(1) Recession Paddy

Photoperiod insensitive early/medium duration varieties such as IR66 and IR42 are presently planted in the Study Area. In the future, they will still remain as the major varieties. IR42, released in the Philippines in 1977, has high yield potential and is pest resistance but with longer growth duration and taller height than IR66 (growth duration: 135 days, plant height: 110 cm). Some farmers may replace from IR42 to other varieties because of its longer growth duration that will need more irrigation water. Also taller height is subject to lodge. Some improved varieties, as IR72, Kru and IR Kesar, released by CIAP in 1990 are recommended for irrigated early duration paddy (see Table 2.6).

The rehabilitation of reservoirs will provide more water that makes it possible to irrigate more recession paddy fields by gravity. Consequently, working hours for irrigation will decrease but some operation/maintenance works for canals and reservoirs will be necessary.

Draft animals, both cattle and buffaloes, are generally used for land preparation, plowing and harrowing. At higher elevation fields distributed in Prek Tamerk and Vihearsour, first plowing is conducted on July before flooding. In other fields, land preparation is usually begun one month before transplanting. As floodwater is receding, transplanting is operated from October to February, from highland to lowland. The age of seedlings is usually 20 to 30 days. Harvesting season commonly starts on January to May, about three (3) months after transplanting (see Figure 2.2).

Although the present input rate is little, inorganic fertilizers are customarily used for recession paddy. Half of recession paddy practicing farmers use agricultural chemicals. At first, it is strongly recommended to use effectively natural material, such as manure, green manure, plant waste and ash, for improvement of soil fertility. However, the application of inorganic fertilizers and agricultural chemicals will be more popular in the future because the improved

varieties are usually reactive to inorganic fertilize. They also need appropriate cultural management practices to obtain high yield.

(2) Rainfed Paddy

Photoperiod sensitive medium/late duration traditional varieties such as Sar Thungun and Bonla Phdau are presently planted. In 1992, CIAP released three high-yielding improved medium duration varieties developed by the IRRI, namely, Santepheap 1, Santepheap 2 and Santepheap 3 (santepheap means piece in Khmer). With suitable cultural management practices in station experiment, their yields exceed 3.5 ton/ha. On-farm experiments conducted from 1992 to 1995, for these three varieties had 4-16% yield advantages over the local varieties (see Table 2.7).

Also in 1995, six (6) additional high-yielding traditional varieties (CAR 1 to CAR 6: 3 of which are of medium duration and the three (3) others are of late duration) were released by CIAP. They are pure line selections from traditional Cambodian rice germplasm. CAR 1, CAR 2 and CAR 3 are suited for rainfed lowland paddy areas requiring photoperiod sensitive medium duration varieties and CAR 4, CAR 5 and CAR 6 are suited for rainfed lowland paddy areas requiring photoperiod sensitive late duration varieties. Their yields are superior to local check with various conditions (see Table 2.8).

If it is possible to obtain certified seeds of these high-yield varieties, it is recommended to replace present traditional varieties with new released varieties because the yield advantage of new varieties is obvious even in on-farm level.

The construction/rehabilitation of canal systems will enable irrigation water to keep near paddy fields. This will make possible the easy distribution of water. Also water is secured and available even with occurrence of erratic rainfall.

Land preparation and seedling raising are usually conducted from June to July. Transplanting is done continuously. Harvesting season starts on November for medium duration varieties and December for late duration varieties.

Generally, farmers do not use both inorganic fertilizers and agricultural chemicals for rainfed paddy. This is because rainfed paddy has more possibility to be affected by flood damage than recession paddy. Farmers therefore do not invest/apply fertilizers and agricultural chemicals for rainfed paddy. Initially, it is strongly recommended to use natural material, such as manure, green manure, plant waste and ash, as much. However, if flood damage would be reduced, the application of inorganic fertilizers and agricultural chemicals might become more common since appropriate application would evidently enhance crop yield.

(3) Upland Crops

At present, upland crops such as sesame, cassava and maize are popular in wet season. In dry season, mungbean, tomato and watermelon are common. In the future, these planted crops will still be planted but some vegetables will be increased gradually.

It takes less than one (1) hour by ferryboat and car or motorcycle from the Study Area to Phnom Penh, the largest market. Some farmers in Prek Tamerk have already started to sell leafy

vegetables to Phnom Penh since it is lucrative even if they pay transportation fees. Marketing of fruit vegetables have also high potentials if both quality and volume are satisfied. Water availability is one of the constraints in the area but after the rehabilitation of colmatage canals, it is possible to use water stored in the canals.

At present, seedling pots and mulching using natural material are common among the farmers. It is strongly recommended to effectively use natural materials, such as manure, green manure, plant waste and ash, to improve soil fertility.

The application of inorganic fertilizers and agricultural chemicals depends on the type of planted crop. Cassava and maize are customarily planted without inorganic fertilizers and agricultural chemicals. On the other hand, sesame and vegetables are planted with some inorganic fertilizers and agricultural chemicals at present, although the application amount is very little. If the farmers recognize that the application of inputs will enhance crop yields, the application of inorganic fertilizers and agricultural chemicals will become more popular.

(4) Farm Types and Labor Requirement

Considering the Rural Socio-economic Survey, land use and proposed cropping patterns, three typical farm types are designated as follows.

Farm Type	Commune Distribution	Farm Size(ha)
Recession Paddy + Upland Crops	Prek Tamerk, Puk Reusei, Prek Ampil	0.5-1.0
Recession Paddy/Rainfed Paddy	Vihearsour	1.0-2.0
Rainfed Paddy/Animal Husbandry	Sanlung	0.7-1.4

According to the proposed cropping patterns, labor requirement in the Study Area will be at the maximum in December due to transplanting of recession paddy, harvesting of rainfed paddy and land preparation of two kinds of upland crops. Based on the estimation of labor requirement and labor supply, the available labor force in the Study Area will be able answer the demand for labor requirement

2.3.3 Yield and Production

Considering the Rural Socio-economic Survey, present yields in the Study Area were estimated. Except for the yields of paddy, the yields of upland crops are much higher than the yields of district and province (ex. Mungbean in dry season: calculated value-1.85 ton/ha, district yield-0.65 ton/ha, provincial yield-0.77 ton/ha). So for study purposes, the district yields are applied as the present yields for mungbean, vegetables and maize, and the provincial yield is applied for sesame.

Considering the experimental results of CIAP and statistic data, projected yields are estimated. As for recession paddy, the experimental data and the statistic data of dry season paddy are both relatively high, ranging 3.45-4.20 ton/ha. Average of those data is 3.74 ton/ha which represents 129% of present one. Practical projected yield is set as 3.48 ton/ha, 20% higher than the present one. For wet season paddy, the experimental data and the statistic data are also high, ranging 2.09-4.24 ton/ha. Average of those data is 2.81 ton/ha which represents 175% of

present yield. Practical projected yield is set as 1.93 ton/ha, which is 20% higher than the present yield as same as dry season paddy (see Tables 2.9 through 2.11 and Figure 2.3).

The projected production is calculated with these projected yields and the planted areas by each development stage (see Tables 2.10, 2.11 and Figure 2.2).

2.4 Agricultural Infrastructures

2.4.1 Basic Development Concept

The agricultural land use area is divided into recession paddy area, rainfed paddy area, irrigation paddy and upland crops' area including some areas of waste/grass/bush area. Basic development concept should be formulated taking into account the characteristic of each land use area. Most of farmers listed poor transportation system of input/output products, absence/lack of irrigation system, and prevention of flood, as the constraints to development. Provisions of such infrastructures are therefore the most urgent subjects in the Study Area.

Since most of farmers hold on the possession of their farm lands that is about 1.0 ha on average in the Study Area, the acquisition of land for new construction of reservoir dikes, farm roads and canals would be difficult. It would therefore be more advantageous if the present facilities be rehabilitated instead of constructing new ones. Considering that operation and maintenance of the facilities would be conducted by farmers themselves, structure of the facilities should be simple and small in scale.

2.4.2 Rehabilitation of Reservoirs

There are 37 reservoirs that will be rehabilitated as irrigation water storage pond in the Study Area. Semi-closed type reservoirs are located at the higher elevation area of colmatage farming area. Judging from the topographic condition, heightening the crest of dike would be difficult. There is also no possibility to increase the capacity of reservoir. However, reinforcement of dikes is planned to maintain the original capacity. On the other hand, closed type reservoirs are mainly located at the recession paddy areas. The potential of development as the water resource is high enough by heightening their dikes (see Figure 2.4).

Considering the meteorological data and the proposed cropping patterns, water requirement for recession paddy is estimated at 570 mm. However, evaporation from reservoir surface is about 950 mm during recession paddy cropping. According to the land use plan, irrigable area around the reservoir for recession paddy is estimated at 830 ha. Existing irrigated recession paddy area is estimated at 430 ha. The balance between them is 400 ha. If all of 830 ha would be irrigated, total water requirement is estimated at 9.7 MCM that consists of 4.7 MCM for crop consumption and 5.0 MCM for evaporation of reservoirs. To store the total irrigation water requirement for recession paddy area, it is necessary to increase the height of dike by about 1.0-2.0 m on the existing crest (see Table 2.12).

Typical rehabilitation plan of the closed type reservoir is shown in Figure 2.5. To conserve inundated forest and fish habitat in the reservoir, water conservation area should be set along the often dike by constructing ditch/canal of 10 m in width and 2 m in depth. Freeboard to protect slopes often eroded by rainfall or floodwater would be considered in the design stage. The

width of crest is divided into two types. Three (3) m in width is applied for some parts that are used as main farm roads while two (2) m for reservoir purposes only. To introduce and keep water in the reservoir and to operate in/out flow of water, some intake gates are planned. Simple outlet will be installed at intervals of about 15 to 20 m along the reservoir dikes. To enlarge water storage capacity and potentiality, two reservoirs of Ta Ngen and Trapeang Chouk in Vihearsour commune should be combined due to the topographic condition.

2.4.3 Rehabilitation of Colmatage Canals

The present colmatage canals are rehabilitated to secure irrigation water and control flood intrusion. For rehabilitation purposes, bush clearing, dredging, reshaping side slopes, construction of maintenance road and new bridges crossing along the canals are necessary. Intake gates at the entrance of the Mekong are planned to be installed. For development and conservation of the waste/grass/bush area, the colmatage canals are expanded into the swamps or reservoirs. The total lengths of rehabilitating and expanding canals are estimated at 16 km and 4 km, respectively. When the weir at the Phtea lake will be constructed without any water control facilities at lower elevation land, storage water will flow out into the downstream swampy area through the Slat colmatage canal. Therefore, a water control facility at Slat colmatage would be required. This facility should be constructed in stage-1 development.

2.4.4 Irrigation Plan

Parallel with the rehabilitation of reservoirs, irrigation canals are necessary to distribute irrigation water. The scale of canals is small, earth type. The present canals will become effective with the undertaking of rehabilitation works. Farmers should construct or rehabilitate these canals. With the topographic condition, small movable pumps may be necessary to lift irrigation water from the canals.

There are Pol Pot canals in Vihearsour Commune that are not used at present due to limited capacity with deep sedimentation and eroded slopes. To use them for rainfed paddy, these canals should be rehabilitated. According to the scale of present canals, rehabilitation canal is divided into two types. Depth of canals for both types is two (2) m and bottom width is three (3) m in type-1 and two (2) m in type-2. Also borrow pits along the Phras Konlong road should be dredged and reshaped for new water resource for rainfed paddy.

2.4.5 Construction of Multi-purpose Farm Roads

(1) Farm Roads

The functions of roads are not only for transportation of agricultural products but also for flood protection dikes. Considering the location of reservoirs, farm lands and swamps, farm road network is planned (see Figure 2.6). Considering the surface elevation of the Phras Konlong road that is equivalent to 1/2 return period of flood water level, that of farm roads as flood protection dikes are planned at EL. 9.5 m. The total lengths of farm roads are estimated at 40 km. Some ancillary facilities such as bridges, culverts, and water control facilities are planned along the roads. Two types of width are planned at 2.0 m and 3.0 m.

(2) Development Plan of Swamp Area

After the completion of farm roads, two (2) swamps of Boeng Selap in Puk Reusei commune and Trapeng Kontinring/Tropeng Kosongke in Prek Tamerk commune located in the waste/ grass/bush area will become water conservation area. Flooded water will be impounded by the roads. Stored water is estimated at 1.4 MCM and 0.9 MCM, respectively. By using impounded water, new agricultural land for recession paddy and upland crops might be reclaimed.

Appurtenant facilities such as culvert and water control gate are planned. Especially, installation of gate along the roads should be decided based on the operation and maintenance capability of farmers' organization.

2.4.6 Operation and Maintenance of the Agricultural Infrastructures

Operation and maintenance (O&M) of the agricultural infrastructures should be conducted by beneficiary farmers. The following O&M works shall be carried out by farmers after the completion of rehabilitation works.

- Bush clearing of reservoir dikes, colmatage canals, irrigation canals, farm roads, etc.
- Dredging of colmatage canals, irrigation canals, reservoirs, etc.
- Leveling of road surface, reshaping of side slopes for colmatage canals, irrigation canals, farm roads, reservoir dikes, etc.
- Proper operation of gates of reservoirs, canals and farm roads.

To carry out these works, establishment of farmer's organization is indispensable. Training activities to operate the water control facilities are also necessary for farmer's organization. Considering the severe flooding conditions, the O&M works should be carried out at least 2 times a year during the agricultural off-season months in May or June.

To support the O&M works by farmers' organizations, the district agricultural office and proposed operation and maintenance supporting office should play important roles. Facilities and equipment/machinery, such as movable pump, tractor, bulldozer, backhoe, grader, pick-up truck, etc. are required for their O&M and training works.

2.5 Inland Fisheries

2.5.1 Setting of Sanctuaries

Development plan should be formulated considering the conservation of fishing resources and effective use of natural resources. A part of the Fishing Lot No.17 is delineated as part of the Study Area. Both farming and fishing are practiced in the overlapped area, however, land use is not clearly defined. The objectives of fishery development are to conserve the fishing resources for sustainable fishing and farming through effective use of resources and to conduct productive fishing in and around the Phtea lake. For plan formulation, institutional approach and physical measures are considered as mentioned in the Master Plan Study.

Fishing area and fish habitat distributed in the reservoirs/inundated forest/vegetation around the Phtea lake should be conserved and maintained as sustainable and productive fishing ground. However, since the areas are being disturbed and deteriorated by uncontrolled agricultural, fishing and firewood collection activities at present, they should be conserved as sanctuary areas. High fish production is always achieved to coincide with inundated forest and vegetation in the reservoirs. A part of the inundated forest/reservoirs should be protected and proclaimed as sanctuary with clear demarcation. Considering the above consideration, the area around the Phtea lake is strongly recommended for them, namely, the wetland in the northeast of the Phtea lake till Som Say Reservoir, Tanon reservoir, Pleuv Tuk reservoir and Promok reservoir (see Figure 2.7).

Fishing and farming inside these sanctuaries should be prohibited. It should be preserved as its natural conditions, except for collection of dead branches that may be taken for firewood. Control and management of land use in these areas should be authorized by DOF, MAFF, in line with the present regulation or law related to fishery management. Operation and maintenance works including firewood collection should be managed by operation and maintenance groups organized under the proposed operation and maintenance supporting service office.

2.5.2 Swamp Rehabilitation

(1) Construction of Small Scale Weir

As the physical measure to conserve fishery resources and to secure fishing ground, it is recommended that the Phtea lake be rehabilitated by constructing a weir at about 6 km down stream of the outlet. The scale of weir should be so designed as a small structure that it would not restrict the present recession paddy farming. The top of weir, retention water level, should be EL. 5 m since the elevation of recession paddy field is distributed at over five (5) m elevation. The bottom of canal or lake is assumed at EL. 3 m. Retention water depth in the Phtea lake during dry season comes to about 2 m. This weir will be submerged during flood season as inundated water level is rising. During dry season under EL. 5 m of inundated water level, the top of weir could be used as farm road.

(2) Rehabilitation Effect

With the construction of the weir, inundated water during flood season would be retained for longer time than the present. Consequently, vegetation area of waterside of the Phtea lake could be maintained as submerged or swampy area. Agricultural activities repeated during dry season in the waterside of the Phtea lake would be limited to some extent, but, fishing area during dry season would be extended.

After the rehabilitation, the water surface of the Phtea lake during dry season will increase from about 312 ha to 500 ha with an increment of about 188 ha. Amount of water availability is estimated at 9.9 MCM at EL. 5 m of water retention.

The area to retain water is very small as compared with the total Fishing Lot area of 8,828 ha. The area to be rehabilitated is only about 500 ha of which 188 ha is being expanded from the present condition or only about 2% of the Lot area. Fishes are still allowed to be caught until the water surface in the lake reaches EL. 5.0 m.

With the peak flood of EL. 9.0 m, the water head that the licensee can catch fish is 4.0 m. This is more than the water head of two (2) m retained in the lake. This means that the licensee can use water for fishing to as much as 20,000,000 cu.m. from the lake plus another 176,000,000 cu.m. from the flooded area inside the Lot. The water in the flooded area outside the Lot where the licensee can use for his benefit is not yet included. Thus, the water retained in the lake is only 9,900,000 cu.m. or only 5% of total water volume available to the lot licensee. This can be considered as negligible.

The direct or quantitative benefit that will be derived is the increment of fish production that will be caused by the extended water surface area and increased retention water volume.

Benefit expected from this kind of rehabilitation comes from two sources. These are the water surface area expansion from 312 ha to 500 ha during the dry season, (i.e. area increment of 188 ha) and additional water volume retention of about 8 million cu. m.

Together with 1.9 million cu. m. of water in its outlet, the total volume of water of 9.9 million cu. m. will be available during the dry season. This excess water, apart from natural fishery benefit, can be also used for aquaculture development as well as irrigation during the dry season, provided the facilities such as irrigation canal and aquaculture supporting system are available.

Resulting from this enlargement of water surface area and increment of water volume, fish production will be enhanced by two dimensions, horizontally and vertically.

Horizontally, in expanding water surface area of 188 ha, with average production 0.06 ton/ha/3 months (Section 2.8.2) or 0.24 ton/ha/year; or 0.204 ton/ha/yea (by MEI Method), it is expected that fish production will increase to about 38 - 45 ton/year.

Vertically, besides the above production, fish production increment can be estimated by using the following assumptions:

- Average water volume during flood season (0.3 m depth) : 3,000 m^3/ha;
- Fish production (0.24 ton/ha/year) : 0.08 kg/m^3;
- Total water volume increase (620 ha x 1.5 m) : 9.9 m^3;
- Expected fish production increment : 792 ton/year.

The total benefit from the proposed rehabilitation of the Phtea lake for fish production is expected to be as much as 837 ton/year.

This level of production is very high as compared with estimated production. However, if average value per ha is considered, it is still reasonable because the production is only 1.35 ton/ha. This is the average production from most of the extensive grown out ponds. Furthermore, this figure may be confirmed by estimation by using production/biomass ratio. In most of the standing waters in Southeast Asia, the ration is "3", that is, one gram of existing fish biomass will be increased to three grams in one year or three times' turnovers in one year. When actual standing crop of fish biomass would be found to be 345 kg/ha (refer to 1.8.2), three times of this figure would sum up to 1,035 ton/ha that is very close to the above production forecast. To reach this level, it is mainly dependent on the operation and management.

However, more significant benefit is that it will cause increase of per capita consumption of fish and employment. For per capita consumption, it will add up another 50 kg/person/year that is more than the international standard requirement of 20 kg/person /year. Together with the existing consumption of 9.7 kg/person/year, it would sum up to 59.7 kg, of which about 30 kg/person/year or a total of 800 ton can be expected to give monetary return.

Considering the following assumption, gross monetary return can be estimated:

- Dry season average farm gate fish price for all grades : 1.7 mill. Riels/ton;
- Fish production increment : 790 ton/year;
- Total gross monetary return : 1,343 mil.Riels/year.

Furthermore, this can absorb an additional self-employment of 12 man-day per ha or 2,256 person/day until the time of fish exhaustion. Provided a person catches fish of 0.005 ton/day, the duration of employment may last for 70 days. It can absorb total employment of 158,000 man-days.

Besides the above direct benefit, aquaculture in the Phtea lake can be developed due to assurance of storage water during dry season. Storage water in the Phtea lake will also be used as supplemental irrigation water for recession paddy in the periphery of the Phtea lake.

However, since this proposed development is in the Fishing Lot, there will be some controversial issue. Fishing Lot operation has been a long tradition and deep in the thought of entrepreneurs, government official as well as the government. The main concern is whether the proposed weir will obstruct the catching of fish of the lot licensee(s). If it is negative, the lot licensee may bargain for lowering of auction fee which in turn may affect government revenue.

The survey reveals that majority of people agrees with the rehabilitation being proposed. Furthermore, it was found that those who show negative response for swamp rehabilitation feel that fishing may not be allowed with rehabilitation or that their farmland will be submerged for longer time. They are not aware that the stocking of fingerlings is for their benefit and for those living around the Phtea lake below EL. 5.0 m where farmland is very scarce.

The other minor point that should be considered is that the construction of dike or weir in the fishery domain is prohibited by law. Permission from the DOFi, MAFF should be sought before the construction taken place.

2.5.3 Supporting System of Fisheries

(1) Operation and Maintenance Supporting Office

A supporting group should be organized in the proposed operation and maintenance supporting office to assist the various fishing activities including conservation and maintenance works. Institutional approach should be in conjunction with the proposed operation and maintenance supporting office managed by inter-departmental committee. Fishery section should be incorporated and integrated in a way of multi-utilization of resources and facilities.

In this context, fishery operations that include seed production together with aquaculture extension and supervision of swamp fisheries are crucial to the success of the project.

In connection to these functions, four (4) fisheries' officers, two (2) seed production and two (2) swamp fishery supervisors, exclusive of technicians and labors, should be assigned to this supporting office. They can be taken from the relevant agencies, but serve both as staff. However at the beginning, this staff shoould be trained abroad or being trained at site by expatriate experts in their particular fields. In the latter case, two expatriate experts of relevant fields should be assigned along with project operation and management. They will serve as supporting staff for training and diffusion of fishing technology.

(2) Establishment of Fishery Credit Group

The fishermen depend mainly on the money lender as source of credit. The interest rates of these money lenders are high. They are compelled to sell their produce at lower price to the lenders. It is therefore recommended to establish a small credit organization among the fishermen. Loans can be arranged by group guarantee. Selected fishermen, after passing through a training program in integrated aquaculture at the supporting office, can be accredited to a loan, considering the credit systems of NGOs particularly for aquaculture development not for fish capture. This credit organization may be integrated with other agricultural credits.

(3) Seed Production

Seed production is undertaken for two reasons, stocking of the rehabilitated swamp (the Phtea lake) and distribution to fish farmers at low price, either for stocking in a rice cum fish culture or in an integrated fish farm.

Assuming a swamp stocking of one (1) fingerling per 2 m^2 in the rehabilitated swamp with a total area of 620 ha (500 ha in the lake and 120 ha in the outlet), the seed requirement will be 3,100,000 pieces per year.

There is no information on the acceleration of diffusion of aquaculture to fishermen. However, when farmers see positive results, fast adoption of the technology is expected. Despite this difficulty, the assumption below is being used to anticipate aquaculture growth in the Study Area for facility design.

Average household number	:5.4 members/household;
Total population in the Study Area	:27,000 persons;
Estimated total household number	:4,990 households;
Assume 10% are innovated	:495 households;
Average farmland holding per household	:0.9 ha;
Extensive stocking density	:450 ha;
Total fish seed requirement for aquaculture	:2,250,000 fries/year.

To support swamp rehabilitation program and extensive aquaculture, the seed production station should be designed to produce at least 5,000,000 seeds per year. To facilitate the production of 5,000,000 fries, the following assumptions are set up:

One brood fish yield	:2,000 fries/year;
5 million fries requires	:2,500 brood fish;

Stocking density of brood fish	:1 per 8 m^2;
Pond's water surface area for brood fish	:20,000 m^2;
Fry productivity	:100 pieces/m^2;
Rotation of nursery pond	:3 crops/year;
Pond's water surface area for fries	:16,000 m^2;
Total pond's water surface requirement	:36,000 m^2.

In connection to this context, preliminary estimation indicates that land requirement of 50,000 m^2 is compulsory and considered as minimum. Maturation tanks, hatching tanks, fry acclimatizing tanks, water filter and storage system, wet lab and dry lab should be provided in the hatchery. General layout of fish seed station is shown on Figure 2.8. The seed station should be constructed in the area of operation and maintenance supporting office. It will become available at the stage-3 development targeting intensive agriculture inside the area.

(4) Aquaculture with Farming Practice

Aquaculture and farming to be developed should be integrated and sustainable. Maximum efficiency of water utilization is considered to propose aquacultural-agriculture system being described below. Whenever possible, all agricultural by-products will be considered to be incorporated into aquacultural benefit.

Three types of aquaculture are proposed to be developed, namely rice cum fish culture, livestock cum fish/cash crop culture and semi-intensive fish pond culture. Rice cum fish culture model has already been explained in the Master Plan Study.

Location for rice cum fish culture should be selected in the area where irrigation is available.

Livestock cum fish/cash crop culture will maximize land and water utilization in a sustainable way. Research has already been conducted and the results confirm that this model had provided a self-sustainable yield for several years. Land and water will be rotated by using half of the year for aquaculture while the other half for cash crop growing.

For both operations, fish feed and manure is derived from agricultural waste such as chicken drop and pig dung. Necessary input is only animal feed that may be obtained from agricultural by-product such as broken rice, brand, growing and natural vegetable. A model for integrated farming as example, is shown in Figure 2.9.

Location for this type of integrated aqua-farming can be easily accessible, preferably in the farmer's home area where more intensive care of plants and animals can be conducted. All year round availability of water should be provided.

However, the farmers should be trained at the O&M supporting office, where the integrated aqua-farming is exhibited and operation process is demonstrated. Only after training, they can be provided with incentives to run a farm like this, since it needs some general knowledge in growing cash crop, looking after animals and keeping fish.

For benefit from aquaculture system, since it will be taken as direct benefit from fry production

of which 2,000,000 fries will be sold to farmers at 35 - 40 Riels/piece, gross monetary return will be expected to as much as 80 million Riels/year. This will in turn lead to multiple benefit in the grown up system.

For the integrated growing system, with a stocking rate of 5,000 fries/ha and a survival rate of 50%, the production of 330 ton will be achieved (as fish will grow up to 3 pieces/kg for 3-4 month growing period). Gross monetary return will be around 560 million Riels. Since the integrated culture does not need high input for feeding and after subtracting fry cost assumed at 80 million Riels, value added of 480 million Riels per year can be generated.

Furthermore, in supporting swamp rehabilitation, the benefit from the 3,000,000 fries stocking in the rehabilitated Phtea lake, assuming a 20% survival rate, and fish growth of 3 pieces/kg, additional 200 ton can be expected from such kind of stocking besides natural fish. However, for this operation, value from the fry cost of 220 million Riels should be added based on making higher survival rate by nursing fry to fingerling before stocking.

2.6 Agricultural Supporting Services

2.6.1 Strengthening for Agricultural Research and Extension Services

To strengthen present agricultural extension services for farmers, the following two proposals should be done simultaneously with the development of agricultural infrastructure.

Increase in Agricultural Extension Personnel

- It is obvious that the number of agricultural extension officers is insufficient for 18 communes. (According to the target of Cambodia Australia Agricultural Extension Project, CAAEP, one agricultural extension officer covers 2 communes.) Without the personnel increment, it is difficult for farmers to receive ample extension services not only in the Study Area but also in the whole district.

Training of Present Agricultural Extension Officers

- Since both Ksach Kandal district and the Study Area have a variety of farming types, skilled officers with wide knowledge are necessary. However, the two (2) available agricultural extension officers have never attended college/university. Although there is no fixed training schedule provided through CAAEP, systematic training should be given to them.
- Some of the agricultural chemicals used in the Study Area are organophosphorus insecticides and are therefore toxic. Since they are sold in the local market, agricultural extension officer should initially learn the appropriate usage of both agricultural chemicals and inorganic fertilizers and furthermore spread it to the farmers. Instead of high toxic chemicals, low toxic ones should be used in the future.

To assist farmers immediately and directly until the establishment of agricultural extension system, the present periodical seminar should be continued even if only oral lecture is given. Some agricultural institutes, NGOs and other donor countries conduct similar seminar. One option therefore is to request these groups to provide necessary seminars at the proposed operation and maintenance supporting office.

Research activities in Cambodia are still outdated. Even the national research institutes do not work efficiently at present. It is difficult to conduct research activity only for the Study Area. However, useful research results applicable to agriculture in the Study Area should be spread through the extension services.

2.6.2 Agricultural Credit System

Despite the need for rural credit, informal credit with higher interest rates has been practiced in Cambodia because of absence of institutional credit system. The result of the Rural Socio-economic Survey indicates that most of farm households in the Study Area have incomes below the poverty line. Marginal households facing rice deficit even for home consumption has to borrow rice and/or reduce their food intake/consumption. In addition, nearly 100% of borrowers from GRET apply for short-term credit. This indicates that most farmers are in need of money to buy agricultural materials and rice.

Development of agricultural credit, therefore, is necessary to support households. Credit should be provided not only for household rice deficits but also for improvement of paddy cultivation. Expansion of this agricultural credit will help improve food security among poverty groups and foster sustainable farm households. Agricultural credit is also needed to develop small-scale agro-processing and home industries in the rural areas.

Experiences by GRET and other NGOs working in and around the Study Area should be evaluated because of its acceptable organizing system of farmers and lending system based on collective guarantees. The Cambodian government established the Credit Committee for Rural Development (CCRD) by the Sub-decree No. 30 on February 1995. It is suggested that central financial institute be created to serve as the center of agricultural and rural credit for all class of farm households under the management and coordination of CCRD. Experiences of NGOs like GRET will contribute to the conduct of a successful agricultural and rural credit.

2.6.3 Post-Harvest, Processing and Marketing

The Study Area has been facing food constraint on paddy/rice deficit. Only a little number of livestock like pigs, piglets and ducks, which are transported to Phnom Penh is sold to the market. These imply that efforts to increase paddy production through the improvement of irrigation systems should be given priority more than provision of processing activities.

At present, some home industries such as mat production, noodle and smoked fishes are being undertaken in small-scale in the Area. These small-scale home industries should be encouraged and extended to improve family income. Rush and mat grass could be processed not only into mat but also cushion (Kapok inside), huts, etc. For that purpose, rural credit services should be strengthened to motivate farmers to invest in these home industries.

Processing technologies should not only be limited to few farmers must be made available to all class of farmers, particular poor households, to alleviate regional disparity in incomes and human/institutional development.

Development of credit system and strengthening of technologies mentioned above will be supported by the district office and the proposed operation/maintenance supporting office.

Rice mills would be the major post-harvest activities soon. The number of rice mills and their capacities could meet rural requirement.

2.7 Strengthening of Farmers' Organization

2.7.1 Approach for Establishment of Farmers' Organization

Several types of farmers' organization are required for efficient agricultural development. Survey results indicate that most of farmers want agricultural cooperative and water users' association in the future. Among them, WUA (Water Users' Association) is the most required organization.

Agricultural cooperatives are useful for collective production and marketing of products and purchase of materials and machinery. Possible cooperatives to be established in the Study Area are grass mat producers' cooperative or lotus seed producers' cooperative. Women's association is also recommended to help women ease their difficulties, involve in development and improve house keeping.

The development plans are related to the rehabilitation of reservoirs, canals and rural roads. Their O&M will be the most important factor to promote the plans smoothly.

After the completion of rehabilitation, rehabilitated facilities will be transferred to the beneficiaries. Since the facilities installed in each reservoir belong to a small scale irrigation system (less than 200 ha of irrigated area), according to the GDIMH's guideline, these facilities should be operated and managed by their beneficiaries.

Since farmers are not used to farmers' organization, they are not expected to be trained and guided accordingly by the concerned agencies. There is a governmental policy that the MAFF/GDIMH is responsible in the organization and supervision of irrigation system. Considering the scale of the existing reservoirs in the Study Area, the district agricultural office is responsible for organizing WUA.

The responsible person to take charge of organization should be selected as organizer from the hydrology section of the office. The organizer should be well experienced in organization and training. However, the task would be too much for one person for all the water users of the 37 reservoirs. Therefore, it is recommended to start with the existing managers of each reservoir, then each manager will explain the significance of establishment of WUA to their water user farmers. After the farmers agree to establish the WUA, they should be led to elect committee members through a democratic procedure. The committee members should never be nominated by the authority of district or commune. Considering the above, an approach to establish WUA is summarized in the following activities.

1) to select responsible person from the district office
2) to train the selected person as organizers in charge in a course or by an experienced expert or related agencies
3) to train the present manager of each reservoir by the organizer
4) to train farmers by the managers

5) to have common consent to establish WUA among the water users/beneficiary farmers

The above activities may be supervised by the operation and maintenance supporting office as proposed in 2.8

2.7.2 Operation and Management of the Organization

The WUAs of each reservoir are small scale and the numbers of committee members will also be limited as well. Each committee will be composed of three persons, a chairperson, an accountant and an operator. The accountant should be different from the chairperson. The committee operates the organization. The operator works on a daily basis to close and open gates and to watch for breakage in the dike. The basic maintenance work shall be undertaken in the committee. At the beginning stage of the organization, necessary actions may be managed by the operation and maintenance supporting office or the district office.

Female headed farmers shall be treated equally as a member or be given some advantages in speaking in the meetings, water charge or labor contribution for maintenance. The following are the prerequisites for good operation and management of WUA.

1) The committee members of WUA shall be elected through a democratic procedure. Chairperson should be trusted personally, especially on money.
2) WUA should prepare regulations on organization itself and water use.
3) Members of WUA shall pay water charge necessary for operation, management and maintenance and provide labor, which should be written in the regulations.
4) WUA shall set up an operation hall/office and a storehouse of O&M machines, spare parts and its operation management. In this plan, the proposed operation and maintenance supporting office will provide them for WUA.
5) The committee members shall be provided remuneration of reasonable amount.
6) Special consideration should be taken to female headed household.

Each WUA may decide its regulations. If there is difficulty in the provision of the regulations, its draft may be prepared by the operation and maintenance supporting office or district agricultural office. This can be modified by the members of WUA when necessary.

The financial aspect was the biggest constraint to operate and maintain irrigation facilities in the past. With the completion of the development project, farmers will benefit more than the present from the rehabilitated reservoirs with appropriate management under the organized WUA. It is indispensable to collect water charge (paid by money or rice) for successful operation and maintenance. As an example, a WUA in Takeo Province collects 230 kg of rice per ha with direct irrigation system and 160 kg for indirect irrigation system. The collected water charge can be spent for O&M of the facilities.

2.8 Proposal of Operation and Maintenance Supporting Office

2.8.1 Objectives of Operation and Maintenance Supporting Office

It is necessary to provide technical assistance for farmers to establish WUAs and to manage O&M activities. In addition, support services on farming technique, agricultural credit and fishery management are required to attain the development target. The operation and maintenance supporting office should be established aimed at the provision of technical assistance to farmers who are the core of O&M activities.

The supporting office will be set up near the district administrative area, equipped with building for meeting hall and torchouse to support various activities of WUAs. Considering easy access from each commune, two storehouse for materials and machines is recommended to be constructed.

The function of the supporting office is to give necessary advice to WUAs, to provide a hall for WUAs for meetings and training, and to lend pumps and agricultural and O&M machines to farmers and WUAs members. Since required support differ by development stage, necessary services should be provided according to the needs for farming and fishing. At stage-3, where intensive agriculture can be introduced, fish seed production facilities will be constructed. Sale of fries, diffusion of aquacultural technique, spread of management technique for integrated system of farming and fishing will be involved. The hall/office may also provide some training opportunities on sewing, dress making, hair dressing, living improvement, etc. for rural women.

Installed gate will be operated by established WUA. The office will be requested to train WUA how to operate and manage gates. The office should monitor their operation activities and compile them as the operation record. Accumulated records will be the effective date for development of similar areas.

2.8.2 Operation of Office

The supporting office shall be managed by the agricultural section of the district agricultural office. The staff of agricultural section hold its work concurrently. They may request some assistance from other agencies when necessary. The supporting office shall be supported financially by water charge collected from WUA and by renting portable pumps and other farm machines.

The proposed development project is considered as a model project for other similar areas. Since personnel complement of the district agricultural office is limited, it has to recruit some experts from related agencies or NGOs at the beginning stage of establishment of supporting office.

2.8.3 Proposed Facility and Machine/Equipment

The supporting office requires the buildings such as meeting hall, office and storehouse, and the machine/equipment such as portable pump, tractor, grass cutter, bulldozer, truck, backhoe and vehicles, to function as it is designed. They have to be prepared at the time of establishment of the office (stage-1). The facility of fish seed production will be constructed at stage-3.

2.9 Rural Infrastructure Improvement Plan

2.9.1 Rural and Farm Road Networks

Existing district roads planned to be connected to farm roads will play important role as basic rural facility for rural people. According to the Rural Socio-economic Survey, provision of road network is listed as one of priority development. As the agricultural development in the area is going on, marketing and transporting of agricultural products will be apparent.

Considering this situation, existing district roads should be rehabilitated to establish transportation routes of agricultural products and to contribute to the regional agricultural development and the stable rural communication. In the development plan, urgent remedial work should be taken in the section of 5.2 km in the Prek Tamerk and Puk Reusei communes (see Figure 2.6). In this rehabilitation work, the road surface should be upgraded to gravel-pavement and the slopes should be reshaped with canal improvement. For the on-going rehabilitation section of 6.7 km in the Phras Konlong road (between Prek Tamerk and Vihearsour), reshaping of the slopes is proposed while borrowed pits of both sides are re-excavated and improved as a canal or water storage band.

2.9.2 Rural Water Supply

Considering the present conditions of rural water supply system, improvement of drinking water supply system is planned as follows.

(1) Area close to the Mekong River, Prek Tamerk, Puk Reusei and Prek Ampil Communes

In these communes, simple water supply system has been provided, in which water storage tanks with unit capacity of about 300 liter, are linked with each other by pipes. Treatment facility, however, is not provided in the tanks. As a short term improvement plan, it is proposed that simple treatment facility by means of gravel or sand should be added to the existing system. It is also recommended that in the medium and long term scheme, water supply systems with deep wells should be provided based on the development study conducted by JICA and MRD.

(2) Far area of the Mekong River, Vihearsour and Sanlung Communes

Tube-wells have been developed so far, which are distributed satisfactorily compared with the other areas. It is used as source of drinking water. In the development plan, therefore, it is proposed that maintenance work should be strengthened through the promotion activities of sanitation program by hospitals and schools.

2.9.3 Rural Living Infrastructures

(1) Sanitary Facility

Living environment should be improved as the standard of rural life would be upgraded with the implementation of the proposed development plans. To improve living environment, sanitary improvement should be undertaken in which provision of toilet is the basic requirement. NGOs is implementing the promotion program of toilet facility in the area through the credit system and sanitary training. Sanitary improvement should be undertaken through public assistance and

NGOs activities.

(2) Electricity

No development plan of public electric supply service in the area has been prepared so far. Although private small scale electric supply system has been provided in the area, public electric supply system should be constructed while the living standard would be upgraded.

CHAPTER 3 FACILITY PLAN AND PROJECT IMPLEMENTATION PROGRAM

3.1 Facility Design and Planning

3.1.1 Agricultural Infrastructures

The agricultural infrastructure improvement under the development plan consists of construction of the following key facilities.

(1) Reservoir

1) Dam body

The reservoirs in the Study Area is categorized into closed and semi-closed types. Key dimensions of dam bodies have been planned as follows. For the closed-type reservoirs, dam bodies will be elevated to increase storage capacity for irrigation. For the conservation of inundated forests and fish habitant area, a ditch (10 m bottom width and 2 m depth with side slope of 1:2.0 inside the dam body) will be excavated in each reservoir. For the semi-closed reservoirs, dam bodies will not be elevated but be reinforced and reshaped.

- Dam crest width: 2.0 m for O&M purpose while 3.0 m for sections for O&M cum farm roads as standard widths
- Side slope: 1: 2.0 for upstream side and 1: 1.5 for downstream side slopes of embankment
- Freeboard: 0.5m against waves by winds and other factors
- Elevating height: H = 1.0 m (Type-I), H = 1.5 m (Type-II), H = 2.0 m (Type-III)

2) Intake gate

To lead flood water into the reservoirs, intake gates will be installed at each reservoir. To meet the reservoir size, the standard cross-sections of the gates will be of two types as follows.

- Type-I: steel-made slide gate, 2.0m(B) x 2.0m(H) x 2 sets
- Type-II: steel-made slide gate, 2.0m(B) x 2.0m(H) x 1 set

3) Outlet

To manage reasonable irrigation water distribution, outlet facilities equipped with 75 mm tap and 300 mm RC pipe will be installed at an interval of 100 m.

(2) Farm Road

1) Road type

The roadbed elevation of the Phras Konlong road currently under rehabilitation in the Study Area is at EL. 9.5 m. Since the elevation is equivalent to the 1/2 year return period flood water level in the Study Area, the designed roadbed elevation of the farm

roads will also be EL. 9.5 m. The type of road will be two for main road, branch farm roads with width (B) of 3.0 m (Type-I) and 2.0 m (Type-II). The side slope of the banks will be 1: 2.0.

2) Appurtenant facilities

The appurtenant structures for the farm roads are as follows:

Cross culvert

Culverts will be of two types with RC pipes and dimensions are presented below.

Type	Culvert bore (mm)	Bottom width of leading section (m)	Length of leading section (m)
I	1,000	2.0	4.0
II	800	1.5	4.0

Gate

Some partial sections of farm roads may at the same time be used as reservoir dikes. The gates are therefore the same type as that of the reservoirs.

- Type-I: steel-made slide gate, 2.0 m (B) x 2.0 m (H) x 2 sets
- Type-II: steel-made slide gate, 2.0 m (B) x 2.0 m (H) x 1 set

Bridge

Two types, Type-I, (B=3.0 m, L=10.0 m) and Type-II (2.0 m, 10.0 m), will be applied by road type.

3) Rehabilitation of Pol Pot canal

To provide supplementary irrigation water sources for wet paddy, the five (5) Pol Pot canals in Vihearsour commune will be dredged. Among the farm roads planned, farm roads from R9 to R13 are located along Pol Pot canals (see Figure 2.6). Dredging will therefore be worked out together with the farm road improvement. The rehabilitated cross-sections of the canals are of two types as follows.

Type	Bottom width (m)	Canal height (m)	Side slope 1:n	Remarks
I	3.0	1 : 2.0	1 : 2.0	R10
II	2.0	1 : 2.0	1 : 2.0	R9, R11, R12, R13

(3) Colmatage Canal

1) Canal type

According to the master plan study, colmatage canals consist of five (5) types. Application of each type of canals is supposed to be made based on the results of the field investigations. The following five (5) canal types will be applied to the five colmatage canals in the Study Area.

Type	Bottom width B (m)	Canal height (m)	Freeboard (m)	Side slope 1 : n	Canal name
A	less than 6.0	2.0	0.4	1 : 1.5	
B	6.0~10.0	2.5	0.4	1 : 1.5	Agn Cheng, Ta pang
C	10.0~15.0	2.5	0.4	1 : 1.5	
D	15.0~20.0	3.0	0.4	1 : 1.5	
E	more than 20.0	3.0	0.4	1 : 1.5	Tamao, Kong Van, Ta Kheum

2) Appurtenant facilities

Intake gate

The standard cross-sections of intake gates at the beginnings of each colmatage canal will be the following five (5) types to coincide the colmatage canal types. The size and type of gates will be the same but different number of gate units will be employed to coincide with the canal sizes for O&M convenience.

Type	Bottom width (m)	Canal height (m)	Gate unit
A	3.0	3.0	1
B	6.0	3.5	2
C	10.0	3.5	3
D	15.0	4.0	5
E	20.0	4.0	7

N.B. Gate size fixed as 2.0m (B) x 2.0m (H)

Bridge

Bridges will be planned for the rehabilitation of antiquated wooden bridges. New bridges will be installed at required places across the extended colmatage canals. The bridges will be concrete-type according to the following five (5) standard types to coincide with the canal types.

Type	Length (m)	Width (m)	No. of span	Remarks
A	3.0	4.0	1	Box-culvert-type
B	6.0	4.0	1	
C	10.0	4.0	1	
D	15.0	4.0	1	
E	20.0	4.0	2	

Maintenance road

For easy and smooth O&M, maintenance roads of 3.0 m width on either side of banks of colmatage canals are planned. The roads will be laterite-paved.

3.1.2 Other Infrastructures

Relevant to the agricultural infrastructure improvement, the following programs for infrastructure improvement and construction have been planned.

(1) District Road

1) District road along the Mekong river

The development plan being a pilot scheme for demonstration to the other areas, will include improvement of roadbed. A five (5) m-wide gravel pavement in a 2,000 m-long partial section of a district road along the Mekong river shall be improved. The roads will be equipped with side ditches on both sides of the road.

2) Phras Konlong road

The road improvement is as follows.

Reshaping of borrow pits along the Phras Konlong road and use of the pits as reservoirs
The road improvement of borrow pits in the past that have been left in irregular shapes, will be reshaped into ditch-like areas to form small reservoirs. The reservoirs will function as water sources for supplementary irrigation water to the nearby paddy fields. The dimensions of reshaping are as follows.

- Bottom width : B = 4.0 m
- Depth of ditch : D = 2.0 m
- Side slope : 1 : 2.0

Roadbed surfacing
After implementation of this development project, more traffic by heavy vehicle is anticipated so that the roadbeds of the 3,600 m-long partial section of the road will be surfaced.

Flood control gate
The flood water from the Mekong river in Srey Santhel District, Kampong Cham province located northeast area of the Phtea lake flows into the Study Area through the bridges and culverts across the Phras Konlong road. To control the flood water, a water level regulating gate will be constructed at Phras Konlong. The gate type will be the same as Type-E for colmatage canal.

(2) Weir at the Phtea Lake

As mentioned in Section 2.5.2, a concrete-built weir to regulate water level will be installed at six (6) km downstream from the Phtea lake. The weir crest will be, as mentioned in the Section 2.1.4, a part of the ring roads being constructed in the final stage. The key dimensions of the weir are as follows.

- Crest width : B = 2.5 m (b = 2.0 m effective)
- Side slope : 1 : 0.1 in upstream, 1 : 1.0 in downstream
- Downstream apron length : W = 9.6 m
- Fixed weir length : L = 70 m
- Appurtenances : a fish way, a navigation lock & 2 sand sluices

In addition, a water level regulating gate (Type-B for colmatage canal) will be installed at the

mouth of Slat colmatage canal.

(3) Fish Pond

The fish culture facilities as mentioned in Section 2.5.3 will have the following dimensions.

- Reservoir : 90m x 240m x 2.5m x 1 unit
- Brood stock pond : 30m x 70m x 1.8m x 6 units
- Nursery pond : 20m x 50m x 1.2m x 18 units
- Hatchery, feed mill, office, etc. : 1 L.S.

3.1.3 Operation and Maintenance Supporting Facilities

The facilities and equipment for implementation of the operation and maintenance supporting programs as mentioned in Section 2.8, have been planned as follows.

(1) Building

As a center of the supporting activities, a 300 m^2 building for office and meeting space has been planned.

(2) Equipment

- 4WD vehicle : 1 unit
- Motor cycle : 40 units
- Portable pump : 111 units
- Tractor : 5 units
- Weed cutter (motor-driven) : 15 units
- Bulldozer : 1 unit
- Dump truck : 1 unit

As mentioned in Section 2.1.4, stage development has been proposed. Bill of quantities for each stage of project implementation is shown in Table 3.1.

3.2 Project Cost

3.2.1 Basic Condition

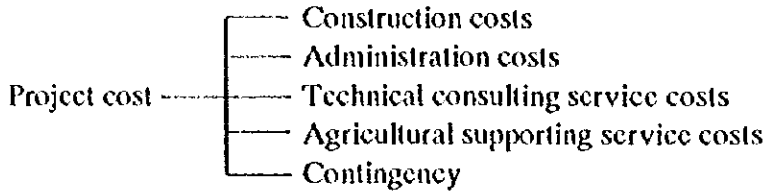
The Project costs have been estimated based on the following conditions.

(1) Method of Project Implementation

Considering the nature and size of project components, project execution will be made on contract bases by agencies concerned.

(2) Cost Composition

Compositions of the project costs are as follows.



1) Construction costs

Construction costs include materials, fuel, labor, equipment, operational and overhead costs of contractors.

2) Administration costs

Administration costs are composed of temporary labor costs and miscellaneous administrational costs to be borne by the project sponsor during implementation.

3) Technical consulting service costs

Technical consulting service costs composed of the costs for re-evaluation of the project feasibility by the project executing body, detailed survey and design, bidding proceedings and construction supervision. About 10% of the above (a) have been estimated under this costs.

4) Agricultural supporting service costs

Agricultural supporting service costs are the costs for agricultural supporting activities mainly composed of costs for the expertise required. The costs have been estimated based on the required number of experts.

5) Contingency

Contingency may cover up the incremental costs at the time of project design stage due to unexpected change or modifications of the project components. 10% of the total cost has been estimated.

(3) Unit Cost

Unit costs have been appraised by work category by combining operational costs of construction equipment such as unit costs of labor, materials, depreciation, repair, maintenance, fuel, operators pay rate, etc. The base unit costs are based on the GDIMH and on the inquiry survey in the market as of 1997. The base materials have been estimated by setting the rates between local and foreign currencies. Exchange rate of currency has been set at US$ 1.00 = Riel 2,740.0 = Yen 115.

(4) Overhead

Overhead consist of site office expenses, profit, taxes, compensation costs, insurance costs, etc. and have been estimated by referring to similar project implementation nearby.

- Site expenses and profit = 10% of direct construction costs
- Taxes and others = (direct construction costs + site expenses and profit) x 5%

(5) Implementation Period

The project implementation is programmed by stage-wise development in three (3) stages as stage-1 (3 years), stage-2 (2 years), stage-3 (2 years).

3.2.2 Project Cost

The project cost components for each stage of implementation are as follows. The details of breakdown are shown in Table 3.2.

Stage-1:	US$	6,662,030
Stage-2:	US$	2,931,425
Stage-3	US$	1,694,361
Total	US$	11,287,816

3.3 Project Implementation

3.3.1 Project Management and Implementation Agency

According to the proposed project, development plan covers various components related to agricultural and rural development. The project shall be implemented in close cooperation with the governmental agencies such as MAFF, MOE, MPWT and MRC. Most of the project components are under the MAFF. The leading agency is the MAFF. Related departments in the MAFF are the GDIMH, DOA, DOFi, DTEE, etc.

During project implementation, simultaneous with the provision of infrastructure facilities, the participation of beneficial farmers is necessary as they will operate and manage the facilities. Operation and maintenance (O&M) organization should be established. For the successful O&M by farmers, their participation in all stages of project implementation is necessary. To promote the participation of farmers and to implement the proposed project, local governmental institutions of Kandal province, Ksack Kandal district and related six (6) communes, and NGOs should be involved in project implementation.

To ensure smooth and successful implementation of this project, it is recommended to establish the following committees and project unit task force under the supervision of MAFF.

- Project executive committee (related ministry level)
- Project coordinating committee (related departments and local government level)
- Project unit task force (project site level)

The project executive committee is the top executive body. The chairperson will be selected from the department concerned in the MAFF. The members will consist of the representatives of the above mentioned ministries and Kandal province. Their major functions shall be as follows.

- To formulate the scope of the project and necessary policy.
- To formulate the implementation program and arrange the working budget.
- To perform external coordination among the agencies concerned.

- To supervise the overall works and formulate evaluation program of the project.
- To resolve problems and difficulties in project implementation.

The project coordinating committee is set as an MAFF internal coordination, of which members shall consists of representatives from the departments concerned in MAFF and district development committee. The chairperson shall be appointed by the project executive committee, but, shall be from GDIMH since the major development component is the construction of agricultural infrastructure facilities. The major functions shall be as follows.

- To prepare working program with budget estimation.
- To manage the progress of the project implementation and report the results to the project executive committee
- To perform internal coordination among the departments concerned.
- To assist the project according to their responsibilities and to resolve problems in project implementation.

District development committee would serve as the coordination agency for construction, operation and maintenance of the facilities among related communes, villages, farmers, local government offices and NGOs.

The project unit task force is set as an implementation body at the field level. The key staff will be selected from GDIMH and a chairperson will be appointed by the project coordination committee. The chairperson shall appoint a project manager for the unit task force who will manage the progress and daily operation of the construction works with full support from district office.

After completion of the construction works, operation and maintenance of the project would be performed by the proposed operation and maintenance supporting office and the district office.

3.3.2 Issues for Project Implementation

(1) Financing

The financial source for the project would be from domestic fund of the Government of Cambodia or foreign government fund or international development fund. However, it is very difficult at this time for the Government of Cambodia to provide working budget for the project due to domestic financial limitation after civil war. It is, therefore, desirable that whole project cost including foreign and local portions should be financed by foreign government fund or international development fund.

(2) Employment of Consulting Firm

Considering the implementation capability of the project implementation agency and the procurement of project finance from foreign or international development agencies, it is essentially required to employ experienced consulting firms. The consulting firms shall be required to undertake detailed design, tendering and supervision of construction works under the supervision of the proposed project committees and task force.

(3) Procurement of Land

Procurement and compensation of land for road, canal, reservoir dike shall be the responsibility of the proposed project management and implementation agencies.

3.3.3 Project Implementation Schedule

The project will be implemented by setting up project committees, coordination among related agencies and acquisition of required financing after completion of the feasibility study. In this study, three stage development plans is proposed, each of which would generate a certain degree of development benefits. The three proposed development stages need not be implemented continuously and intensively. Their implementation shall be programmed based on the amount of fund available. However, it is recommended that the stages-1 and -2 should be implemented as short and medium term plan until 2005 while the stage-3 as long term plan until 2010, based on the proposed implementation program in the master plan.

Project implementation schedule is planned and programmed based on the above consideration. This shall include necessary procedure for fund arrangement, coordination works including procurement and compensation of land, detailed design and supplementary survey for facility construction, preparation of tender document, tendering, construction works operation and maintenance. Construction works of facilities are programmed to be implemented under the dry condition.

One key component of the project is the supporting services to the farmers on farm management, water management, etc. Necessary activities promoting farmers' participation into the project implementation and establishment of farmers' organizations for coordination with the project implementation body, are much required. These activities have to be extended parallel with the coordination activities between the government agencies concerned. Meanwhile, the agricultural supporting service activities may be implemented at an earlier stage before the completion of the rehabilitation of facilities.

The Project implementation schedule has been programmed as shown in Figures 3.1, 3.2 and 3.3.

3.4 Project Operation and Maintenance

3.4.1 Operation and Maintenance Organization

Agricultural infrastructures needing regular maintenance works are the reservoir dikes, roads, canals and gates, which are inundated with water during the wet season. Maintenance works needed are reinforcement of reservoir dikes, dredging and reshaping of canals, repair of road surface and gates, etc. Water control gates are also operated for proper water management.

The operation and maintenance works shall be conducted by the WUA groups organized under the operation and maintenance supporting office. Working plan shall be prepared by the beneficiaries of each WUA together with the district office and the supporting office. Simple works should be operated with labor contribution from beneficial farmers. Engineering works will be conducted in cooperation with GDIMH, district office and other related agencies. Operation and maintenance supporting office shall provide necessary equipment and machines

for the successful O&M by farmers. Participation of farmers in all stages of the project is also necessary. Related to the regular maintenance works of reservoir dikes, some WUAs shall manage the inundated forest in the reservoirs to prevent over-cutting for firewood.

3.4.2 Operation and Maintenance Cost

The costs for operation and maintenance of the project facilities are composed of periodic patrol of facilities and those for maintenance and management of the constructed facilities especially farm roads and canals. The estimated cost for O&M at each stage has been estimated as follows.

after Stage-1: US$ 20,660 per year

after Stage-2: US$ 22,277 per year.

after Stage-3: US$ 23,363 per year. (total stage completion)

CHAPTER 4 PROJECT JUSTIFICATION

4.1 Basic Concept for Project Evaluation

4.1.1 Basic Concept

The Project is the agricultural development project for about 27,000 beneficiaries of about 5,000 households living in the Phtea lake area in Ksach Kandal district in Kandal province. The formulated project component covers both hard and soft aspects. However, institutional and human development involving establishment of water user's association (WUA), strengthening of agricultural extension and credit services and training for farmers, etc. should be carried out by the government of Cambodia. The implementation of construction works on rural infrastructure and institutional development is expected to increase agriculture and fishery production. Hence, the ultimate objectives of the project, that is, increase of foodstuffs and improvement of farm economy and living standard, will be attained through this project. These are according to the objectives of the First Socio-Economic Development Plan (1996~2000), aimed at attainment of food security and poverty alleviation, etc. As the implementation of the project consists of three (3) stages, the benefits will be generated by each development stage.

4.1.2 Assumptions

(1) Prices

Prices used in the project justification are based on the prices collected during the first and second field survey in 1997. For the economic evaluation, prices of traded commodities such as paddy, maize and urea are calculated based on "the Prices Prospects for Major Primary Commodities, by the World Bank. Prices of non-traded commodities, such as, vegetables and fishes are based on the prices collected from the Rural Socio-economic Survey and marketing survey (1997). The exchange rate of Cambodian Riels to US dollars is estimated at 1US$=2,740 Riels. The standard conversion factor (SCF) of 0.938 which is used to convert local cost to economic cost for the evaluation is calculated based on import and export statistics over five (5) years. Current market prices are used for the financial analysis.

(2) Project Cost

Project cost is estimated at 11,287 thousand US$ in financial price, which is equivalent to 10,220 thousand US$ in economic price. When converting to the financial project cost, 1) applying SCF to local portion of the project cost, 2) excluding taxes, price escalation, compensation cost and subsidy, are applied. The annual operation and maintenance cost are also calculated with the same principle.

Replacement costs necessary to replace deteriorated facilities such as gates and small movable irrigation pumps are taken into account at 30 years for gates and 10 years for pumps.

(3) Project Life and Economic Index for the Justification

The project is justified both from the viewpoint of national economic and financial aspects. Economic evaluation will be practiced for the former and financial analysis for the latter. The

project life is assumed at 50 years. Economic rate of return (EIRR) is applied as an index to justify the economic feasibility of the project.

(4) Sensitivity Analysis

Sensitivity analysis is undertaken to analyze influence on EIRR in case some possible factors occur as in changes in project cost and benefits.

4.2 Project Benefits

Direct and indirect benefits are expected to be generated with the implementation of the project from the national economic point of view. The project benefits consist of quantitative benefit that can be estimated in monetary terms and non-quantitative benefits that cannot be accounted with money (see Figure 4.1).

4.2.1 Tangible Benefits

(1) Agricultural Benefits

Agricultural benefit centering on paddy production will be generated through the implementation of the proposed project components and the strengthening of soft aspects such as agricultural extension services, etc. mentioned in 4.1.1. The benefits by stage will be:

Stage-1 1) increase of planting area for recession paddy and its yield, 2) expansion of inland fishery, 3) land reclamation of waste land, 4) prevention of flood damage,

Stage-2 1) increase of planting area for upland crops and dry season paddy in the command area of colmatage canals, and

Stage-3 1) double cropping of paddy and upland crops and fishing as the study area-basis.

The agricultural benefit will be estimated as the difference of net production value between "without project" and "with project." This can be calculated based on the estimated improvement in crop yield, cropping intensity and increase in planting area for proposed crops as shown below.

Incremental Agricultural Benefits (unit: million Riels)

	Crop Production	Land reclamation of Uncultivated Lands	Prevention of Flood Damage
Stage-1	718	393	385 (every 10 year)
Stage-2	1,061	(393)	-
Stage-3	148	(393)	-
Total	1,927	393	385

(2) Fishery Benefits

The weir will be constructed at the downstream of the Phtea lake at stage-1 development. Water surface area of the Phtea lake will be expanded and fish production in the lake and paddy fields will be increased as shown below:

	Fish Culture		(unit: million Riels)
	Fish Catch	Reservoir	Paddy Fields
Stage-1	243	-	51
Stage-2	243	-	51
Stage-3	243	270	51

4.2.2 Intangible Benefits

Indirect benefits or intangible benefits that cannot be estimated as monetary term as agricultural and fishery benefits are also be expected.

(1) Study Area-Basis

The rehabilitation and construction of roads at stage-1 development will improve a) crop transportation of farm crops, b) transportation of materials from household to farms. The completion of the road network at stage-3 will improve internal exchange of agricultural and agro-processing and O&M technology between the western and eastern parts of the area. This will result in the alleviation of regional disparity.

The establishment of the operation and maintenance office will enable farmers to maintain rural infrastructures and contribute to the improvement of rural life, expansion of agricultural and agri-based processing techniques, enlightening women about health and sanitation, etc.

Employment opportunity for the local people will be increased with the construction activities of the facilities and with the expansion of the farming activities.

Increase of agricultural production will cause higher incomes, resulting in the promotion of improvement of nutrient condition, education and sanitation of the farm households.

WUA established will foster ownership of irrigation facilities among the members. It will provide farmers the opportunity to sustain operation and maintenance of facilitates. It will foster harmony among the members and contribute to the expansion of communication on efficient water use, cropping technology, marketing information, etc.

(2) National Level

There are many development potential areas in the whole flood plain that have similar conditions as the Study Area. The planning and implementation of this project will serve as model case for areas being developed in the future. In particular, developing method for area in which agriculture and fishery coexist will involve the way of O&M by beneficiaries and institutional

development plan.

4.3 Economic Analysis

4.3.1 Comparison of Cost and Benefit

(1) Economic Internal Rate of Return (EIRR)

EIRR is used as an index to justify economic viability of the project. EIRR means the discount rate by which total net present value (NPV) of cost and benefit is equal. EIRR can be calculated by discounting economic cost and benefit converted to financial cost by using specific discount rate for 50 year's project life. This is then compared to the total NPV of discounted cost and benefit. EIRR of the project is estimated at 8.6% (stage-1), 10.9% (stage-1+2), and 11.0% (stage-1+2+3). Compared with the value of each EIRR, the value of stage-1 is relatively lower. This is because stage-1 involves not only many indirect benefits (conservation of fishery resources, stable rural life through establishment of farmers' organization and increase of agricultural productions) but also investment for setting up of the operation and maintenance supporting office that will bring direct benefit in all stages. Stage-1 also includes basic infrastructure required for all stage developments. Considering 10% opportunity cost of capital in Cambodia, 11.0% for all stages is found to be economically feasible.

(2) Sensitivity Analysis

Sensitivity analysis was made to examine the influence of possible factors on the results of EIRR by assuming some parameters that might occur when implementing the project, that is, a) increase in project cost, b) reduction of benefits, c) delay of benefit generation.

1) In case of increase in project cost

   Assuming 10% increase in project cost due to increase in commodity prices, EIRR in this condition will be reduced to 9.8%.

2) In case of benefit reduction

   It will be difficult to accomplish projected benefits in agricultural and inland fishery sector without any government and NGO's support on agricultural extension and credit. In case of 10% reduction of project benefit, EIRR will be 9.7%.

3) In case of delay of benefit generation

   It is forecasted that benefit generation will be delayed if government and NGOs supporting services for the beneficiaries will not be efficiently and judiciously implemented after the completion of the project. In the case of three (3) years delay of benefit generation, EIRR will be reduced to 8.1%.

Results of the sensitivity analysis are summarizes as follows:

Sensitivity Analysis

Case	EIRR (%)
1. 10% increase in project cost	9.77
2. 10% reduction of benefits	9.66
3. 3 years delay of benefit generation	8.13
4. Combination of 1 and 2	8.56
5. Combination of 1 and 3	7.35
6. Combination of 2 and 3	7.26

4.4 Financial Analysis

4.4.1 Improvement of Farm Economy

Current farming type in the Study Area differ depending on water requirement as in the case of rainfed, recession rice and upland. Financial analysis is made considering the typical farm households in the a) beneficial area of colmatage canals, b) recession rice areas, and c) rainfed areas (see Table 4.1). Annual farm household income in the Study Area, which is currently lower than the poverty line income of 2.23 million Riels will be improved with the implementation of the project.

4.4.2 Cost Recovery

Since farm households in the Study Area live on incomes below the poverty line, it would be difficult to charge amortization cost to individual farmers. However, O&M cost must be charged to the individual beneficiaries according to the concept that O&M works after completion of the project will be turned over to the WUA established. The amount of annual O&M cost is estimated at 23,363 US$, which is equivalent to about five (5) US$ (13,700 Riels) per farm household per year. As estimated above, in case of with project, farm economy will be improved by earning disposable income, indicating that beneficiaries can bear the necessary O&M cost for irrigation facilities.

4.5 Comprehensive Evaluation

As the result of financial and economic analysis, the 11.0% of EIRR shows that the project is economic feasibility. This value is higher than 10% opportunity cost of capital in Cambodia. Should the project end only at stage-1, the value of EIRR is relatively low. This is because non-qualitative benefits are included in stage-1. Considering the financial study of typical farmers, farm economy will also improve with the implementation of the project. Also, O&M cost can be charged by the beneficiaries. Consequently the project is evaluated as economically viable.

CHAPTER 5 ENVIRONMENTAL IMPACT ASSESSMENT

5.1 Environmental Impact by Project Implementation

5.1.1 Social Environmental Impact

Implementation of the project will bring direct impact on agricultural activities. The direct impacts on the improvement of agricultural infrastructure are expansion and improvement of farming activities and promotion of distribution system of agricultural products. No negative effects on social environment, as resettlement, rapid population increase, intensification of conflict between farmers and fishers, etc. are foreseen.

The proposed development plans are 1) stage-1 : rehabilitation and construction of multi-purposed reservoirs, farm roads and dikes, water conservation weir, 2) stage-2 : rehabilitation and extension of colmatage canals, and 3) stage-3 : construction of linkage roads and flood control gates.

Rehabilitation of the reservoirs will cause the stable production of recession paddy and increase of production. At the same time, effective use of reservoirs and canals will cause the recovery of farmland productivity and makes crop diversification possible. Stabilization of rural society is expected with the improvement of agricultural production. If vegetation in the reservoirs and flooded forest will be preserved and managed, firewood resources will be provided to the rural people.

Appropriate management of the protected vegetation area, flooded forest and vegetation areas, induces preservation of fishery resources and as a result, sustainable fishery. If the area is preserved and used as a water source of irrigation at the same time, social problems such as recession of flooded forest and conflict between farmers and fishermen will be mitigated. It consequently will cause stabilization of society. The establishment and management of protected vegetation area will not induce infringement on the rights of licensees of No. 17 Fishing Lot.

Since proposed development will not change the present farming system, application of agricultural chemicals and chemical fertilizer will not be intensified. However, some farmers may apply inputs inappropriately for expansion of agricultural activities. Excessive input will cause destruction of fishery resources and negative impact on fishery. It is necessary to provide the farmers' knowledge and information on the proper usage of chemicals.

The rehabilitation plan of the existing reservoirs and their utilization will not alter present way of water use. The beneficiaries will have to organize the operation and maintenance systems based on the present system. The operation and maintenance supporting office and the district agricultural office shall monitor and supervise the farmers to avoid conflict over the use of water.

If roads are improved in stage-3, agricultural activities will be made active in and around the Study Area. However, it will not bring major impact on social environment.

5.1.2 Natural Environmental Impact

Most of arable areas are already exploited for paddy cropping. However, the natural ecosystems are still preserved in the flooded forests, vegetation and wastelands areas. They are directly influenced by the flood cycle of the Mekong river. Proposed plan is for the agriculture and fishery activities with natural flood cycle. Therefore, there will be no disturbance on the flooded forest and vegetation areas with the rehabilitation and construction of reservoirs and roads. No change in the present flood cycle of Mekong and other rivers is expected. The proposed plan will hardly bring negative impact on the present ecosystem.

The hydro-cycle of flood intrusion, inundation and water recession observed in the area will not be changed exceedingly from present condition by the development of stage-1 and 2. On the other hand, if water control facilities at the district roads are constructed in stage-3, flood intrusion from the northern part will be controlled in the area. Though they seem not to lead immense change of flood cycle, it is required to coordinate with other relevant projects on flood control in and around the area.

The project implementation will not give any impact on fish life of spawning, growth and migration suitable to the natural environment in the area. Conservation of flooded forests and vegetation in the proposed sanctuaries will lead to the preservation of the living environment of fish. Water conservation in the Phtea lake with the construction of the weir will also be useful.

Thirty-five (35) species of fish including snakehead, catfish, gobi, barb, etc. are identified in the area. These species are captured and sold in the market. Large size species of this kind are expensive. However, the number of these species has been decreasing. The construction of weir and reservoirs proposed will not bring any negative impact on their migration and capture.

Among 83 species of plants that are listed in the inventory prepared by MAFF, there exist 62 species in and around the area. Of this number, about 54 species are densely distributed and eight (8) are sparsely distributed. Most of them grow from seeds or seedlings. Eighteen (18) species out of 62 have no scientific name. Five (5) grows into trees and used as firewood. They grow easily and rapidly. The living environment of these plants and utilization as firewood will not be changed with the project implementation.

As a result of survey on 31 waterfowl species including heron, snipe, wild goose, wild duck, etc., it was found that four (4) of them were not seen in the area, eight (8) have been missing recently, 15 often come, and eight (8), including two (2) unspecified with scientific name, were seen all seasons. Most of them feed on fish. Several kinds of tortoise and snake are found in the area. Poisonous snake called Pos vek lives on trees during the flood season. Another kind of snake named Posthlann catches rats in paddy fields. The living environment of these wild lives will not be changed with the project implementation except during the period of construction of facilities.

5.2 Environment Conservation Plan

Since conservation and management of flooded forests in the reservoirs are essential to provide firewood resources, patrolling and monitoring activities by O&M organizations are indispensable

to prevent illegal logging and for equal distribution of benefit to farmers.

Although intensive farming is often practiced with the much use of agrochemical and chemical fertilizer, fishery resources tend to be affected with its inappropriate utilization. Therefore, the MAFF should guide and monitor farmers in the proper application of them. The Integrated Pest Management Program (IPMP) conducted by CIAP should be promoted because it has already taken effective measures to restrict application of agrochemical. At the same time, some pesticides including organo-phosphates, which are listed in the WHO guideline as highly hazardous chemicals to human body, should strictly be restricted and regulated.

It is important to accumulate observation data on hydro-environment to manage and conserve natural environment in the middle and long term. Since movement of flooding water is not uniform in the area, flooded water level should be observed at the main installation points of water control gates. Accumulated date will be used to grasp the seasonal change of flooding water in the area and the relations with flooding of the Mekong river. The change of water quality will affect natural environment and fishery resources. The GDIMH should have the district office to collect yearly water samples at the upper and down points of the Phtea lake at the beginning and end of dry season, and analyze and observe the changes of water quality.

The DOFi should conduct field survey on fish species captured in the area during both dry and wet seasons for preservation of fishery resources and sustainable production.

As living standard of rural people will improve gradually with the improvement of social infrastructures and promotion of agricultural activities, it is required to take appropriate measures against increasing firewood consumption, waste and sewerage. Though the MOE has been promoting the strengthening of organization and human resources at both central and rural levels, it should take further step to increase awareness of villagers on hygiene improvement and preservation of natural resources. Especially, over-consumption of firewood causes recession of flooded forest. Besides the diffusion of toilet, activities on the improvement of living environment should be promoted.

The inventory survey of plants and animals and their living environment becomes a fundamental data for preservation of natural environment. The DOFo should collect and review the regional data with the cooperation of the villagers, and promote awareness among villagers about importance of resource preservation.

CHAPTER 6 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

For the Agricultural Development Study of the Mekong Flooded Area in Cambodia, three (3) types of basic development plans as, Colmatage Farming Improvement Plan, Agricultural Development Plan Harmonized with Fisheries and Rainfed Agricultural Development Plan are formulated based on the advantages of traditional farming practice with annual hydrological and ecological cycle of the Mekong river. The proposed plan coincides with the aims for rehabilitation and reconstruction in Cambodia as indicated in the First Socio-Economic Development Plan.

In this study, priority projects and areas were identified in the flooded areas for agricultural development since it is not practical to implement simultaneously these development plans in the whole flooded area due to financial limitation and capacity of implementation body in Cambodia. It is proposed that development plans should be implemented in the selected priority area as the pilot projects.

Agricultural development project harmonized with fisheries in the priority area is expected to produce many agricultural benefits and environmental conservation effects on fisheries resource. Based on the economic analysis, the economic viability is high. As a conclusion, the proposed project is considered to be feasible.

The project will also contribute to the national agro-economic growth through the increase of agricultural production and the stabilization of rural life. The project plan is recommended to be implement urgently.

6.2 Recommendations

It is recommended to implement the proposed project considering the following.

- Constructed and rehabilitated facilities should be operated and maintained by beneficial farmers. However, improper operation and maintenance of them would cause unexpected deterioration of farming and fishing resources. To ensure sustainable agriculture and fisheries and to prevent deterioration of the facilities, it is required that beneficiary farmers actively participate in the development of the project

- To realize farmer's participation for the project, it is requested to establish and strengthen the farmers' organization. For that purpose, some measures should be taken from the initial implementation stage in parallel with the provision of the facilities.

- To ensure sustainable fishing in the area, some farming and fishing activities currently being undertaken in the present reservoirs should be controlled to preserve the inundated forest and vegetation areas. It is therefore necessary that besides the proposed infrastrutural measures, training and propagation activities aimed at the successful harmonized farming and fishing to the related farmers should be undertaken and supported by the related agencies such as DOFi and DOFo.

- The proposed development of weir construction is located in the Fishing Lot. For the development, permission from the DOFi and the lot licensee should be considered before construction. Fishing and farming inside the proposed sanctuaries should be prohibited and preserved. Control and management of these area should be authorized by DOFi, in line with the present regulations or laws related to fishery management.

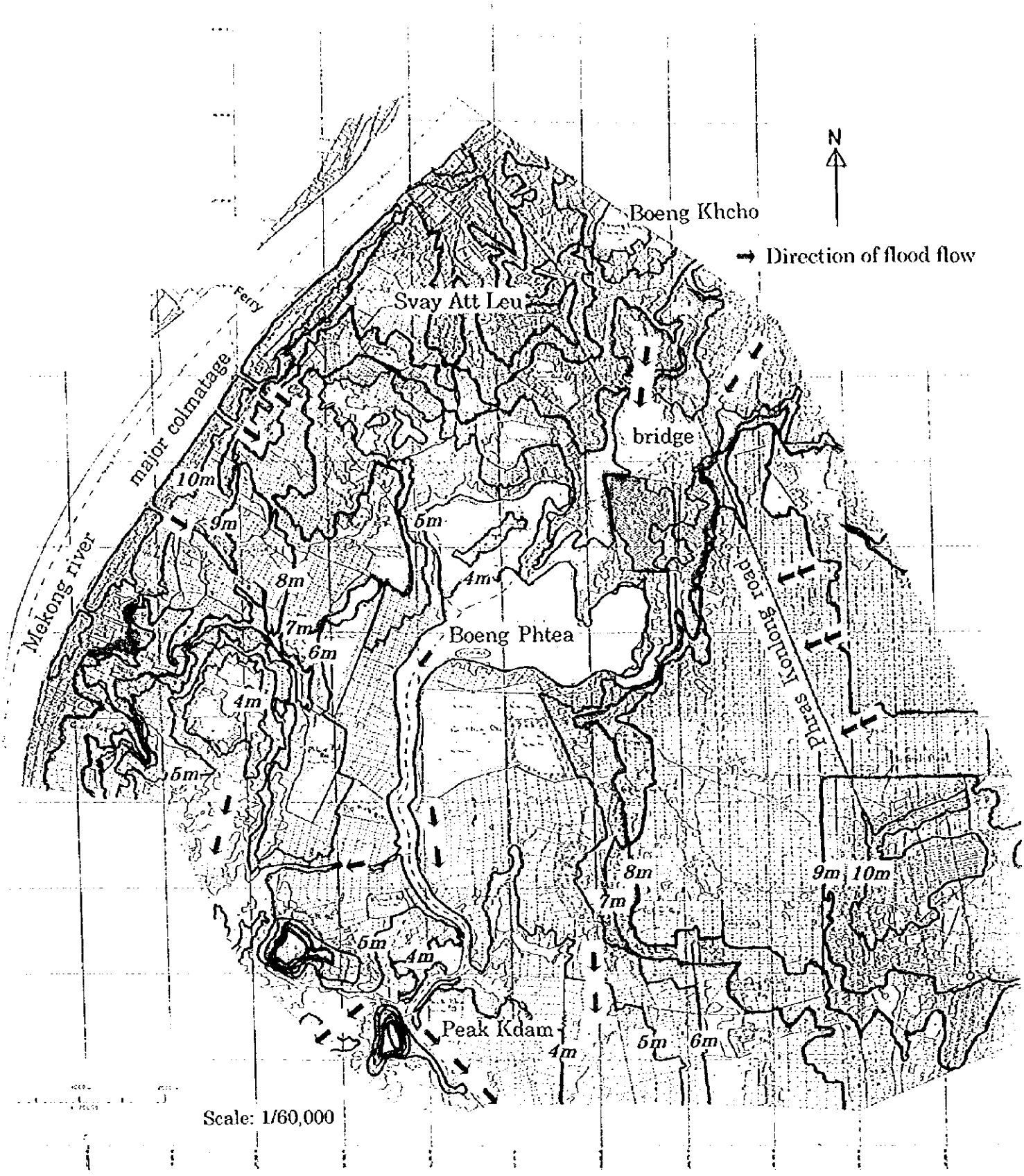


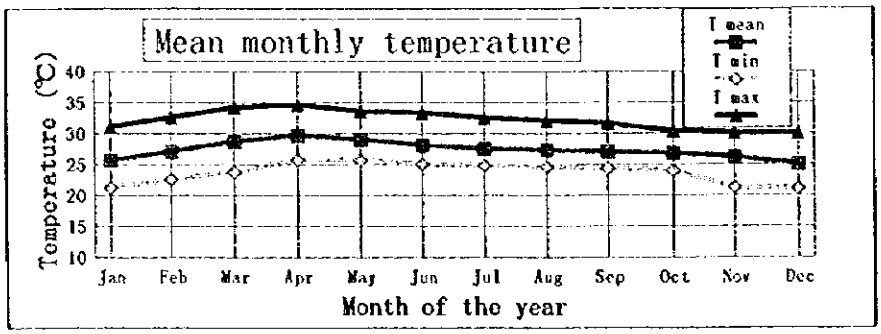
Figure 1.1 Topography and General Direction of Flood Flow

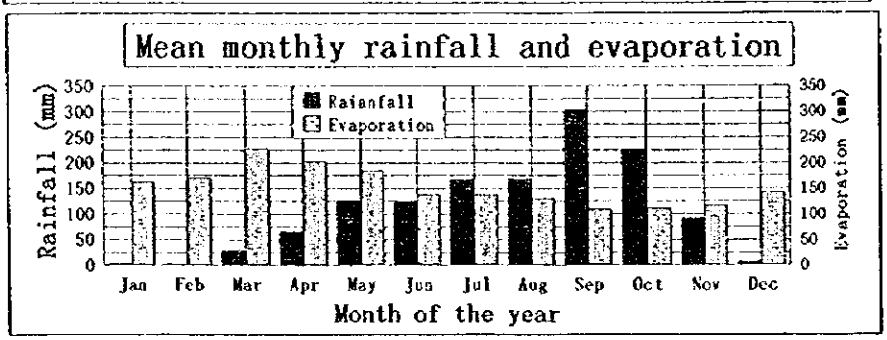
Basic meteorological data - Pochentong Station

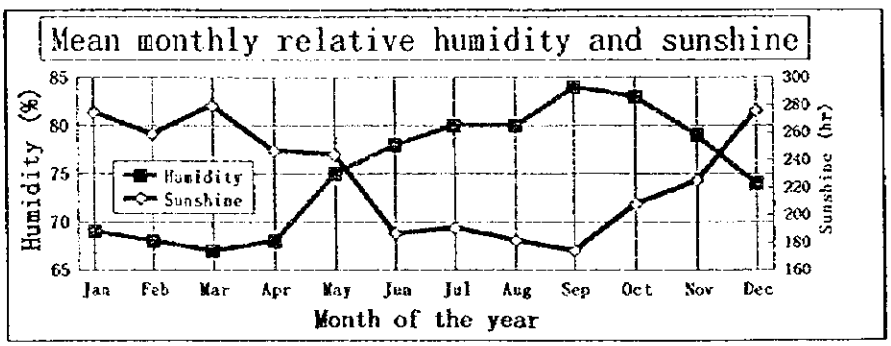
Month	Jan I	Feb II	Mar III	Apr IV	May V	Jun VI	Jul VII	Aug VIII	Sep IX	Oct X	Nov XI	Dec XII	Total
Rainfall	3.6	2.8	29.5	66.3	124.6	122.5	167.7	168.3	303.4	225.5	92.5	6.5	1313.2
Temperature													
T mean	25.7	27.1	28.7	29.7	29	28.1	27.5	27.4	27	26.8	26.2	25	
T min	21.3	22.6	23.8	25.8	25.7	25	24.9	24.6	24.4	24	21.3	21.1	
T max	31.1	32.6	34.2	34.6	33.6	33.4	32.5	32.1	31.6	30.4	30.1	30	
Humidity													
U mean	69	68	67	68	75	78	80	80	81	83	79	74	
Evaporation	162	170.7	227.5	202.6	184.6	137.8	137.5	130.1	108.8	111.2	117.6	142.2	1832.6
(mm/day)	5.2	6.1	7.3	6.8	6.0	4.6	4.4	4.2	3.6	3.6	3.9	4.6	
Sunshine	274.9	258.8	279.7	246.9	241.1	186.5	190.3	181.5	173.9	207.9	225.1	276.1	2745.7
(hr/day)	8.9	9.2	9.0	8.2	7.9	6.2	6.1	5.9	5.8	6.7	7.5	8.9	

Meteorological data - Pochentong (1985～1995)

(No. 991, 11° 33'N, 104° 51'E, 10m M.S.L.)







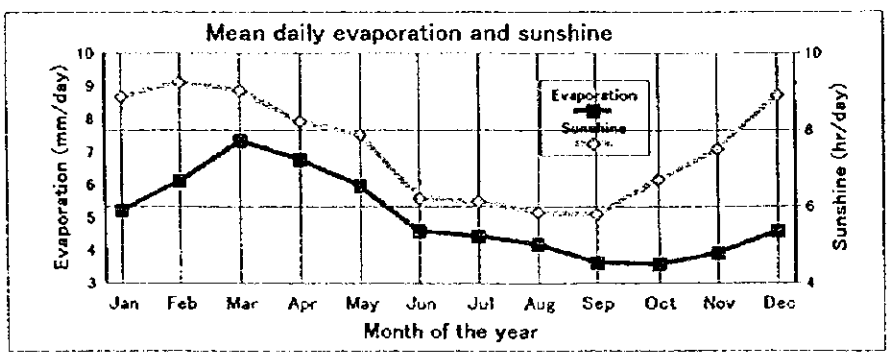


Figure 1.2 Bassac Meteorological Data - Pochentong Station

Monthly rainfall - Pochentong Meteorological Station

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	Average
Jan	0.4	0.0	1.4	0.0	0.0	0.0	0.0	15.0	0.0	0.0	3.1	0.0	0.4	0.0	1.5
Feb	0.5	0.0	1.1	1.1	4.5	0.0	22.9	0.0	0.0	0.0	2.5	0.0	0.0	0.0	2.3
Mar	11.2	0.0	0.0	0.0	4.5	0.0	22.2	51.0	0.0	0.0	0.6	0.0	161.2	18.0	19.8
Apr	181.0	0.0	128.7	157.6	48.7	0.0	96.3	63.2	26.2	83.4	35.0	0.0	61.1	91.3	69.7
May	196.8	47.5	62.2	102.7	149.8	24.6	70.2	183.5	227.1	53.4	93.4	47.5	157.7	231.6	117.9
Jun	158.9	55.1	142.6	77.0	90.9	150.2	172.9	38.4	63.8	301.5	113.9	55.1	106.1	146.8	119.7
Jul	74.9	170.1	127.1	117.6	181.3	138.2	152.9	86.6	166.8	281.3	219.5	170.1	96.5	156.4	153.0
Aug	161.1	312.2	106.1	92.5	224.5	183.6	177.8	162.4	174.6	193.7	198.4	312.2	151.3	208.9	190.2
Sep	246.7	174.1	261.3	283.7	301.3	474.3	445.0	398.7	246.6	120.2	216.5	174.1	332.9	277.1	282.5
Oct	218.5	203.1	292.7	260.8	235.1	257.1	137.4	328.6	98.3	210.2	197.2	203.1	126.9	243.6	215.2
Nov	107.5	155.4	51.5	168.6	86.9	323.8	71.4	107.3	138.7	2.2	10.9	155.4	5.6	22.4	102.0
Dec	0.1	3.2	1.1	0.9	23.8	0.0	0.0	0.0	0.0	1.7	3.8	3.2	17.9	11.2	4.8
Annual	1360.6	1120.7	1178.8	1282.5	1351.3	1551.8	1369.0	1437.7	1142.1	1453.6	1091.8	1120.7	1223.6	1413.3	1278.6
Max	91.8	80.0	83.3	62.5	75.4	113.5	128.0	96.9	74.0	85.2	80.0	80.0	79.2	110.5	

Note: Max is maximum daily rainfall

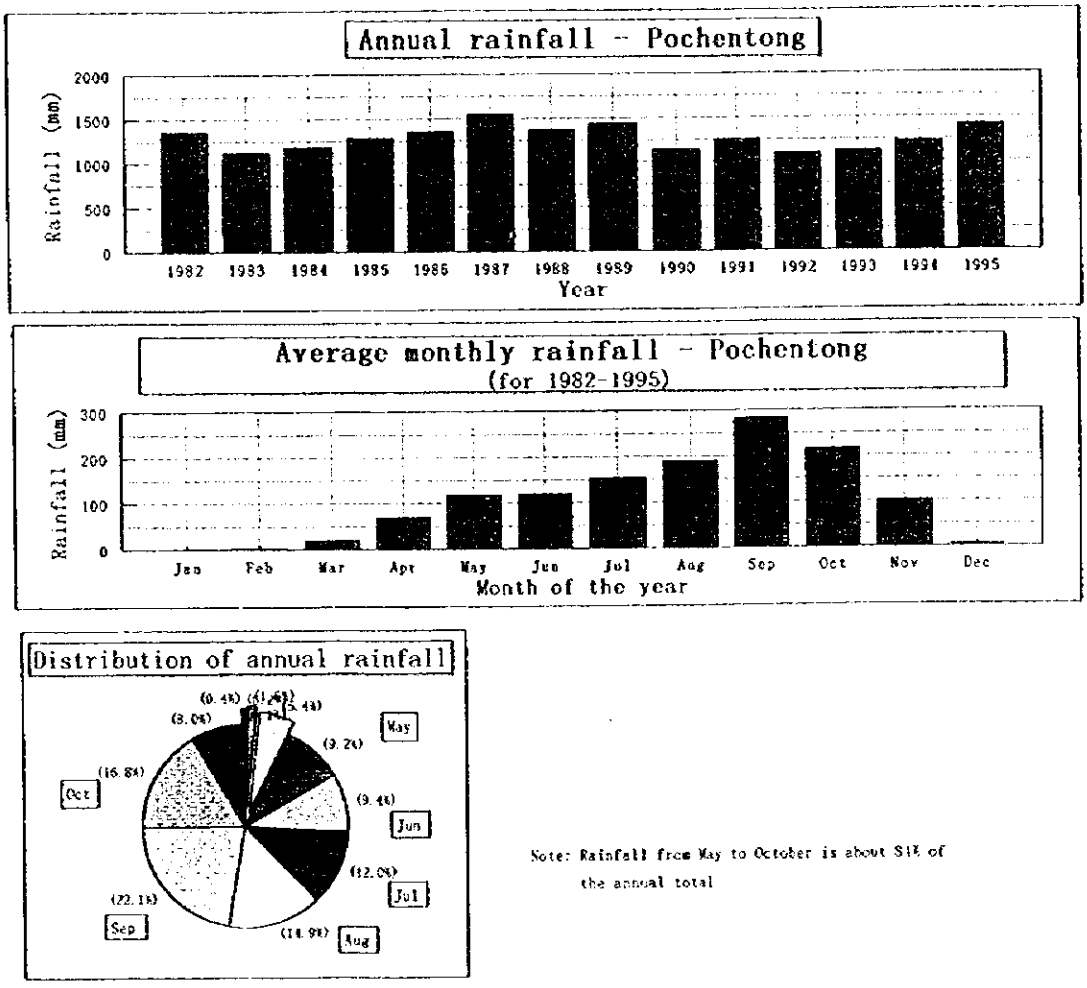


Figure 1.3 Monthly Rainfall (1982-1995) - Pochentong Station

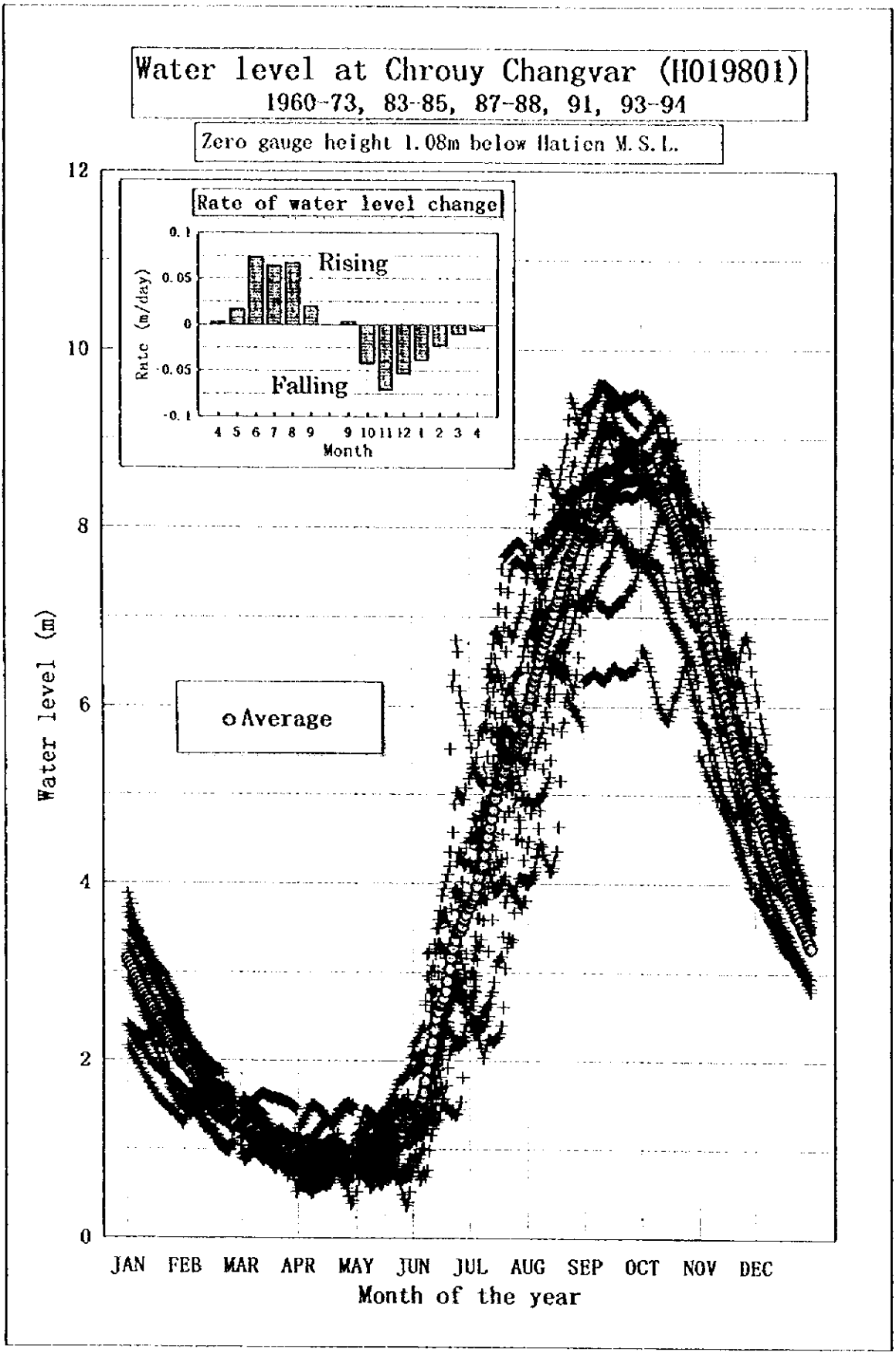


Figure 1.4 Periodic Flood Level of Mekong River - Chrouy Changvar

Inundation depth - July to December - 1985 (1/2 R.P.)

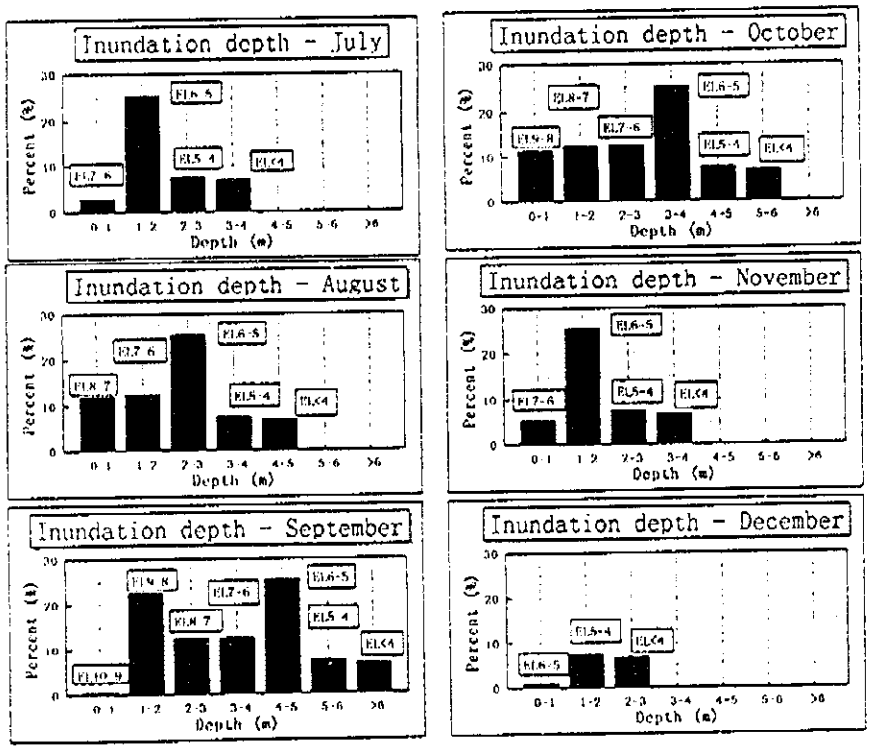
Unit : (%)

Month	Water level (m)	Inundation depth (m)								Total
		0	0-1	1-2	2-3	3-4	4-5	5-6	>6	
Jan	3.11	6.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Feb	2.14	6.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Mar	1.70	6.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Apr	1.40	6.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.91
May	1.87	6.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Jun	3.76	6.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Jul	6.22	0.00	2.75	25.37	7.55	6.91	0.00	0.00	0.00	42.58
Aug	7.97	0.00	12.09	12.49	25.37	7.55	6.91	0.00	0.00	64.41
Sep	9.06	0.00	0.51	22.60	12.46	12.49	25.37	7.55	6.91	87.89
Oct	8.51	0.00	11.53	12.46	12.49	25.37	7.55	6.91	0.00	76.31
Nov	6.44	0.00	5.49	25.37	7.55	6.91	0.00	0.00	0.00	45.32
Dec	5.04	0.00	1.02	7.55	6.91	0.00	0.00	0.00	0.00	15.48

Inundation depth - July to December - 1966 (1/10 R.P.)

Unit : (%)

Month	Water level (m)	Inundation depth (m)								Total
		0	0-1	1-2	2-3	3-4	4-5	5-6	>6	
Jan	3.01	6.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Feb	2.07	6.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Mar	1.56	6.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Apr	1.11	6.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.91
May	1.81	6.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Jun	3.27	6.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.91
Jul	5.90	0.00	22.83	7.55	6.91	0.00	0.00	0.00	0.00	37.29
Aug	8.34	0.00	7.68	12.49	25.37	7.55	6.91	0.00	0.00	60.00
Sep	9.93	0.00	7.82	22.60	12.46	12.49	25.37	7.55	6.91	95.20
Oct	9.00	0.00	22.60	12.46	12.49	25.37	7.55	6.91	0.00	87.38
Nov	6.70	0.00	8.74	25.37	7.55	6.91	0.00	0.00	0.00	48.57
Dec	4.80	0.00	6.04	6.91	0.00	0.00	0.00	0.00	0.00	12.95



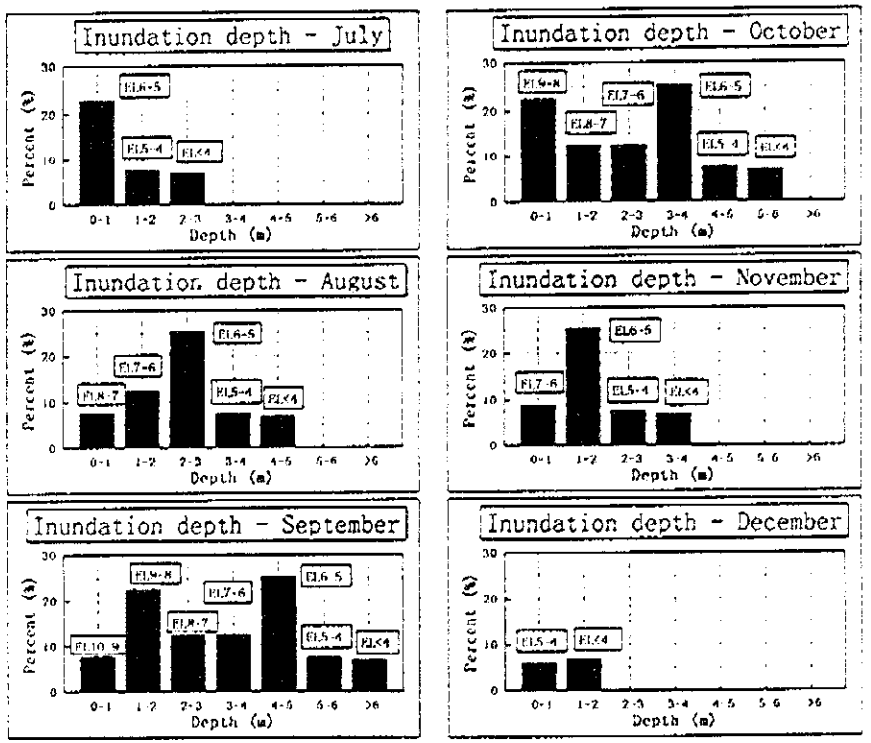


Figure 1.5 Mean Monthly Inundation Depth (1/2 & 1/10 Return Period)

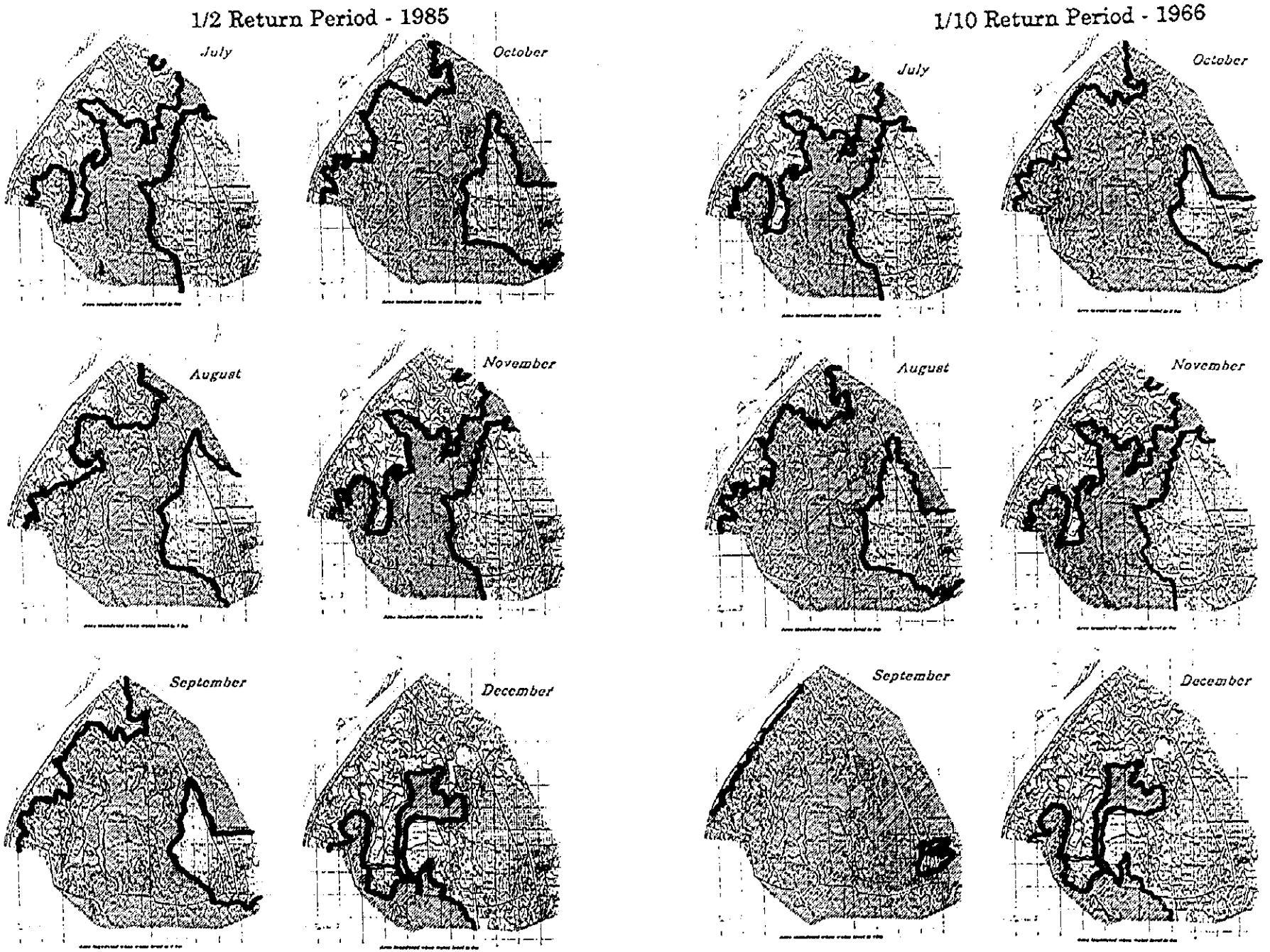


Figure 1.6 Mean Monthly Inundation Extent (1/2 & 1/10 Return Period)

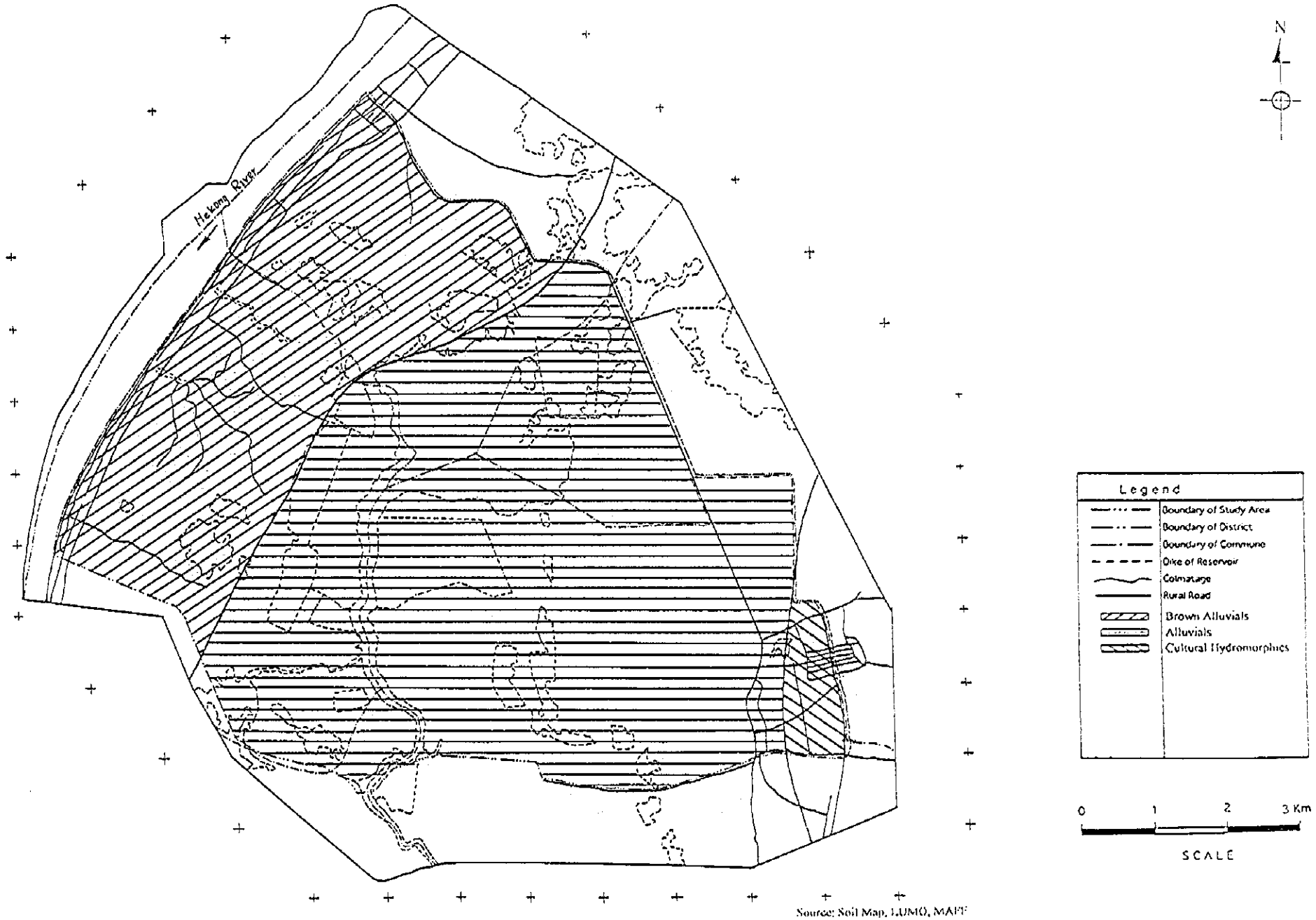
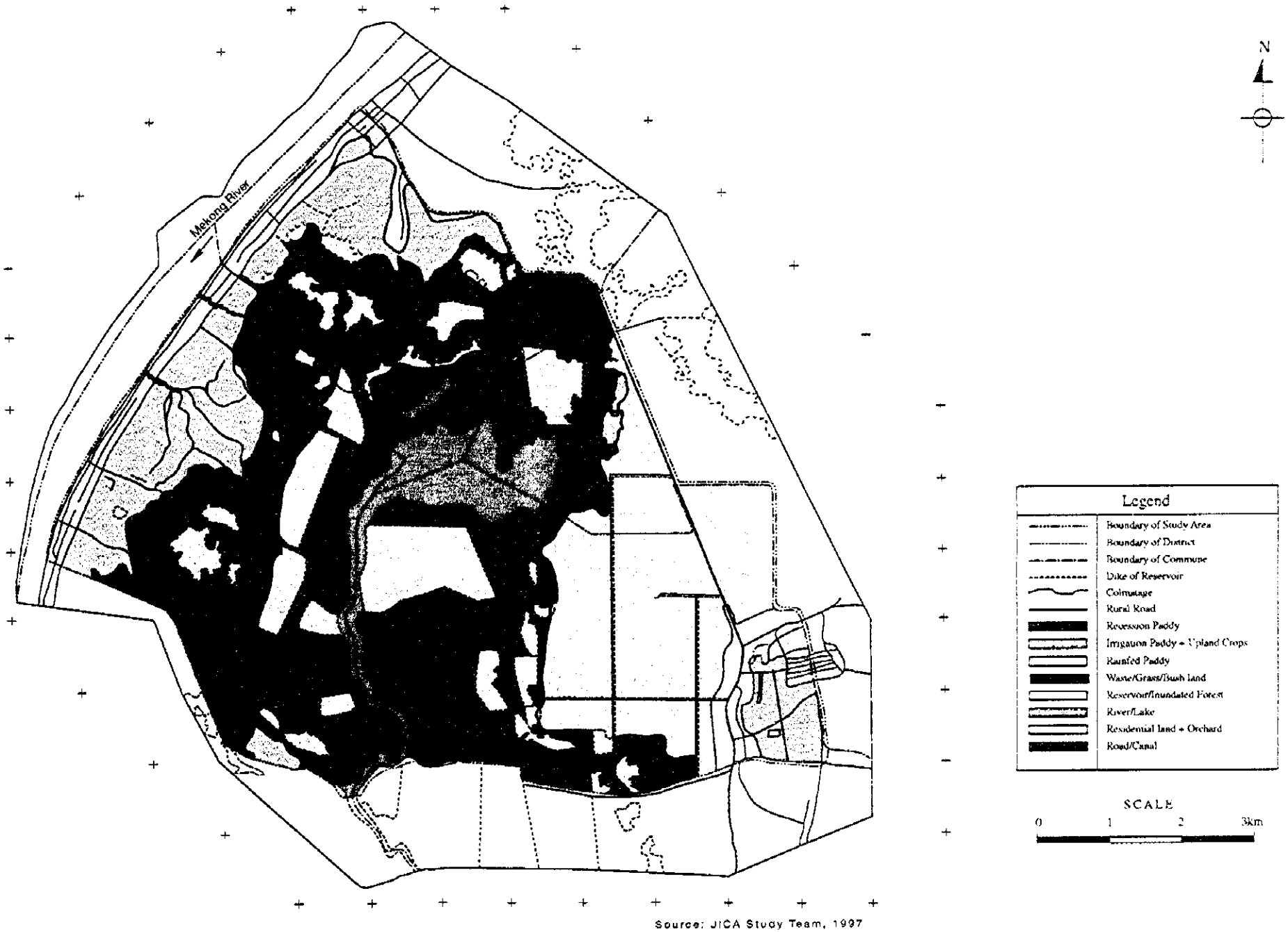


Figure 1.7 Soil Map of the Study Area



Source: JICA Study Team, 1997

Figure 1.8 Present Land Use Map of the Study Area

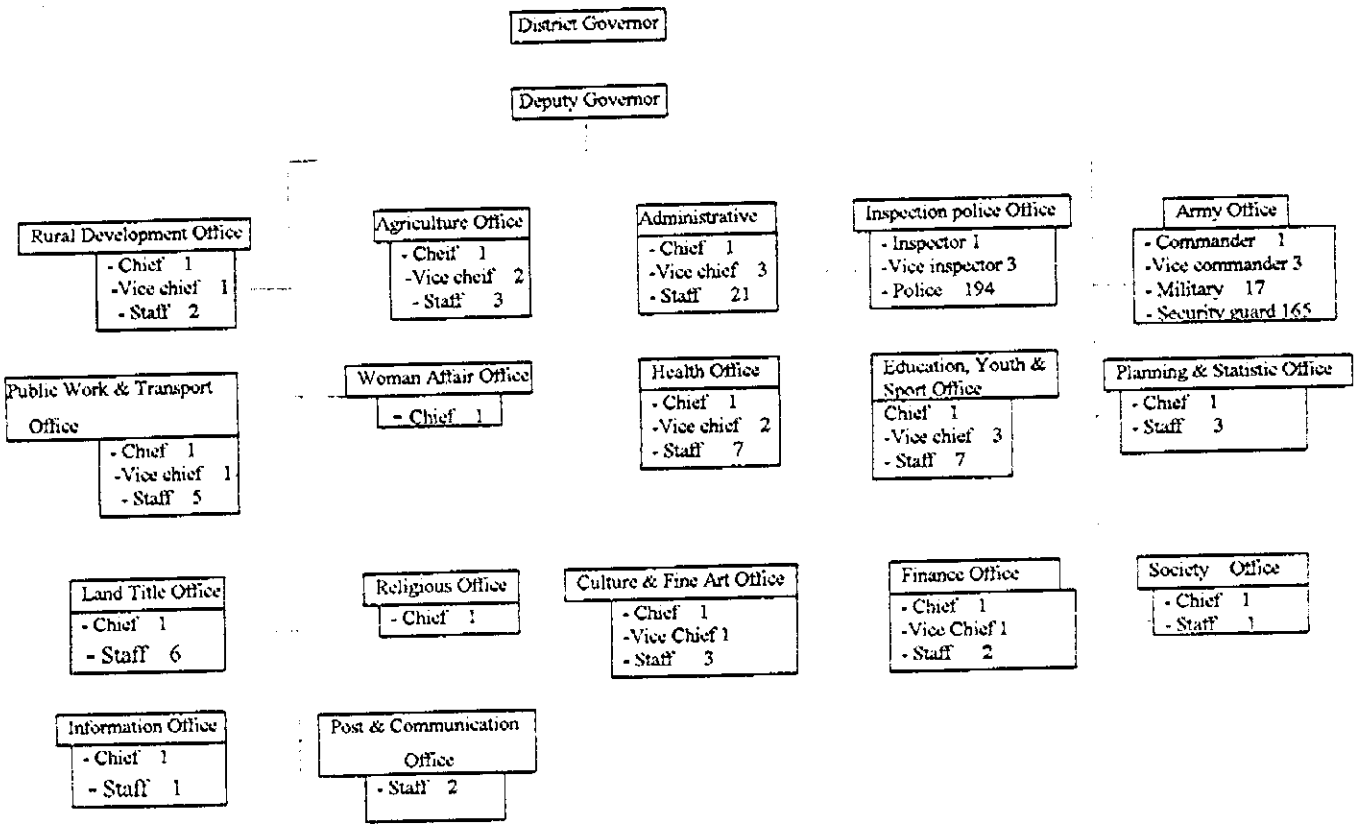


Figure 1.10 Organization Chart of District Office

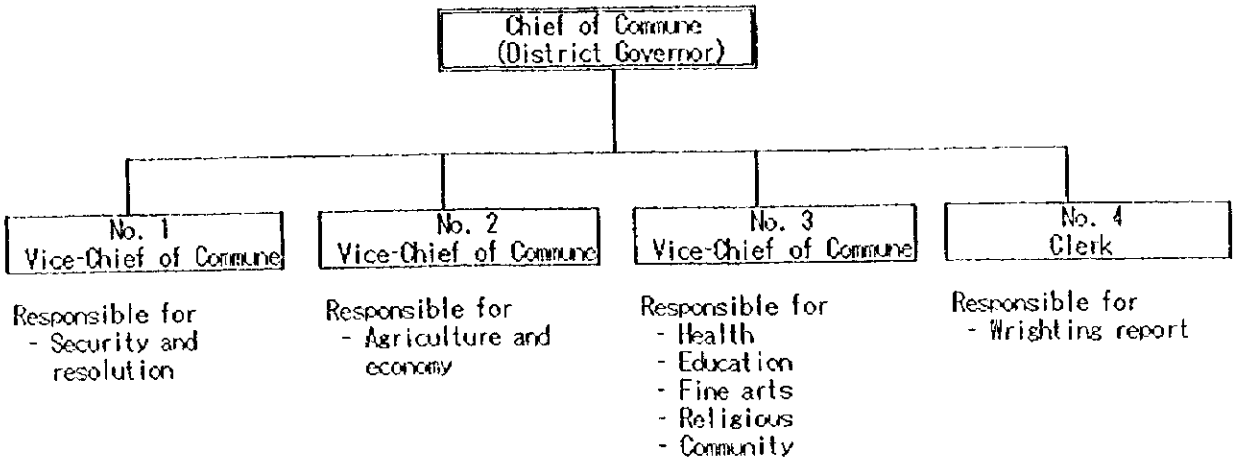


Figure 1.11 Organization Chart of Commune Office

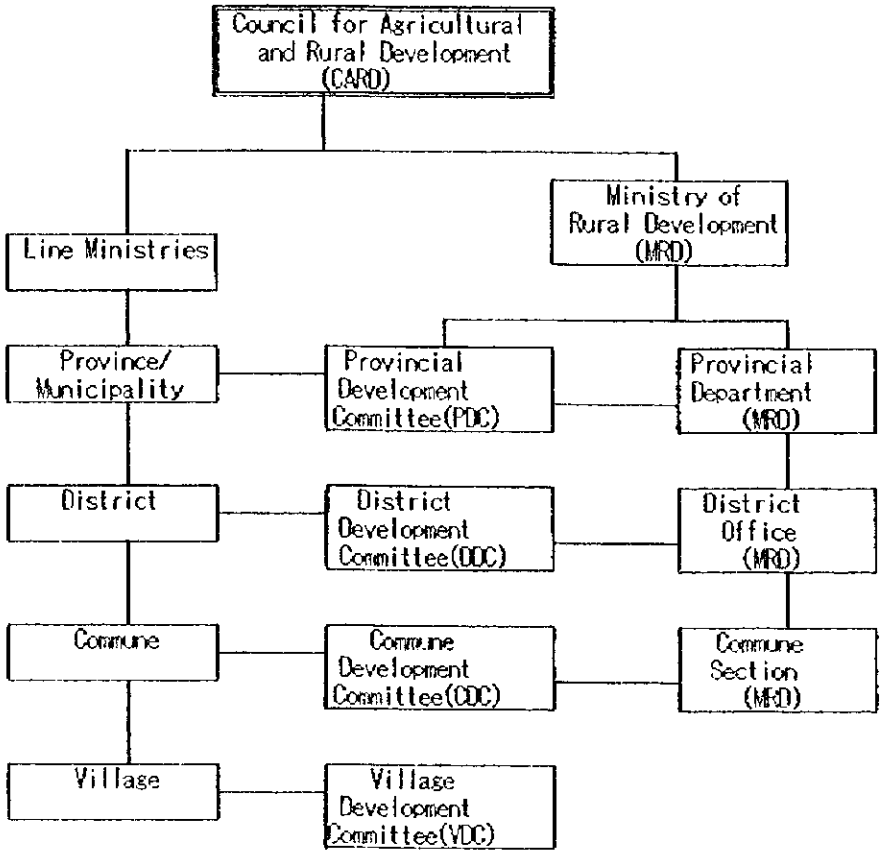


Figure 1.12 Coordination and Communication in the Rural Development System

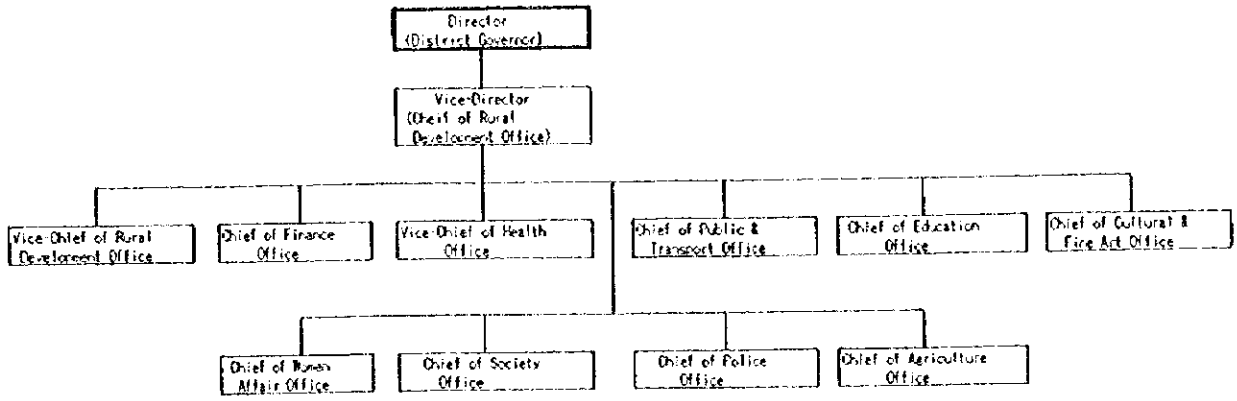


Figure 1.13 Organizational Chart of District Development Committee

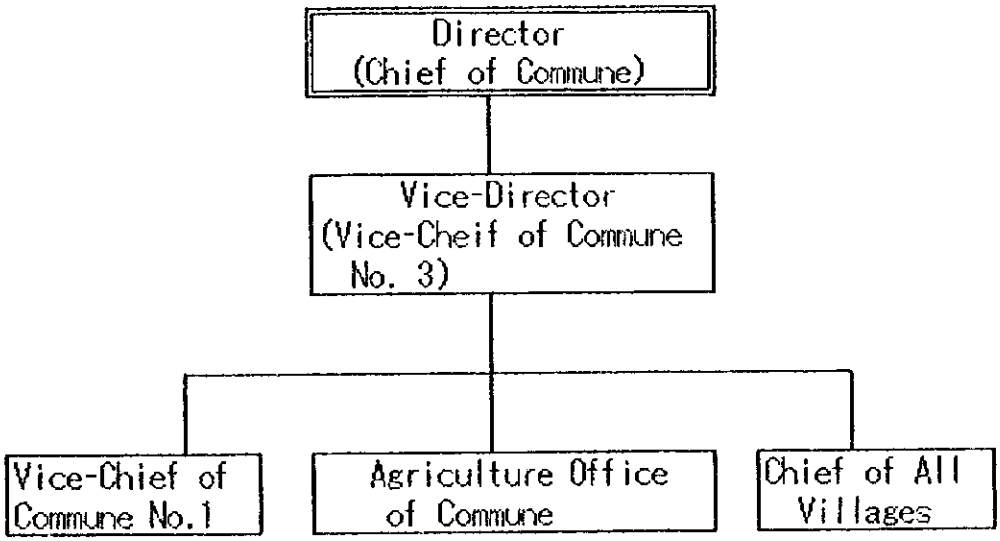
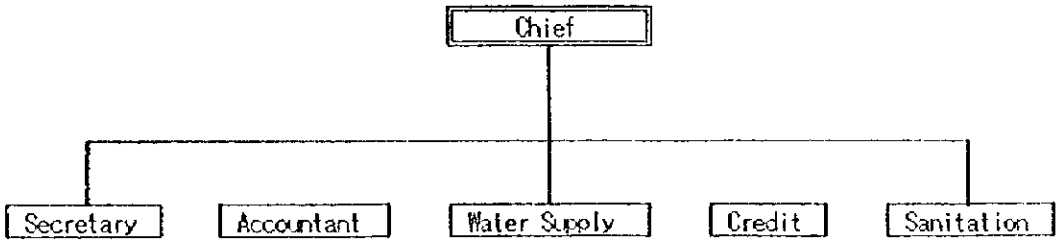


Figure 1.14 Organizational Chart of Commune Development Committee



Source. Ministry of Rural Development
Note.Number of members under the chief is 5, 7 and 9 depending on village size and responsibilities of members are vary in each village.
Chief is elected by village people every three(3) years.

Figure 1.15 Organizational Chart of Village Development Committee