The younger flood plains are subject to flooding from the Prek Thnot River or its tributaries, while the older plains are not susceptible to flooding. The northern part of the Kandal Stung Study area is sometimes flooded by the Prek Thnot River due to the small capacity of the river channel. The Stung Toch River collects spilled water from the upstream reaches of the Prek Thnot, which spreads in the Kandal Stung area. Many fish fences, bushes, or earth bunds for the irrigation intake are present in the Pol Pot canals. Due to the lack of the flow capacities of the road crossing structures and the back water effects of the above-mentioned diversion structures, inundation of the low-lying areas on the west side of the National Road No. 2 sometimes occur in the rainy season.

(2) Irrigation and Drainage Conditions of the Tonle Bati Study Area

The Tonle Bati Study area is located in the Bati District of the Takeo Province, extending over an area of 6,900 ha. The Study Area is bounded by the Tonle Bati Lake and the Tonle Bati Rivers on the north, the Cheung Loung Lake on the east, the National Road No. 2 on the west and a district road toward Kompong Cheung village on the south. Topography of the area is rather flat with a slightly elevated area in the central part of the area. Land units of the area belong mostly to older plains except the limited younger floodplains in the northern part.

In the Pol Pot regime 1975 to 1976, irrigation canals and their related structures were constructed in the Tonle Bati area. The irrigation water is taken from the Tonle Bati Lake. During 1987 to 1990, an irrigation system for 900 ha was rehabilitated by the Department of Hydrology with the assistance of the World Council of Churches (WCC). In August 1991, the irrigation facilities of the Tonle Bati Project were damaged by flood. In February 1992, rehabilitation of some parts of the damaged canal embankment was executed by the Mekong Secretariat (executing agency) with the financial assistance of UNDP. However, irrigation facilities are presently not functioning well mainly due to insufficient rehabilitation, insufficient water levels/storage of the Tonle Bati Lake and the lack of an O&M system.

The irrigation water supply in the Tonle Bati Project area has not ban reliable for a long time. Farmers have been using different kinds of lifting irrigation, such as indigenous tools or private small capacity engine-driven pumps. The only irrigation system in the Tonle Bati Study area is the Tonle Bati Irrigation Project which was rehabilitated during 1989 to 1991, but is not functioning well at present.

The Tonle Bati Study area faces the Cheung Loung lake in the east. The low-lying areas located on the eastern edge up to an elevation of about 5.3 m, are prone to inundation from the lake in the rainy season. About 600 ha of receding paddy cultivation is practised in these low-lying areas. The other areas are not subject to flooding. Run-off from Phnom Tamao, a hilly area lying on the west of the Tonle Bati Study area, discharges to the Study Area and stagnates in the western part of the Study Area for a few days, when heavy rain occurs. This is used to supplement irrigation.

3.5.2 Kompong Tuol Irrigation Intake

(1) History of Kompong Tuol Irrigation Intake

In order to maintain the required water level in the Prek Thnot River and to create a reservoir for supplying irrigation water to the Kandal Stung area and Tonle Bati area, the Prek Thnot by-pass channel and the Tuk Thla regulator were constructed from 1975 to 1976 at the Kompong Tuol village, together with the National Road No.3 dike and the Kompong Tuol regulator. A flood dike along the right bank upstream of the Kompong Tuol village was also constructed to protect the existing paddy fields from inundation of the Prek Thnot river. These facilities are hereinafter referred to jointly as the Kompong Tuol Irrigation Intake.

In August 1991, the National Road No.3 dike between the Kompong Tuol and Tuk Thla regulators was washed out by floods. At the beginning of 1992, rehabilitation of the road dike was executed by the Mekong Secretariat (executing agency) with the financial assistance of UNDP under the "Rehabilitation of Hydraulic/irrigation Structures damaged by 1991 Floods" project. The works were implemented by the Department of Hydrology. But it was washed out again by the flood in October 1992. It was rebuilt again in December 1993 with the assistance of NGO's. Then, in March 1994, the road dike was breached again by the high flow. Urgent rehabilitation of the road dike was carried out. On August 3, 1994, when it was breached again, at two locations, by the floodwater. This has meant the Kompong Tuol intake has not been functioning for long time.

(2) Present Conditions of Kompong Tuol Irrigation Intake

i) Tuk Thla Regulator

This structure was constructed in a spillway channel excavated across large meanders in the Prek Thnot River at the Kompong Tuol village. The regulator consists of 25 manual-operated wooden slide gates with an average width of 1.1 m and a gate height of 2.4 m. A bridge for the National Road No.3 is immediately downstream of one gate, and has a net width of 18.5m and a length of 37.4. Downstream of the bridge is a gradual-inclined stilling basin with a bottom level 2.5 m lower than the gate. A spillway channel is 2.2 km long and about 50 m wide. The channel berms upstream and downstream are eroded by flood flows. The bridge and stilling basin are located in acceptable conditions except for the unprotected left bank slope.

The gate operation, although not functioning properly at present, is as follows. All gates were closed after the high water season ended, and at the beginning of the next rainy season when high water levels occurred, one gate was opened first. As the water level rose further, successive gates were raised until the reservoir level was stabilized. The gates were raised very slowly and required considerable effort to open. Two gate operators had to work simultaneously on one gate. It took one day for one gate to open using 8 operators. To fully open all 25 gates, it required 6 to 8 days using 25 to 30 gate operators.

The flood flow on August 3, 1994 is as follows. The gates could not be fully opened. The discharge through the gates is estimated to be about 180 m^3/sec, while the maximum flow capacity is estimated to be 260 m^3/sec, if the gates are fully opened.

ii) Kompong Tuol Regulator

The Kompong Tuol regulator consists of 6 manual-operated slide gates with an average gate width of 1.5 m and gate height of 3.6 m. A bridge for the National Road No.3, immediately downstream of one gate portion, is located at El 14.03 LBKS, and has a width of 8.0 m and a length of 12.0. Downstream of the bridge portion, there is a gradual-inclined stilling basin with a bottom level 1.2 m lower than the gate portion. The control of water levels is mainly made by the Tuk Thla regulator. The Kompong Tuol regulator is mostly closed and is opened only to supplement the release of high floods. The maximum flow capacity of the Kompong Tuol regulator (in case of full opening) is estimated to be 130 m^3/sec. At present, the outflow from the gates attacks the embankment of the east route of the National Road No.3 eroding its slope. Seepage was observed on the right side of the outlet wall.

Some gates of the two regulators are damaged and do not operatie. The gates are too narrow and have numerous difficulties and problems to ensure smooth operation during floods. The present maximum flow capacity of both regulators is estimated to be about 400 m^3/sec. The 100 year flood discharge of the Prek Thnot River is estimated to be 1,900 m^3/sec. The present flow capacity of the gates is insufficient to reduce high

floods. Repair or replacement of gates to increase the overall capacity of the regulator sites is urgently needed.

iii) National Road No.3 Dike

On August 3, 1991, flood waters in the Prek Thnot river overtopped the road dike at two locations between the Tuk Thla and the old river channel, resulting in breach; south and north of the Kompong Tuol regulator. The north part was breached due to overtopping of the flood water and the south part was breached by severe piping through the road dike. Both locations were damaged by the flood of August 1991. There are similarities between the two cases.

Flood waters also crossed the recently heightened road embankment between the old river course and the Stung Toch River and flowed through the Kandal Stung Irrigation intake, causing damage to the intake and the main canal embankment.

The National Road No.3 bifurcates into the western original and eastern extension routes after passing the Tuk Thla regulator. The Kompong Tuol regulator is located on the western route and the breached portion is on the same route. After breaching of the road dike by the flood in August 1991, the route was diverted to the eastern route by the Ministry of Public Works. It crosses the Prek Thnot river using a Bailey bridge. The eastern route is presently used as a main route. This route was laterite paved in June 1994, having a width of 10 m and shoulders of 2 m each. The Government intends to rehabilitate the western route as the main route of National Road No.3.

iv) Flood Dike along the Upstream Right Bank of Kompong Tuol

To protect the paddy fields on the right bank against inundation from the Kompong Tuol intake, a 5.2 km long flood dike from the Kandal Stung intake to the railway embankment was constructed, during the Pol Pot regime. The flood waters on August 3, 1994 flowed over the dike, resulting in heavy erosion especially near the National Road. The flood water also enters the paddy field area through culverts and bridges under the railway.

(3) Operation and Maintenance

O&M of the Kompong Tuol intake was carried out by two related districts. The Dangkor District office of Phnom Penh municipality for the Tuk Thla regulator and the Kandal Stung District of Kandal Province for the Kompong Tuol regulator. 25 gate operators for the Tuk Thla regulator and 6 for the Kompong Tuol regulator were appointed from the two districts. In order to coordinate the operation of the gates, a coordinating committee composed of representatives of the Hydrology Office of the two related districts and Phnom Penh municipality was organized. There has always been operation conflict between the related districts. The farmers in the Kandal Stung irrigation area wanted to raise water level to increase the diversion volume while the farmers in both bank areas immediately upstream of the regulators tried to lower the water level to lessen inundation damage to their farmland. Sufficient institutional set-up for operation of the regulators is required to solve these issues smoothly.

3.5.3 Kandal Stung Irrigation Project

(1) History of the Project

Under the Pol Pot regime from 1975 to 1979, a new irrigation canal system was constructed in the Kandal Stung area, together with the Kompong Tuol Irrigation Intake, without taking into consideration previous plans and the completed canals and structures of the Prek Thnot Multi-purpose Project. Distribution canals for irrigation were constructed

following latitudinal and longitudinal gridlines regardless of topographic conditions. Intake- and canal-related structures were constructed together with canals. Major canals were located 1 km from each other, and distribution canals and field borders were provided in principle at 100 m intervals.

In the period from 1987 to 1991, the rehabilitation/construction of the irrigation facilities for about 2,000 ha under the Kandar Stung Irrigation Project was carried out by the Department of Hydrology with assistance of the Mennonite Central Committee (MCC).

In August 1991 when the dike on the National Road No. 3 between the Kompong Tuol and Tuk Thla regulators was washed out, the irrigation facilities of the Kandal Stung Project were also severely damaged by floods. In February 1992, rehabilitation of some parts of the damaged canal embankment and structures of the Kandal Stung Project was executed by the Mekong Secretariat (executing agency) with financial assistance of UNDP under the "Rehabilitation of Hydraulic/Irrigation Structures damaged by 1991 Floods" project. The works were implemented by the Department of Hydrology. In August 1994, about 400 m of the headreach of the main canal were washed out and the head regulator was damaged by flood. The Kandal Stung Irrigation facilities were not functioning for a long time due to repeated damage.

(2) Irrigation and Drainage Facilities

i) Irrigation Facilities

Irrigation canals and related structures were rehabilitated in a period from 1987 to 1991 by the Department of Hydrology, with the joint effort of the Kandal Stung District, Kandal Province and with assistance of MCC. Most of the works were completed for an area of about 2,000 ha.

Irrigation water to the Kandal Stung area is diverted from the old river course of the Prek Thnot using the control structures of the Tuk Thla and Kompong Tuol regulators. The irrigation system consists of main, laterals and tertiary canals with related structures and drainage canals. The distribution canal system basically follows the Pol Pot layout, and some existing canals are incorporated in the system. The following are the general features of the canals and structures rehabilitated/constructed so far:

Description	Total Length	Number
Irrigation Canals	(km)	(nos)
Main Canals	5.30	1
Lateral Canals	13.23	5
Tertiary Canals	38.03	35
Related Structures		
Structures related to main and lateral canals	-	28
Turnouts for tertiary canals	-	38

The capacity of the main canal to serve an area of 3,100 ha inclusive of an extension area is 9.73 m^3/sec at its head. The water levels never reach the originally designed one due to lower water levels controlled at the Tuk Thla and Kompong Tuol regulators . Heavy erosion occurs on inside and outside slopes of canals in some places.

Most of tertiary canals cannot receive water from the main canal and lateral canals, and some tertiary canals are served with water from drains. In most cases water is insufficient, and water levels in the canals are so low that gravity irrigation is difficult. Tertiary canals having a length of about 1 to 2 km in the upstream area are provided at about 1 km intervals. The present tertiary system makes it difficult to attain efficient on-farm water management and sustainable O&M of on-farm facilities by water users.

In order to prevent erosion on canal slopes on the erodible soils, slope protection by means of lining and sod facing as well as reshaping of canal embankment will be needed. Most lateral and tertiary canals require reshaping of their cross sections and improvement of their embankment. Additional on-farm canals are required to enable equitable water supply to the fields.

Many turnouts and check structures for irrigation have no gates and barrels of turnouts are often filled with sediment. Most of the structures need repair or desiltation and the elevation of structure bases should be adjusted with reference to the design.

ii) Drainage Facilities

Drainage water discharges to the Cheung Loung lake through the Project drainage canals and Pol Pot canals. Many obstacles in such drainage canals are preventing smooth flow of water. Smooth drain flow is sometimes disturbed due to insufficient number and size of cross drainage structures, and inundation or flooding often occurs.

Many fish fences, bushes or earth bunds for irrigation intakes are often seen on existing drains. Pol Pot canals had been improved for use as drainage canals in the Study Area. The design drainage water requirement of 0.5 lit./sec/ha was used. This has a return period of about 1/5 to 1/10, based on the drainage module commonly applied to the Southeast monsoon areas.

iii) Irrigation and Drainage Conditions

The rehabilitation of the irrigation system was completed in 1991. However, breach of the road dike at the Kompong Tuol regulator occurred in August 1991, and succedingly in 1992 and 1994. Since then, the irrigation canals have been completely empty, because water was not set up and the water level in the Prek Thnot River was too low to enter main canal. Therefore irrigation from the canals system cannot be carried out even in the rainy season. Farmers have excavated the canal embankments to take the rain water gathered in the canals for their farmland, accelerating the deterioration of the canal facilities.

To cope with these difficulties, farmers in the Kandal Stung project area are using small scale pumps for supplementing rainwater for paddy cultivation, and the number of pumps has increased. The farmers are keen for the rehabilitation/improvement of the irrigation canal system.

The ground surface generally slopes toward the east with an average gradient of 1/1,500 to 1/2,000. Although the ground surface gradient is sufficient for natural drainage, the drainage water sometimes stagnates in the rainy season in the low-elevated area adjacent to the National Road No. 2. It is attributed to the low flow capacities of the Pol Pot canals downstream. Most Pol Pot canals are dual purpose and have diversion structures. These irrigation structures raise the water levels, reducing the canal flow capacities.

(3) Operation and Maintenance

The Kandal Stung District Office is responsible for the Kompong Tuol regulator and intake gate. The communes operate the gates in their areas. Maintenance of their canals and structures is not carried out due to the lack of a systematic O&M organization and O&M fund. Responsibility of the operation of the two regulator gates belongs to the Kandal Stung District, but the related villages are operating them, depending on the water level conditions, without orderly regulation. Fifteen technicians are assigned to the regulator gate operation.

3.5.4 Tonle Bati Irrigation Project

(1) History of the Project

In 1975 to 1979, the canal system of the Tonle Bati area was constructed, based on the water source from the Tonle Bati Lake. The NS and EW canals were constructed regardless of the topographic conditions of the irrigation area. The intake and pumping station were constructed at the head of North-South canal 84 (NS 84 canal). A spillway for the Tonle Bati lake was provided, with stoplogs at the outlet, on the eastern part of the lake, improvement was made in 1992 with the provision of 4 slide gates in front of the previous outlet of stoplogs.

In 1985, the World Council of Churches (WCC), Geneva, prepared a plan of the integrated agricultural development project of the Tonle Bati Area. It consisted of the rehabilitation of an irrigation canal system for an area of about 6,000 ha including of a pump station, setting-up of an agricultural and demonstration centre, and the provision of some agricultural extension services. During the period from 1987 to 1990, the rehabilitation of an irrigation system for an area of 900 ha was executed with the assistance of WCC.

In August 1991, the irrigation facilities of the Tonle Bati Project were damaged by the flood. In February 1992, rehabilitation of some parts of the damaged canal embankment was executed by the Mekong Secretariat (executing agency) with the financial assistance of UNDP under the "Rehabilitation of Hydraulic/irrigation Structures damaged by 1991 Floods" project.

However, it is presently not functioning well mainly due to the insufficient water level/storage of the Tonle Bati lake and the lack of a systematic O&M system.

(2) Irrigation and Drainage Facilities

i) Irrigation Facilities

The Tonle Bati Irrigation Project was planned to irrigate 6,000 ha. Irrigation water to the Tonle Bati area is diverted from the Tonle Bati Lake through intake and a pumping station. The irrigation canal system consists of main, laterals and tertiary canals and related structures. The distribution canal system is based on the Pol Pot layout, and since then many efforts to introduce lake water were made using new canals and structures constructed by the Department of Hydrology.

The following are the general features of the canals and structures rehabilitated/constructed so far:

Description	Total Length	Number
Irrigation Canal	(km)	(nos)
Main Canal	9.70	3
Lateral Canal	9.11	7
Tertiary Canal	20.00	21
Related Structure		
Structures related to main and lateral canal	-	19
Turnout for tertiary canals	-	22

The design capacity of the main irrigation canal (M1) at its head is 9.78 m^3/sec in order to cover about 4,000 ha of land inclusive of the future extension area. At present, the main canal is closed by an earth dike cutting water supply. Heavy erosion occurs on the inside and outside slopes of the canals in some places. Newly provided irrigation canals often hinder smooth drainage flow. Most tertiary canals can not receive water

from the main canal and lateral canals, and some canals are served with water from drains. In most cases the amount of the water is scarce and water levels in the canals are low prohibiting gravity irrigation. Some farmers take water from drains using private pumps.

To prevent erosion on the canal slopes lining and sod facing will be required as well as reshaping of the canal embankment. Most canals require reshaping of their cross sections and improvement of their embankment. Almost all tertiary their systems require reshaping of their canal cross sections, and improvement their embankments. In related structures, many turnouts and checks require gates and the structure barrels need desiltation work.

ii) Related Facilities

The Tonle Bati Lake is a water source of the existing Tonle Bati irrigation project. The lake is a natural reservoir with a total storage capacity of 16.7 million m^3 and a water surface area of 750 ha at the lake water level of 7.80 m. The catchment area is very small, causing the lake water to lower quickly after the rainy season. The lake is surrounded with embankments on the north and east with crest levels ranging from 8 m to 10 m. There is a Pagoda and recreation centre adjacent to the southern coast. The embankment is needed to be extended for protection of Pagoda from intrusion of the lake water, as well as repair of the dike on some parts. The Tonle Bati recreation centre is located west of the Pagoda. The water level in the dry season has to be preserved for guests of the centre.

Pumping station has been provided with three sets of diesel engine-driven pumping equipment, having capacities of 8 m^3/min (one set) and 5 m^3/min (two sets). The pumping capacity is not sufficient to supply irrigation water to the whole Project area. It is used only for supplying supplemental water for the dry season cropping. The fuel for pumps was supplied from WCC and Kandal Province totalling 9,000 lit. in 1993. Pump operation in 1993 was made in May and September to supply irrigation and domestic water. Farmers have to use small private pumps to lift water from canals to their fields, even in the rainy season.

A spillway with a bridge for the National Road No. 2 is located at the outlet of the lake. In the 1992 improvement, 4 slide gates were provided in front of the stoplogs gates of the Pol Pot structure but the bridge still remains heavily damaged. Lake water spilled over the lower part of the National Road No. 2 in the flood periods of 1991 and 1992 due to insufficient capacity of the spillway.

A connection canal was constructed on the north-south No. 78 during the Pol Pot time to convey water from the Prek Thnot River via the Stung Toch River to the Tonle Bati River. The canal was re-constructed by the Department of Hydrology but it does not function due to its high bottom level and lack of a diversion structure in the Stung Toch River. Since the canal runs at a relatively high-elevated area, the canal is too deep and the canal berm encounters dispersive clay layers. Further, the canal slopes and spoil banks are heavily eroded, and eroded soils are deposited on the canal bottom. Removal of soils and slope protection will be needed.

iii) Irrigation and Drainage Condition

The water source of the Tonle Bati area depends on the stored water in the Tonle Bati lake which has a gross storage capacity of 18 million m^3 at the maximum water level of 7.80 m. The water level has to be maintained at less than El. 7.80 m to avoid the submergence of the Pagoda located lake side. On the other hand, the Tonle Bati Project area is of fairly flat topography having a high elevation of El. 7.5 to 7.8 m. Water levels in the lake draw drown considerably after the rainy season, causing the gravity irrigation from the lake to be difficult, and inevitably requiring pump operation . The

dry season irrigation area is estimated to be 30 ha, and the rainy season supplemental irrigation is estimated to be 100 ha.

Low-lying areas located on the eastern edge are prone to inundation by lake water in the rainy season. Drainage problems are not evident except the above-mentioned low-lying areas. The receding paddy cultivation is practised in these low-lying areas by the use of stored water from small reservoirs. According to the results of field investigation and aerial photo interpretation, there is no clear delineation of existing canals and paddy fields from a ground elevation of about 5.3 to 5.5 m.

(3) Operation and Maintenance

The Bati District is responsible for the pumping operation and spillway gate, and the communes are operating the canal gates in the Tonle Bati area . Maintenance and repair of the canals and structures is not carried out due to the lack of a systematic O&M organization and O&M fund. Responsibility of the operation of the spillway gates belongs to the Bati district. In fact, however, the gate operation is made according to the requests of farmers downstream of the Tonle Bati River to supply irrigation water to their fields, regardless of the overall water management for the Tonle Bati area. Farmers organizations do not exist yet, therefor O&M of on-farm systems and water management are not executed.

3.6 Existing Rural Infrastructures

3.6.1 Existing Road Networks

(1) Transportation Systems

Transport of farm products from farms to residences is made by various means such as human labor, ox and ox-cart, motorcycle, and cart drawn by motorcycle, with ox and ox-cart being the most common. Transportation in the Study Area is usually motorcycles or bicycles, since almost all farmers possess them, and rural roads are narrow and impassable by cars in the rainy season.

(2) Road Networks

Access from Phnom Penh to Cang Dan, the capital of Kandal Province, and to Takeo, the capital of Takeo Province, is facilitated by Natonal Road No. 2. Another direct access to the Study Area from Phnom Penh is National Road No. 3 which connects Phnom Penh and Sihanouk Ville, a sea port of Takeo Province. National Road No. 3 and No. 2 connect with Provincial Road No. 105, which runs through the Kandal Stung irrigation Project area.

In the Study Area, there are about 14.3 km of national roads and about 16.4 km of provincial roads in Kandal Province. The National Road No. 3 passing the western extremity of the Kandal Stung Study area is paved with asphalt. The National Road No. 2 located at the western extremity of the Tonle Bati area is mostly paved with asphalt. The road condition of Road No. 105 is slightly better than other provincial roads, even though the condition is not satisfactory. The provincial road No. 104 in the Kandal Stung area is asphalt-paved but is severely damaged, so that only four wheel drives can is pass in the rainy season.

The district roads remain unpaved and therefore are affected by erosion. The district road of Kandal Stung is impassable due to the collapse of the bridge on the irrigation canal. Farm road networks are insufficient for the transport of farm inputs and outputs. In the rainy season, these roads are nearly impassable due to mud or serious erosion.

3.6.2 Domestic Water Supply

(1) Present Domestic Water Use

In the Study Area, ground water is main source for drinking and domestic purposes. At present, 149 dug wells and 97 tubewells have been installed under programs of UNICEF and two foreign NGOs in the Kandal Stung Study area and 17 dug wells and 35 tubewells have been installed in the Tonle Bati Study area. Dug wells have a depth ranging from 5 to 10 m, while tubewells range from 30 to 40 m in depth.

In most of these dug wells, water is drawn with a well bucket and brought to a water tank in the homestead. While, tubewells are equipped with jetmatic manual operating pumps. River water or pond water is also used for domestic purposes. In the dry season, many wells dry up so that most villagers are compelled to take water from other sources such as lakes, canals, or ponds. Generally they face severe shortages of domestic water.

The Tonle Bati area suffers from a severe lack of water supply facilities. On the other hand, the central part of the Kandal Stung area is comparatively well served and has less dry wells. It is desirable that approximately 50 families use one well. In this context, the number of wells in the Study Area is extremely low.

(2) Water Quality

In order to identify the quality of water in dug wells, tubewells and ponds, water quality tests were carried out in the Water and Soil Laboratory, Department of Hydrology in December 1993. As far as the pH value of water is concerned, the water sampled, ranged within the permissible limit of 6.5 to 8.5. The result of the chemical analysis shows that most water is permissible. However, some water samples show an abnormal reading of turbidity and color.

3.6.3 Social Infrastructures

(1) Health Facility

Both the Study Areas, Kandal Stung and Tonle Bati, have similar public health service facilities. There are 11 khum clinics and a main hospital in the khum Anlong Remeath in the Kandal Stung area. One khum clinic is basically provided for each khum. The existing condition of the 11 clinic buildings are, 4 in good condition, 4 in fair condition, and 3 in marginal condition. According to information from the District hospital, the minimum size required for a khum clinic building is 8 m by 12 m and each clinic needs three rooms including a dispensary, ward, and medicine stock room. There are five khum clinics in the Tonle Bati area.

(2) School Facilities

School facilities such as buildings, books, and science equipment are inadequate. In order to overcome the shortage of classrooms for enrolled pupils, schools are managed with a rotation system which changes the class by school hours. Some wooden schools are so dilapidated that replacement or additional buildings are indispensable in improving the quality of education. The present condition of the schools is summarized below;

Item	Kandal Stung area		Tonle Bati area	
	Primary school	Middle school	Primary school	Middle school
Number of school	19	1	13	1
Number of class room	110	25	104	11
Number of student	6,329	1,120	4,365	353
Average area of class room (m^2)	46	56	57	75
Average area per student (m^2)	0.8	1.3	1.4	2.3

The average classroom size is 45 m^2 to 55 m^2 for primary schools and 55 m^2 to 75 m^2 for middle schools. The current status of schools in the Tonle Bati area is better than that of the Kandal Stung area.

(3) Community Center

No community center exists in both the Kandal Stung and the Tonle Bati areas.

(4) Market Facility

There are three market facilities nearby National Road No. 3 and three small markets along National Road No. 2 in the Kandal Stung area. The Kompong Tuol Market at commune Anlung Romeat is the largest where daily necessities, foods and miscellaneous goods are sold to people in and around the Study Area. In the Tonle Bati area, there is only one market facility at Samrong Yong which is larger than the Kompong Tuol market and is crowded with people from in and around the Study Area as well as passengers passing on National Road No. 2. The market density in the Study Area is rather satisfactory, however, the facilities and access to them need to be improved.

(5) Rice Mill Facility

There are 60 operating rice mill facilities in the Kandal Stung area and 67 in the Tonle Bati area. Those facilities are sufficient in quantity and quality at present.

(6) Communication Facility

There is one radio communication facility at the Kandal Stung District Office. No telephone system is available for residents. In Cambodia, a telephone system is only available at limited cities such as Phnom Penh, Sihanouk Ville and Kep. Present communications in the Study Area are basically portable radios and television sets, however, only 30 % of residents have these.

(7) Electricity Power Supply Facility

No electricity supply is available in the Study Area at present. There are two small generators at the Kompong Tuol market area and the Samrong Yong market area. Limited electricity power is distributed to a few customers engaged in market business.

3.7 Environment

3.7.1 Environmental Situation

The most striking feature in the study area is the absence of natural systems such as undisturbed forests, grasslands or wetlands. The absence of natural forests is common to both Kandal and Takeo provinces. Consequently, biological diversity is poor and larges animals are not evident. With the elimination of the habitat, many ecological benefits usually derived from natural systems, gradually disappeared.

Commercial forestry has been largely responsible for the depletion of the forests, along with their proximity to large urban centres like Phnom Penh, where, a big demand for firewood exists. Significant wetlands are not evident, and what would once have been excellent wetlands around the Cheung Loung lake, have been converted into paddy fields.

The aquatic habitat is also greatly disturbed. Although waterbodies abound, most dry up in the dry season, and water for domestic purposes is in short supply. River and stream banks are eroding and riverine vegetation that provides natural stability to river banks has disappeared in many places. The new network of canals that were constructed in the 1970s is reported to have interfered with the natural inundation.

Sediment generated by eroding rivers and canal banks has contributed to reducing channel capacity, affecting water flow, and increasing water temperature, among other environmental effects. Finer particles of silt and clay affect turbidity. These ill-effects interfere with the physiological functions and population dynamics of aquatic life. It has been reported that species of fish have declined in abundance and perhaps in diversity too. Poor maintenance is a major reason for the present state of the canals.

The study area has been a man-made ecosystem for a long period of time. Rice cultivation predominates during the wet season but during the dry season, soil moisture limits the cultivable area. A variety of fruits and vegetables are grown throughout the area and home gardens have an assortment of trees and shrubs. Fertilizer use is not consistent with the objective of higher productivity as farmers do not have access to easy credit.

Limited amounts of farmyard manure are used, particularly on paddy nurseries. The benefits of farmyard manure do not seem to be understood well by the farmers, as the collection and storage of manure is not widespread. Preliminary trials carried out by the Cambodia-IRRI-Australia Project, indicate that the use of organic materials in paddy

cultivation, can give appreciable yield increases. Poor technology, inadequate inputs, and soil moisture fluctuations are some of the factors that limit the extent and yield of the paddy.

Pesticide use is not extensive in the study area. These are not generally used in the wet season paddy. Varying amounts are used in dry season cultivation. However, the hazardous nature of some pesticides, and the doubtful quality of many, warrant a careful examination of the import, distribution, and farm use, especially in line with the introduction of environmental safety.

Study surveys revealed that hazardous chemicals are imported and sold without any restriction. For example, methyl parathion (folidol) and mevinphos, which WHO classifies as extremely hazardous, are freely available. When some random samples were analysed, many were found to be sub-standard. Study surveys also showed that farmers have little knowledge of either chemicals, or the pests which they are attempting to get rid of. A variety of ill-effects such as poisoning of humans and livestock have been reported. The damage caused to beneficial life forms is a serious disadvantage of indiscriminate pesticide use.

There are reports of successful trials in the Integrated Pest Management (IPM) programme which the researchers and the government believe, will ultimately prove itself as a safe and effective way of pest control. A taxonomic survey conducted at Kap Srau, has shown that the ratio of natural enemies to pests to be nearly 2:1; indicating the availability of an ecologically sound and economically advantageous potential weapon for pest control.

Recently, the preparation of draft legislation to control the import and sale of pesticides has engaged the attention of the government. The aim of this legislation is to "obtain the benefits from the use of pesticides with minimal adverse effects to man and the environment."

Although livestock are reared extensively, the integration of crop and livestock husbandry has not seriously taken place. Often manure goes to waste. Pigs and poultry are free range; thereby making their excreta unavailable. Pasture grass is in short supply and is transported from a distance. The practice of growing fodder is limited. Crop residues such as paddy straw, and household leftovers provide supplementary feed. By adopting better management, livestock rearing can raise the family income. It can also play a very useful role in maintaining soil fertility which is fundamental to sustainable farming.

Analyses carried out during the study indicate water quality to be satisfactory except in a few localised instances where iron has been found to be excessive, imparting an unpleasant taste to the water.

Firewood is in short supply throughout the study area. Part of the domestic needs are supplied by home gardens and part from nearby waste lands. In the urban centres, people purchase firewood and charcoal for cooking and for industrial use. In the Tonle Bati district, part of the firewood demand is met from the Phnum Tamao forest reserve which itself has been denuded. People, in their search for firewood, are even cutting 2/3-foot plants which the Department of Forestry has grown in its efforts to replace the forest in this reserve.

The tile and brick factories in Tonle Bati and elsewhere also use firewood and obtain it from natural forests in other provinces. Most of the time, quality hardwoods are supplied to the factories by contractors, which is a great loss of a valuable resource.

Afforestation in the country began only about a decade ago and progress has been limited, totalling 5,600 ha in the nine years from 1985-1993. People's participation has been lacking in the departmental programmes and, in the area of the study, no reforestation has been undertaken.

A place of archaeological interest is the Ta Prohm temple at Tonle Bati. It is near the lake, which is also a recreation area, and is very popular during holidays. The recreation area is in poor condition, with large scale erosion taking place.

3.7.2 Environmental Problems

The Study area presents a few environmental issues but these are all of a manageable nature. Extreme degradation has not taken place. There are no polluting industries as industrial development in the country has not advanced. Until quite recently there has been no institutional responsibility for the environment and issues are now being identified for resolution. As environmental problems can cut across institutional boundaries, co-ordination of environmental pollution and management effort has to be carefully handled. The problems and constraints in the study area have been also discussed in the section immediately preceding this.

IV. DEVELOPMENT CONSTRAINTS AND NECESSITY

4.1 Development Constraints and Limitation

4.1.1 Physical Constraints

The major physical constraints observed in the Study Area are summarized below.

(1) Soils

Low soil fertility of older terrace geomorphic province lying southwest of the Study Area. An overall land use plan is needed on the basis that economical viable production will be achieved and the productivity of the land will be sustained.

2) Water Resources

i) Inadequate timely water resources in the dry season and through the early months of the wet season, which limits the development of double cropping using river irrigation.

ii) A high potential for severe flooding, both in terms of damage to irrigation facilities and inundation of cropped areas later in the wet season, for which the provision of inadequate hydraulic structures worsens damage to public facilities and losses of agricultural production.

(3) Irrigation and Drainage

i) A shortage of experienced engineers and technical staff in planning, design and implementation.

ii) A lack of funds for rehabilitation / reconstruction and operation and maintenance.

iii) Inadequate design and implementation due to a lack of design standards and construction specifications.

iv) A lack of a systematic operation of the irrigation system including an O&M organization.

v) An unreliable water supply from the Project canals.

vi) Insufficient irrigation facilities such as:

a. A lack of flow capacity of the Tuk Thla and Kompong Tuol regulators

b. An insufficient irrigation canal system including Pol Pot canals

(4) Rural Infrastructures

i) An insufficient number of rural water supply facilities and a drying-up of water sources in the dry season.

ii) Muddy rural roads in the rainy season which make it difficult to maintain daily transportation access for social as well as agricultural activities in the rural areas.

iii) An inadequate provision of the facilities to promote community organization development.

iv) Inadequate infrastructures including dispensaries to provide health care services to the villagers.

v) No electricity supply system which results in a limitation of profitable development in agro-based industries.

4.1.2 Agricultural and Socio-economic Constraints

The major constraints with respect of agriculture and socio-economic development of the Study Area are summarized below:

(1) Agriculture

i) Irrigation water deficit which results in unstable wet season paddy cultivation particularly at the beginning of the wet season, and limited paddy cultivation area for double cropping of rice

ii) Insufficient agricultural inputs supply especially for i) limited supply of certified seeds obliging farmers to use their own seeds, and ii) shortage of agricultural inputs such as fertilisers and chemicals

iii) Lack of supporting services and improved techniques, especially for researched techniques, and credible extension services to increase crop production

(2) Socio-economic Constraints

i) In sufficient extension services for small scale households as well as FHH families

ii) In sufficient supporting program and supporting system for female headed households

iii) Lack of sufficiently skilled Government staff

iv) Lack of farmers' organization

v) Lack of credit opportunities at reasonable cost/interest rates

4.2 Farmers' Intention to Development and Development Needs

The field interview survey on agriculture and living conditions revealed the following farmer's needs, major problems, and expectations for the agricultural and rural development.

(1) Major Problems in the Dry Season

i) Lack of irrigation water

ii) Lack of domestic water

iii) Insufficient health services

(2) Major Constraints for Production

i) Insufficient supply service of fertilizer and agro-chemicals

ii) Shortage of drought animals

iii) Shortage of improved paddy seed

(3) Major Constraints for Living Conditions

i) Shortage of food for home consumption

ii) Insufficient school facilities

iii) Shortage of living expenses

iv) Inconvenience of medical services

v) Lack of support for FHH families

V. BASIC CONCEPT FOR INTEGRATED AGRICULTURAL AND RURAL DEVELOPMENT PLAN

5.1 Basic Development Concept

The Syudy Area is characterized by their high population density low fertile land for agricultural production, and limited water resources in the dry season. The present socio-economic conditions and infrastructure are still at a minimum, although infrastructure improvement such as irrigation and drainage works had been carried out in the past. Further, the agricultural supporting services are not functioning adequately. Therefore, the agricultural production in the Study Area is still low, and at subsistence levels.

In due consideration of the Government policy applied to the agricultural and rural development and the present socio-economic situation of the Study Area, it is presumable that the following are regarded as the ultimate objectives and development strategies of the integrated agricultural and rural development of the Study Area.

i) The ultimate objective of the Integrated Agricultural and Rural Development is to achieve a substantial and sustainable improvement in the living conditions of the population in the Study Area.

ii) The strategy adopted is to increase farming output in the area through improvement and development of irrigation, drainage and rural infrastructure, together with appropriate support services and structures.

5.2 Development Target

Reflecting the development need and the national development policy, the development objectives for the agricultural development plan in the Master Plan recognized are :

i) To raise the farmer's income level through the enhancement of agriculture, especially rice and livestock productions, by the efficient utilization of land and water development potential in the area,

ii) To contribute to regional and national needs in increasing rice production with the aim of achieving self-sufficiency in rice, and

iii) To raise living standards and improve rural life through generating farm income and by the extension of living techniques.

The practical targets set up for the above objectives are as follows:

i) Production and self-sufficiency in food

In line with the national development plan to supply 310 kg of paddy for consumption per capita per year on the basis of a production target of 400 kg/capita,

ii) Income generation

In line with the national development plan, to increase the present level of total annual farm household income from about 1.12 million Riels (US$ 509) to more than 3.0 million Riels (US$ 1,364), or more than 2.5 times the present level with an increase of 10 % a year.

iii) Living expenses and cost of food

The ratio of expenses for food (Engel's coefficient) to be a maximum of less than 50 % of the total farmer's living expenditures, and savings of about 10 % of income.

5.3 Strategies of Integrated Agricultural and Rural Development

The following development strategies will be taken to attain the above-mentioned development targets and dissolve the present constraints prevailing in The Study Area:

(1) Irrigation and Drainage Improvement

i) Kandal Stung Area

a. Improvement of the Tuk Thla and Kompong Tuol Regulators, and Road Dike,

b. Improvement of existing irrigation and drainage system,

c. Provision of sufficient on-farm system, and

e. Construction of additional irrigation and drainage facilities.

ii) Tonle Bati Area

a. Improvement of existing irrigation and drainage system,

b. Augmentation of irrigation water by means of localized reservoir or other measures,

c. Effective use of the Tonle Bati Lake storage,

d. Provision of a sufficient on-farm system, and

e. Construction of additional irrigation and drainage facilities.

(2) Agricultural Development

a. Increase in double cropping of paddy,

b. Crop diversification with cash crops, and

c. Promotion of livestock raising.

(3) Agricultural Supporting Services

a. Program of rural credit, training for farmers and extension workers, supply of farm inputs and seeds of improved varieties, together with appropriate farming techniques,

b. Activation of the existing Agricultural Development Centre in the Tonle Bati Study Area, and the Rural Development Centre in the Kandal Stung Study Area with additional development centre,

c. Operation in cooperation with each district office, relevant research stations, development centres, and other projects such as IRRI-Cambodia Project, and

d. Functioning of an input supply system, trial and demonstration work, introduction of improved crops, and seed multiplication.

(4) Farmers' Organization Development

a. Attaining to carry out various activities related to marketing, operation and

management of irrigation facilities and rural infrastructures, rural life improvement, and community development, as well as the promotion of agricultural production,

b. Improving and strengthening the existing farmers groups and organizations, and

c. Formulation through the farmers participation, from the project planning to implementation.

(5) Improvement of Rural Infrastructures

a. Rural water supply facilities to areas suffering poor water quality, water shortages in the dry season, and long distances from water sources or wells,

b. Improvement of the provincial roads and feeder roads including district roads, and

c. Improvement of required social infrastructures.

(6) Life Improvement Plan

i) Life improvement

a. Improvement of nutritional conditions of the population,

b. Improvement of living/housing conditions of the population,

c. Creation of work opportunities for the population,

d. Improvement of the supporting services,

e. Improvement of house management, especially for female headed household, FHH

f. Establishment of rural societies, and

g. Improvement of roads as a means of transportation.

ii) Organizational improvement for Life Improvement

a. Field level workshops to ensure beneficiaries cooperation and participation, and

b. Organizing functional grass root groups, such as water users groups, life improvement leading groups, etc.

(7) Establishment of Model Area

The main objective of the model area is to demonstrate and exhibit a model and its effect of the proposed integrated agricultural and rural development to farmers in the surrounding area. The model area is proposed in the selected Priority Development Area.

VI. INTEGRATED AGRICULTURAL AND RURAL DEVELOPMENT PLAN

6.1. Land and Water Resources Development Potentials

6.1.1 Land Resources

In making a land resources development plan, the suitability of the soils for both rainy season and dry season rice and upland crops are assessed on the FAO system as described in Section 3.1.4.

Land units with suitability classes S1, S2 or S3 for the three crop types and the areas involved are summarized in the following table:

Land Suitability for Rice and Upland Crops in Kandal Stung and Tonle Bati

Crop	Agricultural Land			Suitable area			Unsuitable area		
	Kandal Stung	Tonle Bati	Total	Kandal Stung	Tonle Bati	Total	Kandal Stung	Tonle Bati	Total
Wet Season Rice	9,800	6,500	16,300	6,400	5,600	12,000	3,400	900	4,300
				(65%)	(86%)	(74%)	(35%)	(14%)	(26%)
Dry Season Rice	9,800	6,500	16,300	6,600	6,000	12,600	3,200	500	3,700
				(67%)	(92%)	(77%)	(33%)	(8%)	(23%)
Horticulture & Field Crops	9,800	6,500	16,300	7,000	5,600	12,600	2,800	900	3,700
				(71%)	(86%)	(77%)	(29%)	(14%)	(23%)

6.1.2 Water Resources

The main water source for the irrigation development of The Study Area is the Prek Thnot River. Reappraisal of the Prek Thnot Multipurpose Project revealed irrigation potentials in the river basin. It concluded that a total of 4,200 ha could be irrigated with run-of-river of the Prek Thnot. It also concluded that a total of 34,000 ha or 27,000 ha could be double cropped with the Prek Thnot reservoir water under alternative dam operation methods of irrigation priority or power generation priority, respectively.

Since the Study Area is included in the Prek Thnot Multipurpose Project area, and situated furthest downstream of the river basin, the available flow to The Study Area is assessed as shown below.

(1) Run-of-River Water

The flow available for The Study Area is estimated to be the residual flow after sharing the gross irrigation demands of the irrigation schemes located/envisaged upstream of the Tuk Thla and Kompong Tuol regulators. The irrigation demand of the upstream schemes is computed on the basis of 1,700 ha with double cropping of rice as recommended in the Reappraisal. The following table shows the monthly averages derived from the 10-year series of residual flow at Tuk Thla (see detail in ANNEX-I).

Average residual flow at Tuk Thla for the 10-year design period (MCM)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Tuk Thla	8.01	5.3	4.5	6.4	33.0	79.0	140.9	199.0	318.6	433.7	147.9	69.2	1445.7

(2) With Prek Thnot Reservoir

The past studies on the Prek Thnot dam resulted in different irrigation potential. They were derived from different assumed conditions, among which the major influencing factors were:

a. Reservoir operation method of irrigation priority or power generation priority
b. Storage capacity of the dam,
c. Crop water requirements derived from the different cropping patterns and cropping intensity,
d. Irrigation efficiencies which relate to the degree of irrigation facilities provided

The Project Preparation Study of the Prek Thnot Pioneer Agricultural Project in 1975 concluded that a reservoir with a maximum capacity of 1,120 MCM could irrigate up to 50,000 ha, and as much as 66,000 ha if the dam was raised a further 3 m. Reappraisal concluded that 34,000 ha can be double cropped if irrigation is given priority, but this is reduced to 27,000 ha double cropped if power is the priority.

In order to confirm the irrigation potential under the "with dam" conditions referred to in the Master Plan of The Study Area, a trial simulation of the reservoir was carried out by use of the 10-year reservoir inflow series defined in this study and the original irrigation requirements. Since the irrigable area is affected by many factors mentioned above, it should be evaluated by a more detailed analysis than has been undertaken so far. However this is not within the scope of this Project. For the present purposes, it is reasonable to accept the Reappraisal estimates of irrigable area according to the trial simulation. The irrigable area will be in the range 25,000 ha (maximum firm power) to 35,000 ha (irrigation priority) based on the double cropping plan.

6.2 Agricultural Development Plan

6.2.1 Proposed Agricultural Development

(1) Proposed Cropping Pattern

The proposed cropping patterns are formulated on the basis of the following basic points:

a. The main crop is wet season rice and some dry season rice. The most promising crop selected is rice since it has been the established base for farming and economic activities, the staple food supply, and farmers in the area have long experience in rice cultivation. The rice varieties to be introduced are photo period insensitive high-yielding varieties with early to medium growth durations of about 120 to 150 days, while some local varieties will still be cultivated.
b. Some secondary crops such as maize and soybeans are to be introduced in the dry season to improve peoples' nutrition, and increase household income by promoting livestock production, and also vegetables. Maize and soybeans are selected as the main secondary crops in the dry season to promote livestock production especially pigs and poultry. Some vegetables such as Chinese cabbages, cabbages, green string beans, and kale, will be introduced as cash crops in the dry season. Greengrams, groundnuts, sesame, and sweet potato may also be introduced in the dry season.
c. The staggering of the cropping period is made according to the availability of labour, especially for the peak labour requirement in the planting and harvesting

times, and to the availability of irrigation water throughout the cropping season,

The proposed cropping patterns are formulated for the two alternative conditions with the aim of stabilizing the wet season rice crop, and then to introduce a dry season rice crop in about 50 % of the irrigated area, and also to introduce upland crops depending on the availability of water. The proposed cropping patterns are shown in Fig. 12.

i) With Prek Thnot Reservoir Conditions:

The irrigation area under the "with Prek Thnot reservoir condition" will be 8,400 ha consisting of Kandal Stung (4,200 ha) and Tonle Bati (4,200 ha) areas. The proposed cropped area of each crop is shown below:

Crops	Wet Season		Dry Season	
	(%)	(ha)	(%)	(ha)
Rice	100	8,400	50	4,200
Early dry season rice			50	4,200
Early wet season rice	50	4,200		
Middle wet season rice	30	2,520		
Local Varieties	20	1,680		
Maize & soybeans			38	3,192
Vegetables			12	1,008
Total/crop intensity	100	8,400	100	8,400

The total area of wet season rice is 8,400 ha and the dry season rice area is 4,200 ha. The mixed culture of maize and soybeans is about 3,200 ha, and the area for vegetables is about 1,000 ha. About 3,100 ha and 900 ha of rainfed rice field is left without irrigation development in the Kandal Stung and Tonle Bati areas, respectively.

ii) Without Prek Thnot Reservoir Condition:

The proposed cropping pattern for the Kandal Stung (1,950 ha) and Tonle Bati (1,600 ha) areas is as follows:

Crops	Wet Season		Dry Season	
	(%)	(ha)	(%)	(ha)
Rice	100	3,550	48	1,700
Early dry season rice			48	1,700
Early wet season rice	50	1,775		
Middle wet season rice	30	1,065		
Local Varieties	20	710		
Maize & soybeans			14	510
Vegetables			14	510
Total/crop intensity	100	3,550	77	2,720

The total area of the wet season rice is 3,550 ha and that of the dry season is 1,700 ha. The area for upland crops of maize and soybeans is about 510 ha and that of vegetables is about 510 ha. The remanding 5,350 ha and 3,500 ha of existing rainfed rice field in the Kandal Stung and the Tonle Bati areas, respectively, will remain as is.

(2) Proposed Farming Practices

It is necessary to introduce new high-yielding varieties or hybrid seed with the appropriate use of fertilizers and agro-chemicals (minimum use and environmentally sound chemicals such as Fenitrothion, Buprofezin \, Dithiocarbamate, Benomyl, if necessary) along

with the provision of irrigation facilities and institutional support services. The present farming practices prevailing in the project area are basically applied such as animal power for soil preparation and transportation, manual operation for transplanting and harvesting, the wet nursery system, and the ordinary transplanting method. Taking into consideration the present circumstances, rapid introduction of full mechanization is not practicable in the area, but some mechanization is necessary especially for chemical application, threshing rice, and shelling maize and groundnuts.

Regarding plant protection, the farmers will be given guidance by the agricultural extension worker. It is recommended to organize an integrated pest management system for the protection of the crops as well as for the environmental conservation of the area.

The inputs and labour requirement for the proposed farming practices for each crop are summarized in Table 5.

The proper management of livestock is essential in promoting livestock production in The Study Area. It consists of the improvement of feed and houses for the animals. It is also essential to promote disease control of the animals by extending the veterinary services such as vaccination, and by the breeding of healthy animals.

(3) Anticipated Crop Yield and Production

After implementation of the project, the yield of crops will be substantially increased and stabilized after accustoming to the irrigation farming practices with the agricultural support services. The increase of yield without the project is considered to be insignificant. The target yield of crops at the full development stage is assumed below:

(Unit : ton/ha)

Crop	Present	Without irrigation*	With irrigation
Rice: Local Varieties	1.2	2.5	3.0
" H.Y.V	-	-	4.0
Maize & beans (mixed)			
- Maize	1.2	1.5	3.0
- Soybeans	1.0	1.0	2.0
Groundnut	0.7	0.7	1.5
Mungbeans	0.6	0.6	1.0
Sesame	0.5	0.5	1.2

Notes: Yield for rice is in dried paddy, maize and groundnut is for shelled seed. Maize and soybeans are grown as a mixed crop.

* Yield of "without irrigation" condition is assumed under the condition covered by the agricultural support services.

The build-up period is assumed at about 5 years after completion of the project works and starting the proper agricultural support services in view of that some of farmers in the area are rather familiar with the selected crops even for the new varieties.

The anticipated annual rice production at the full target level in the area is estimated below:

	Net area	Planted area	Production
	(ha)	(ha)	(ton)
1. With Prek Thnot Reservoir condition			
1.1 Irrigation development area			
Kandal Stung	4,200	6,300	24,360
Tonle Bati	4,200	6,300	24,360
Subtotal	8,400	12,600	48,720
1.2 Non irrigation development area			
Kandal Stung	3,100	3,224	8,060
Tonle Bati	900	984	2,460
Subtotal	4,000	4,208	10,520
1.3 Study A rea total	12,400	16,808	59,240
2. Without Prek Thnot Reservoir condition			
2.1 Irrigation development area			
Kandal Stung	1,950	2,850	11,010
Tonle Bati	1,600	2,400	9,280
Subtotal	3,550	5,250	20,290
2.2 Non irrigation development area			
Kandal Stung	5,350	5,560	13,910
Tonle Bati	3,500	3,740	9,350
Subtotal	8,850	9,300	23,260
2.3 Study area total	12,400	14,550	43,550

The anticipated rice production in the area at the full target stage under the "with Prek Thnot Reservoir" condition is estimated at 59,240 tons, while that for "without Prek Thnot Reservoir" condition is estimated at 43,550 tons. The present rice production in the whole Study Area is estimated at about 15,600 tons. Accordingly the increment of rice production by the project is expected to be about 43,600 and 27,950 tons for the with and without alternatives, respectively.

The anticipated production of secondary crops such as maize and soybeans is estimated as follows:

	Kandal Stung		Tonle Bati		Total	
	Planted area	Prod.	Planted area	Prod.	Planted area	Prod.
	(ha)	(ton)	(ha)	(ton)	(ha)	(ton)
1. With Prek Thnot Reservoir						
Maize	1,596	4,788	1,596	4,788	3,192	9,576
Soybeans	1,596	2,394	1,596	2,394	3,192	4,788
Vegetables	504	5,040	504	5,040	1,008	10,080
2. Without Prek Thnot Reservoir						
Maize	270	810	240	720	510	1,530
Soybeans	270	405	240	360	510	765
Vegetables	270	2,700	240	2,400	510	5,100

Under "with Prek Thnot Reservoir" conditions, the expected production of the secondary crops is estimated at about 9,600 tons of maize, 4,800 tons of soybeans, and about 10,000 tons of vegetables, while under "without Prek Thnot Reservoir" conditions, the production is estimated at 1,500 tons of maize, 800 tons of soybeans, and 5,100 tons of vegetables.

(4) Anticipated Livestock Production

The anticipated production of livestock is estimated by the increased production of pig which is commonly raised in The Study Area. Maize and soybeans used for aminal feed, can be converted to meat, which would bring about substantial value-added income. Incremental pig production is considered to be raised in proportion to the increase of maize and soybeans produced. The expected increased production of pigs in The Study Area is estimated as follows:

	Grains for Livestock*	Total no. of pigs	Increased no. of pigs per household**
	(ton)	(head)	(head)
1. With Prek Thnot Reservoir			
Kandal Stung	2,150	8,600	2.5
Tonle Bati	2,150	8,600	2.6
Total	4,300	17,200	
2. Without Prek Thnot Reservoir			
Kandal Stung	360	1,440	0.7
Tonle Bati	320	1,280	1.1
Total	680	2,720	

* 30 % of maize and soybeans is for pig feed.

** Number of household included in the irrigation development area is about 3,500 and 3,320 in the Kandal Stung and Tonle Bati areas, under "with Prek Thnot Reservoir" conditions. Those under "without conditions", total 2,170 and 1,140 in the Kandal Stung and Tonle Bati areas, respectively.

Under "with Prek Thnot Reservoir" conditions, the increased number of pigs is about 17,200 heads, while under "without Prek Thnot Reservoir" conditions, it is estimated at about 2,700 heads.

6.2.2 Marketing and Price Prospect

The areas are located in the suburbs of Phnom Penh and are densely populated with a high increase rate. Under these circumstances, considerable rice demand will continue, and a considerable demand for livestock is also expected, especially in the markets of Phnom Penh, due to changes in high protein diet patterns.

The prospective prices of farm output and inputs were estimated on the World Bank's forecasts on the price prospects for rice, maize, soybeans, chemical fertilizers, and agro-chemicals. The present and the estimated prospective economic prices at the farmgate are shown below:

(US$/ton)

Commodities	Present prices	Prospective prices
Paddy	182	207
Maize	218	147
Soybeans	400	283
Chinese cabbage	318	164
Urea	218	261
15-15-15	264	-
Muriate of potash	-	241
Pesticides	511	221

6.2.3 Anticipated Agricultural Benefit

The expected agricultural benefit born by the project is evaluated as the financial increment of agricultural production shown below:

(Unit : 1,000 $)

Area and conditions	Irrigation area	Non-Irrigation area	Total
1. With Prek Thnot Reservoir			
Kandal Stung	6,539	567	7,106
Tonle Bati	6,539	165	6,704
Total	13,078	732	13,810
2. Without Prek Thnot Reservoir			
Kandal Stung	2,459	979	3,438
Tonle Bati	2,122	641	2,763
Total	4,581	1,620	6,201

Under "with Prek Thnot Reservoir conditions", the anticipated agricultural benefit is estimated at about US$ 13.1 million and US$ 0.8 million for the irrigation development area and the non-irrigation development areas, respectively. Under "without Prek Thnot Reservoir conditions", the anticipated agricultural benefit is estimated at about US$ 4.6 million, and US$ 1.7 million for the irrigation development area and the non irrigation development area, respectively.

For the economic agricultural benefit for the irrigation development area under "without Prek Thnot Reservoir conditions", the incremental benefit is estimated at US$ 2.1 million and US$ 1.1 million for the Kandal Stung and Tonle Bati areas, respectively. The total agricultural benefit is estimated at about 3.9 million for the irrigation development area.

6.2.4 Farm Household Economy

In order to evaluate the project feasibility from farmers' household economy, the following four typical household budgets were examined for the irrigation development area and non irrigation development area under "with and without Prek Thnot Reservoir" conditions:

(Unit : US$/year)

	Irrigation area		Non-Irrigation area	
	Kandal Stung	Tonle Bati	Kandal Stung	Tonle Bati
1. With Prek Thnot Reservoir				
Gross income	2,561	2,732	776	798
Production cost	360	390	135	148
Net income	2,201	2,342	641	650
Living expense	1,364	1,364	641	650
Net reserve	837	978	0	0
2. Without Prek Thnot Reservoir				
Gross income	1,635	2,640	776	798
Production cost	158	233	135	148
Net income	1,477	2,407	641	650
Living expense	1,364	1,364	641	650
Net reserve	113	1,043	0	0

In the irrigation area under the "with or without Prek Thnot Reservoir" conditions, each household would receive substantial income sufficient to pay the annual living expenses of

about Riel 3 million(US$ 1,364 equivalent). On the other hand, in the non-irrigated area of Kandal Stung, the annual income of the farmer would be almost the same as the present total income comprising farm and off-farm income. The Tonle Bati households in the non-irrigated area would get about 1.6 times their present income. In the non-irrigated area, however, the households would need to earn off-farm income to improve their life.

6.2.5 Agricultural Support Services Development Plan

(1) Basic Plan of Agricultural Support Services

i) Objectives of Support Services

The main agricultural development components proposed are to raise crop and livestock productions in order to increase farm household income and to enable the farmers to enjoy improved rural life with full use of the facilities constructed under the project. The area to be covered by the agricultural support services is not limited to the irrigation development area but to the entire Study Area.

The proposed support services comprise (i) the agricultural technical extension, (ii) agricultural inputs and equipment supply, rural credit supply and an agricultural insurance system (iii) operation and maintenance of irrigation and drainage, and provided rural infrastructures such as roads and a domestic water supply, and (iv) life improvement extension services.

ii) Organization Strengthening

The development plan includes activation of the existing Agricultural Development Centre in the Tonle Bati Study Area, and the Rural Development Centre in the Kandal Stung Study Area. The Kandal Stung Centre covers about 11,300 ha, which is too large to effectively provide services, therefore an additional agricultural development centre is proposed.

iii) Operation of Support Services

Operation of the centres will be made in cooperation and coordination with each district office, relevant research stations, development centres, and other projects such as the IRRI-Cambodia Project, and various other projects concerning life improvement in The Study Area.

At the initial stage the agricultural supporting services will be carried out by the Agricultural Development Centres directly under the management of the Department of Extension. After the Agricultural Development Centres are operating successfully and have sufficient qualified extension workers and facilities, management will be transferred to each district office. The proposed organization of the Agricultural Development Centres for agricultural services are illustrated in Fig. 13.

(2) Proposed Agricultural Extension

The agricultural extension services will be provided mainly for rice and other secondary crops and livestock raising mainly pigs, poultry and cattle for draft power. To execute the services efficiently, trained extension personnel, vehicles, equipment, and office buildings will be needed.

Key points for emphasis in agricultural extensions are summarized as follows:

a. Introduction of improved varieties

b. Supply of planting materials and inputs

c. Demonstration and guidance on cultivation techniques

d. Strengthening of vaccination service

e. Monitoring and evaluation

The proposed Agricultural Development Centres will be the base for the agricultural extension work in the project area. The covering area of each centre and the required number of staff are summarized in Table 6, and summarized below:

Agricultural Development Centre	Gross Area	No. of Village	No. of Family	Proposed No. of Field worker
	(ha)			
1. Kandal Stung No. 1 (Existing)	5,600	19	2,245	7
2. Kandal Stung No. 2 (Newly proposed)	5,700	48	3,614	10
3. Tonle Bati (Existing)	6,900	34	4,380	10
Total	18,200	101	10,239	27

The proposed number of field extension workers to be assigned to each agricultural development centre, and their specialities, are estimated under the following conditions, summarized below:

a. 300 to 400 households/extension worker,

b. 10 to 16 farmers group/ extension worker(one group consisting of 25~30 farm households),

c. 2 visits a month to each group.

Specialities	Kandal Stung No.1	Kandal Stung No.2	Tonle Bati	Total
Rice/Secondary crops	2	6	6	14
Horticultural crops	2	2	2	6
Livestock/Veterinary	3	2	2	5
Total	7	10	10	27

Besides the filed workers listed above, subject matter specialists for rice, secondary crops and livestock/veterinary are required for each Agricultural Development Centre.

(3) Proposed Agricultural Input Supply System

It is required to improve the existing Government agricultural input supply system organized by the Central Company of Agricultural Material (CCAM). The key points for improvement are:

a. to supply inputs required for the whole project area by CCAM through the Agricultural Development Centres,

b. to strengthen the storage and handling capacity of the Agricultural Development Centres to meet the requirement, and

c . to construct storage for each 2,000 ha of crop land.

The amount of fertilizers and agro-chemicals required for the command area of each Agricultural Development Centre are as follows:

Agricultural Development Centre	Command area (ha)	Inputs requirement	
		Fertilizers (ton)	Chemicals (lit.)
1. Kandal Stung No.1	2,700	1,000	11,000
2. Kandal Stung No.2	4,340	1,500	17,000
3. Tonle Bati	5,700	2,000	23,000

Base for estimation:

i) Command area is estimated as 1.2 and 1.3 ha/family in the Kandal Stung and Tonle Bati areas, respectively.

ii) Requirement of fertilizers and chemicals is 350 kg/ha and 4 litre/ha on average, respectively.

iii) The storage capacity is one crop season for each area.

The number of stores required for each Agricultural Development Centre is one (1), two (2) and three (3) for Kandal Stung No. 1, Kandal Stung No. 2 and Tonle Bati, respectively.

The proposed input supply system forms one of the sections of the Agricultural Development Centre. CCAM is responsible for the handling of materials, i. e. loading and unloading, transportation to the store, and stacking of materials, and individual farmers will receive and transport by ox-cart to their homes.

(4) Establishment of the Agricultural Development Centre

All of the proposed agricultural support services will be extended through the proposed Agricultural Development Centre. The proposed operation system and organization of the Agricultural Development Centre is shown in Fig. 13. Each centre will be composed of 5 sections including Agricultural Extension, Supply and Marketing, Life Improvement, Operation and Maintenance, and Administration. Each section has section chief with staff and facilities proposed for each service activity.

i) Kandal Stung No. 1 Centre

This centre covers the southern part of the Kandal Stung Study area where an irrigation development project will not be implemented under" without Prek Thnot Reservoir" conditions due mainly to the geographical condition. There is a Rural Development Centre operated by the Department of Agriculture in cooperation with WVI. This centre will be improved and reactivated with the provision of staff and facilities. The proposed command area of farm land by this centre is about 2,700 ha, composed of 5 communes. Trapieng Veng, Tbeng, Thmey, Trea, and Prek Roka, and totaling 2,245 families.

ii) Kandal Stung No. 2 Centre

This centre is proposed to be newly established with staff and facilities to cover the northern part of the Kandal Stung Study area. Irrigation development will be implemented under the condition of "without Prek Thnot Reservoir" in some areas, and almost the entire area will be covered by an irrigation development project under "with condition of Prek Thnot Reservoir". The proposed command area of farm land by this centre is about 4,340 ha, composed of 8 communes, Anlong Romeat, Spean Thmar, Rolous, Preas Puth, Kong Noy, Teang, Bakou, and Kok Trop, totaling 3,614 families.

iii) Tonle Bati Agricultural Development Centre

The existing Centre is proposed to be improved with the provision of staff and facilities to cover the Tonle Bati Study area. Irrigation development will be implemented under the condition of "without Prek Thnot Reservoir" in some areas, and almost the entire

area will be covered by an irrigation development project under "with Prek Thnot Reservoir" conditions. The proposed command area of this centre is about 5,700 ha, composed of 5 communes, Champey, Put Sar, Kraing Thnung, Kandeong, and Trapieng Sap, totaling 2,830 families.

The staffing and facilities proposed for each Centre are summarized in Table 6.

(5) Proposed Farmers' Organization

It is required to establish farmers' organizations to carry out various supporting activities through the proposed Agricultural Development Centres, related to the operation and management of the irrigation facilities and rural infrastructures, rural life improvement, and community development, and the promotion of agricultural production. The following groups are anticipated to be established:

a. Water users' association (irrigation water),
b. Drinking water supply group (wells),
c. Small farmers' credit group,
d. Cultivation technique study group,
e. Life improvement leading group, and
f. FHH/women's group.

6.3 Irrigation and Drainage Development Plan

6.3.1 General

The run-of-river water of the Prek Thnot in the dry season is very limited. Without the creation of the Prek Thnot multipurpose dam, the irrigated area in the dry season is very limited. However, under "with reservoir conditions", increased irrigation potential will be realized according to trial simulations of the Prek Thnot reservoir water. In formulating the irrigation development plan of The Study Area, the following development alternatives are noted:

a. Irrigation development plan without Prek Thnot reservoir
b. Irrigation development plan with Prek Thnot reservoir

In formulating the development plan, the following basic considerations are taken into account:

i) Improvement/rehabilitation of the existing irrigation and drainage facilities in the area which can be irrigated by the run-of-river water of the Prek Thnot river,

ii) Development priority in the area with suitable soil for irrigation development,

iii) An equal distribution of available water to the schemes envisaged in the Prek Thnot multipurpose project area,

iv) Stabilization of paddy cropping in the rainy season, and diversification of cropping in the dry season.

6.3.2 Irrigation and Drainage Water Requirements

(1) Irrigation Water Requirements

The crops proposed for the Project are paddy for the rainy season, and paddy, maize and vegetables for the dry season. The irrigation water requirements are separately estimated according to the proposed cropping patterns for the respective irrigation systems, and by using climatic data on the basis of the modified Penman method. The estimate was made on the following conditions:

i) Consumptive Use of Water

a. Consumptive Use by Crops : Consumptive use of water by crops is estimated as a product of potential evapotranspiration by crop coefficients relating to the crop growth stages. The climatic data at Phnom Penh station is used in calculating evapotranspiration by the modified Penman method.

b. Percolation of 1 mm/day

c. Puddling Water of 150 mm : Upland crops are scheduled to be planted within a short time of paddy harvesting. Pre-irrigation for upland crop cultivation is not considered because of the available residual moisture.

d. Nursery Water Requirement of 5 % of the main paddy field

ii) Effective Rainfall

Based on the daily rainfall data at Phnom Penh Station, the effective rainfall was estimated by the daily water balance between rainfall and requirement.

In case of R less than 140 mm (half-month) :

$$ER = 0.67 * R - 3.4 \quad \text{(mm/half-month)}$$

In case of R larger than 140 mm (half-month):

$$ER = 0.21 * R + 60.6 \quad \text{(mm/half-month)}$$

iii) Irrigation Efficiency

Overall irrigation efficiency for paddy and upland cropping are summarized as follows:

Irrigation Efficiency	Paddy Cropping	Upland Crop
Application efficiency	85%	70%
Conveyance efficiency	76%	76%
On-farm canal	(90%)	(90%)
Main and Lateral	(85%)	(85%)
Overall efficiency	65%	53%

Diversion water requirements of the composite cropped areas for the Kandal Stung and Tonle Bati areas are calculated a their respective cropping patterns. The following is the summary of the diversion water requirements of the proposed cropping patterns of Kandal Stung Irrigation Project (1,950 ha), and Tonle Bati Irrigation Project (1,600 ha).

Average diversion water requirement

Unit: MCM

	Jan.	Feb.	Mar.	Apr.	May.	Jun	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Tatal
Kandal Stung	2.27	1.75	0	0.11	2.04	2.98	4.98	2.93	1.26	2.20	2.30	3.29	26.11
Tonle Bati	2.01	1.55	0	0.08	1.67	2.45	4.09	2.41	1.07	1.93	2.02	2.93	22.21

(2) Drainage Water Requirements

The drainage water requirement for paddy fields was estimated on the assumption that 5-year, three day continuous rain storm of 153 mm would be drained from paddy fields within three days. The unit drainage requirement , thus estimated, is 4.4 lit./sec/ha.

6.3.3 Improvement of Kompong Tuol Irrigation Intake

(1) Necessity and Effect of the Rehabilitation

The intake facilities have been repeatedly damaged by the floods of the Prek Thnot river due to the deficient construction and re-worked at those times. The farmers in the intake command area could not recieve reliable water from the intake, leading to the low agricultural production in the area as well as the deterioration of unused irrigation facilities. Especially in 1994, paddy production was seriously damaged by the flood in the begining of rainy season and also the drought in the late rainy season.

The road dike of National Road No. 3 connecting between Pnom Penh and Kampot have been repeatedly washed out by the floods, so that road traffic was hampered severely on thosed occasions.

Insufficient flow capacity of the intake regulation gates has resulted in flooding over the downstream farm land when large flood occured, leading to the losses of agricultural production and damages to the public facilities.

The following effects of the rehabilitation are expected:

i) Increase in irrigation area and crop production

About 8,000 ha of cultivated land will be stably irrigated through the existing canal by the rehabilitation of the Kompong Toul Irrigation Intake. Increasing of yield as well as preventation of damages on agricultural production by the flood and drought are expected.

ii) Improvement of transportation condition of National Road No. 3

About 500,000 households living in the around area (Phom Penh city, and three province of Kandal, Takeo and Kampot) will smoothly utilize for transportation.

iii) Mitgation of inundation damages to the downstream area of the intakes to be rehabilitated

About 5,000 households in the downstream area of the intake will prevent the damage of flood.

iv) Improvement of living environment

v) Creation of tourism resources and employment oppotunity by a reservoir to be provided in front of intakes

(2) Alternative Cases

The improvement plan is prepared on the basis of the following basic design conditions:

a. Design flood is 1,900 m^3/sec in a 100-year return period without the proposed dam construction.

b. Required water level at the existing intake is EL. 11.50 m and the allowable maximum flood water level is EL. 13.00 m during the 100-year return period flood.

In making the best choice for the improvement plan, the following five alternative cases are formulated. (See Fig. 19):

Alternative Cases:

Case-1 Improvement of the existing two regulators and construction of an overflow type spillway.

Case-2 Improvement of the existing Tuk Thla regulator, demolishing the existing Kompong Tuol regulator, and construction of an overflow type spillway.

Case-3 Improvement of the existing Tuk Thla regulator, replacement of the existing Kompong Tuol regulator, and construction of an overflow type spillway.

Case-4 Improvement of the existing Tuk Thla regulator and replacement of the existing Kompong Tuol regulator with a new regulator consisting of a rubber-made dam and bridge.

Case-5 Construction of a new regulator at the Kompong Tram site, located about 25 km upstream of the existing Kompong Tuol Irrigation Intake.

(3) Comparison of Alternative Cases

Moha Sey village, a pagoda, Tuk Thla Village, and a pump station with an irrigation canal are on a the left bank of the Prek Thnot river along the National Road No. 3. On the right bank, there are two irrigation intakes and Kompong Tuol village. Accordingly, the available site for the construction of additional new facilities will be the reach between Moha Sey and Kompong Tuol village, which is a distance of 650 m, if the existing Kampong Tuol, Moha Sey village, and the existing by-pass road are not allowed to be removed for the proposed works.

Case 1 and Case 2 confront the limited site by providing a long overflow spillway. A preliminary cost comparison was made for Case 3, Case 4 and Case 5. The construction of Case 4 was more costly than Case 3, due mainly to the expense of the concrete bridge required for rubber type weirs. Case 5 was also not economically viable due to the high civil work cost for a weir, bridge, and a 25 km connection canal to the Kompong Tuol intake. Case 3 was selected for the recommended plan.

(4) General Features of Proposed Improvement Plan

The general features of the rehabilitation of Kompong Tuol intake are shown below.

i) Tuk Thla Regulator

The gate portion will be replaced with a new structure. The existing bridge for the National Road No. 3, and a stilling basin will be retained, with the additional provision of downstream protection. Five (5) motor driven roller gates, 6 m wide and 3 m high,

will be provided. This regulator will share the release of 400 m^3/sec of the design flood.

ii) Kompong Tuol Regulator

The existing regulator will be demolished and replaced with a new regulator. Five (5) motor driven roller gates, 6 m wide and 5 m high, will be provided with a concrete bridge. This regulator will share the release of 650 m^3/sec of the design flood.

iii) Overflow Type Spillway

The required design capacity of the proposed spillway is 850 m^3/sec. The proposed section has a trapezoidal embankment section covered with concrete coverings and the required length is 400 m in gross. The proposed spillway will be provided at the north side of the new Kompong Tuol regulator. The proposed crest is at EL. 11.50 and will be used for the National Road No. 3, under normal flow conditions of the Prek Thnot River.

iv) Road Embankment:

The crest level of the road will be raised to El. 14.30 m. The cross section is 15 m in total width and 9 m in net width and is asphalt paved. The improved length will be 2,300 m inclusive of structures.

v) Flood Dike along Upstream Right Bank and Left Bank

The present flood dike located on the right bank of the Prek Thnot River is improved through re-shaping of embankment with laterite covering for 4.0 km. The left bank embankment will be extended, to reach the village road, for 1.0 km. The proposed top width of both embankments is 4.0 m.

vi) Radio Communication System

The present water management of the irrigation system including the regulators on the Prek Thnot River is under the respective provincial or district offices. To create effective water management of the Prek Thnot River flow in the dry season as well as the flood season, a radio communication system will be installed. The station network is as follows;

a.	Main station	- Department of Agricultural Hydraulics and Hydrometeorology, Phnom Penh
b.	Branch station	- Water management Office of DAHHM
c.	Site station	- Kompong Speu provincial office of Hydrology (for Roleng Chrey regulator)
		- Kompong Tuol regulator office to be prepared

a) Tuk Thla Regulator	Replacement of gates, (width 6 m x height 3 m x 5 sets)
b) Kompong Tuol Regulator	Replacement of existing regulator, (gate: width 6m x height 5m x 5 sets, bridge: width 15 m)
c) Spillway	Overflow type, 400 m in length
d) Road Dike	Total width 15 m, asphalt pavement &width 9 m
e) Flood Dike on Upstream Right and Left Banks	Length of 4 km for right bank and 1 km for left bank, dike crest width 4 m
f) Radio Communication System	Main, branch and two site stations

After these improvement works, the water level will be controlled by the Tuk Thla Regulator and/or Kompong Tuol Regulator during normal flow conditions. The

control water level will bring about a stable water intake for the two existing irrigation projects, and the existing NR No.3 will not be damaged by floods for a return period of less than 100 years. In addition to irrigation and traffic benefits, the stable impounded water created by the proposed regulators will enable people in and around Phnom Penh to enjoy the area for recreation.

6.3.4 Irrigation and Drainage Plan of the Kandal Stung Area

(1) Irrigation Plan

The area suitable for irrigation development in the Kandal Stung area is 4,200 ha. The extent of the area is summarized below and the location is shown in Fig. 14.

Location	Irrigation area (ha)
1. Existing Irrigation area	1,950
2. Southern and northern areas (Kouk Pring, Kouk Krasang areas)	1,750
3. Saba reservoir plan area	500
Total	4,200

The main irrigation water source to the Kandal Stung area is runoff of the Prek Thnot River, taken at the Kompong Tuol site from the right bank of the Prek Thnot river. In case of "without Prek Thnot reservoir" conditions, the river discharges utilized for the Study Area are the residual after sharing the river water with other Prek Thnot irrigation schemes. The river discharges decrease sharply from December, and the low flows continue through April. The irrigation area using the run-of-river water, therefore, is quite limited.

Trial simulation of the reservoir water of the Prek Thnot multi-purpose dam indicated that, for a storage capacity of 1,120 MCM having a corresponding full supply level of 58.5 m, the net irrigation area would range from 35,000 ha without firm power generation to 33,000 ha with a firm power generation of 2 MW. Therefore, the ultimate irrigation development of suitable land in the Kandal Stung area of 4,200 ha has to rely on the water resource development by the Prek Thnot reservoir.

The irrigable area under both cases are estimated below.

i) Without Prek Thnot Reservoir Case

In order to estimate the irrigation service areas, the water balance simulation under "without Prek Thnot reservoir" conditions for a series of ten (10) years from 1961 to 1970, for which the discharge data were made available, shows that the Kandal Stung area will be served for 1,950 ha from the Kompong Tuol regulator site. The basic condition applied for the simulation is as follows:

a. Water allocation priority is given to the Kandal Stung area especially in the dry season since the Kandal Stung area has no possible local reservoir site

b. Irrigable area under the run-of-river water is determined with an irrigation dependable level of 4 out of 5 years through a half-monthly water balance simulation. The year 1968 is the basic design year according to the simulation of the water supply and requirements.

According to the result, the irrigable area will be 1,950ha, as shown in Fig.15. The following is a summary of the water balance of the basic year 1968.

(Unit : MCM)

Description	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Nov.
Qt	9	5	2	1	4	18	47	99	211	145	316	24
Qa	4	2	2	1	1	13	47	96	206	141	313	20
Wd	4	2	2	0	0	2	3	5	4	2	2	4
Sp	0	0	0	1	1	11	44	91	202	139	311	16

Note : Qt : Total discharges of the Prek Thnot river including tributaries
Qa : Available discharge to the Study Area
Wd : Irrigation water demand of the Kandal Stung area (1,950 ha)
Sp : Surplus discharge

ii) With Prek Thnot Reservoir Case

The run-of-river water of the Prek Thnot River will ensure irrigation for 1,950 ha as mentioned above. The remaining area of 1,750 ha will not be irrigated . If the plan without reservoir case is implemented as a first phase, the remaining area could be implemented only after the realization of the Prek Thnot reservoir as an extension area.

The Saba reservoir irrigation area is about 500 ha which lie between the Stung Toch River and Tonle Bati Lake. Saba Lake has no significant catchment area for water storage, reccessitating a supplemental water supply from the Prek Thnot River. The cost required for irrigation and drainage system, mostly consisting of the construction of Saba dam and a connection canal to introduce water from the Prek Thnot River, is high, compared with its service area. It will have low economic efficiency. The water level of the Saba reservoir will fluctuate greatly without a Prek Thnot dam. The development of this scheme has low priority.

Further, there is a large extent of farm land surrounding but beyond the Study Area, the location of which is as shown in Fig. 14. Judging from the topography and location of this farm land, it can be covered by the Kompong Tuol irrigation intake site through the Kandal Stung irrigation system, when the Prek Thnot reservoir has been created.

With a view to the effective use of the facilities of the Kandal Stung Irrigation Project, the first stage development should be formulated in due consideration of the future land development potential. The following table shows the irrigable area including farm land outside the Study Area, the extent of which is subject to a detailed soil survey.

Development Area	Irrigable Area (ha)
Irrigable Area of the Kandal Stung Study Area	
- "without Prek Thnot reservoir" conditions	1,950
- additional area "with Prek Thnot reservoir" conditions	2,250
Outside the Study Area	
- north area	200
- east area	4,800
Total	9,200

The existing main canal has a design capacity of 9.8 m^3/sec which is sufficiently large to command the possible irrigation area of the Kandal Stung area of 4,200 ha. The southern part will be served by the existing lateral No.1 with provision of a new lateral canal and the northern part will be supplied from the existing lateral No. 2, through its extension. The high elevated area upstream of the main canal will be irrigated by small pumps on a tertiary canal baisis.

(2) Drainage Plan

Most of Kandal Stung Study area is drained to the Cheung Loung lake through via old

Pol Pot canals on an east-west direction. The northern part is directly drained to the Prek Thnot river also using the old Pol Pot canals. The drainage canal system to be constructed consists of major drainage canals, and tertiary and quaternary canals and their related structures.

(3) General Features of the Irrigation and Drainage Facilities

The general features of the irrigation and drainage facilities to be constructed are shown below. The preliminary layout of the irrigation and drainage system is shown in Fig.16.

i) Improvement of Existing Irrigation Facilities

Sections of the all canals are in poor shape due to slope sliding and erosion. To prevent the collapse of the canal embankments and to save future O&M costs, protection will be provided for the main canals by using a 2-phase concrete lining and for the existing laterals by using lining. Most of the canal embankments are also severely eroded and the eroded soils are silted-up on the canal berms. Canal reshaping by earthfill and the removal of sediment will be necessary. The main canal inspection road is not in use due to erosion or breach of its embankments. Laterite pavement will be provided for the inspection road after re-shaping.

The following works are required for the respective canals:

a. Main Canal

- Slope protection by means of a 2 phase concrete lining, and sod facing,
- Re-shaping of the canal's cross sections by removing sediment and earthfill for the embankment,
- Improvement of the canal embankment,
- Provision of an inspection road with laterite pavement,
- Sod facing on the slope of the canal embankment.

b. Laterals and Tertiary Canals

- Re-shaping of the canal's cross sections by removing sediment and earthfill for the embankment,
- Improvement of the canal embankment and the inspection road,
- Sod facing on the slope of the canal embankment,

ii) Provision of Quaternary Canals

The commanding area of the existing tertiary canals range from 30 to 100 ha, averaging 65 ha. Tertiary canals are provided in parallel at intervals of 500 m to 800 m. To ensure equitable water delivery in the tertiary service area, a field ditch will be needed.

The tertiary development program aims for efficient water management by establishing a well organized tertiary system, and through a refined rotational irrigation program. In order to distribute irrigation water equally and efficiently to all parts of the fields using a more intensive water control, it is advisable to sub-divide the tertiary block into several quaternary blocks. The quaternary block is served by its respective quaternary canals. The recommended size of one quaternary block is 10 to 15 ha.

The quaternary canal is a terminal system. Irrigation water to be carried by this canal is distributed directly to fields. The end of quaternary canal is connected to a nearby drainage canal in order to drain off excess water. The average interval of a quaternary canal is limited to 200 m at maximum. All the quaternary canals except the canal to be

constructed in the highest position of the respective areas, are designed to have dual function; irrigation and drainage, where possible.

iii) Related Structures

The following structure improvement /construction will be needed.

- Installation of gates at check structures, diversion structures and turnouts,
- Repair of canal sections downstream of the structures slope protection,
- Provision of required structures or structure parts where not yet provided,
- Replacement of severely damaged structures.

iv) Improvement of Drainage Canals and Related Structures

- Clearing of the canal sections,
- Removal of sediment and enlargement of canal capacity,
- Improvement of canal embankment,
- Construction of inspection roads and
- Replacement of drainage crossing structures where required

The general features of the proposed project works of the irrigation and drainage system are as follows:

Description		First Stage Work	Second Stage Work
Main canal			
- Improvement of main canal	(km)	5.3	0
Lateral			
- Improvement of existing lateral	(km)	8.2	0
- Construction of lateral	(km)	4.0	18.3
Tertiary canal			
- Improvement/construction of tertiary canal	(km)	56.8	65.5
Quaternary canal system	(ha)	1,950	1,750
Saba Scheme			
- Saba dam	(nos)	-	1
- Connection canal	(km)	-	4.5
- Lateral canal	(km)	-	8.0
- Tertiary canal	(km)	-	11.0
- Quaternary canal system	(ha)	-	500
Drainage works			
- Major drainage canals	(km)	18.1	20.9
- Tertiary canal	(km)	64.6	74.5

6.3.5 Irrigation and Drainage Plan of the Tonle Bati Area

(1) Irrigation Plan

The area suitable for irrigation development in the Tonle Bati area is 4,200 ha. The extent of the area is summarized below and the location is shown in Fig.14.

Location	Irrigation area (ha)
1. Existing Irrigation area	1,600
2. Surrounding area	2,600
Total	4,200

The irrigation water source of the Tonle Bati area is the Tonle Bati River with lake storage, but the storage of the lake greatly reduces in the dry season. To increase the irrigation area of the Tonle Bati area, augmentation of irrigation water is inevitable.

The Department of Hydrology has prepared a multi-reservoir plan to augment irrigation water to the Tonle Bati area. The plan envisaged the creation of a series of reservoirs consisting of Stung Toch, Saba and Kok Tel reservoirs, all of which are linked by a dike running between the Kandal Stung and Kok Tel villages. The gross storage volume was estimated to be 29 MCM, with a corresponding surface area of 1,400 ha at the same water level of 12.0 m. On the basis of this plan, parts of the dike from Saba to Kok Tel have been implemented, but work on the main dam embankment has been suspended.

The Department of Hydrology has made another reservoir plan, envisaging construction of the Saba reservoir and the rehabilitation of the connection canal (NS 78) making a direct connection from the Tonle Bati River to the Prek Thnot river via the Stung Toch River. This plan has advantages, as construction of the canal is relatively easy and results will be realized soon. Based on this plan, re-construction of the connection canal has been implemented.

The localized reservoir plan is conceived as follows, in due consideration of the irrigation plan and environmental situation of the reservoir areas:

i) Stung Toch Reservoir

The intake water level at the Kompong Tuol irrigation intake is set to be 11.5 m on account of avoiding inundation and/or the ill-drainage of the areas located upstream of the Kompong Tuol. A large part of the envisaged reservoir area lies on ground levels of 10 to 11 m. Therefore, it is impossible to create the Stung Toch reservoir under the conditions of a revised intake water level.

ii) Kok Tel Reservoir

The Kok Tel reservoir plan envisaged by the Hydrology Department is to construct an earth dam across the Tonle Bati River which discharges water into the Tonle Bati Lake. The reservoir level was set at 12.0 m with a gross storage volume of 18 MCM and a corresponding water surface area of about 700 ha. The dam crest was set to be 14.0 m in elevation with a maximum height of about 9 m. The embankment of the main dam of about 1,300 m remains uncompleted. According to the information obtained during the field survey, the following negative aspects on the creation of the planned Kok Tel reservoir (reservoir water surface of 12.00) were considered.

a. Inundation of three villages, requiring resettlement of about 120 families and provision of infrastructures in the resettlement areas,

b. Inundation of about 400 ha paddy fields requiring additional farm land for the villagers,

c. Loss of living environment for villagers, such as well developed trees.

In order to avoid inundation of the villages as well as to reduce the loss of farm land in the reservoir area, and further taking into account the revised intake water level of El. 11.5 at the Kompong Tuol regulator site, the Kok Tel reservoir water level should be lowered to 10.5 m.

The following alternatives will be conceived for the irrigation plan of the Tonle Bati Study area under "without and with Prek Thnot reservoir" conditions:

Alternative Plan	Prek Thnot Reservoir	Localised Reservoir	Connection Canal
Plan-1a	Without Prek Thnot Reservoir	Without Kok Tel Reservoir	With connection canal
Plan-1b	Without Prek Thnot Reservoir	With Kok Tel Reservoir	With connection canal
Plan-2	With Prek Thnot Reservoir	Without Kok Tel Reservoir	With connection canal

The irrigable areas of the respective alternatives are assessed by means of a water balance simulation which was carried out under the following conditions:

Description	Alternative Plan-1a	Alternative Plan-1b
Localised reservoir storage	Tonle Bati Lake Storage : 16.7 MCM (at HWL 7.8 m into the Tonle Bati Lake) : 5.9 MCM (at LWL 6.0 m into the Tonle Bati Lake)	Tonle Bati Lake plus Kok Tel reservoir Storage : 26.0 MCM (at HWL 10.5 m into Kok Tel reservoir) : 16.7 MCM (at LWL 7.8 m into the Tonle Bati Lake)
Connection canal	Capacity of 7.0 m^3/sec	Capacity of 7.0 m^3/sec
Water requirement	For the proposed cropping pattern (1,600 ha), and for receding paddy cropping of 600 ha	For the proposed cropping pattern (1,600 ha), and for receding paddy cropping of 600 ha
Water loss from reservoir	Percolation loss of 2 mm/day plus evaporation	Percolation loss of 2 mm/day plus evaporation

i) Without Prek Thnot Reservoir Plan

The water balance simulation of Plan-1a indicates that this plan could ensure irrigation to an area of 1,600 ha, as shown in Fig.17. Run-of-river water of the Prek Thnot River, however, reduces sharply from December, showing a minimum in March. Supply from the Prek Thnot River through the connection canal could not be expected during some dry seasons. In the later stage of the second cropping and the beginning of the first cropping, January through May, lake water levels reduce. It necessitates pumping-up irrigation for the dry season irrigation area.

On the other hand, the storage simulation of Plan-1b shows that gravity irrigation will be ensured throughout the year for an area of 1,600 ha

ii) With Prek Thnot Reservoir Plan-2

Irrigation Plan-2 will ensure the sufficient irrigation of the whole area of 4,200 ha without the Kok Tel reservoir. As mentioned above, gravity irrigation can be ensured for the 1,600 ha. It means that the Kok Tel dam greatly contributes to reducing the O&M works. However, in case the Prek Thnot dam is realized soon, the dam will not economically be justified. The implementation of the Kok Tel dam is largely dependent on the construction time span of the Prek Thnot dam.

The implementation schedule of the Prek Thnot Multipurpose Project is not formulated at the present time, and it is not clear whether the Prek Thnot reservoir will become operational on a short or long time. In this situation, it is recommended that the irrigation development of the Tonle Bati area is firstly implemented with Plan-1a; without the Kok Tel dam, and using augmented water through via the connection canal.

The design capacity of the Main Canal M1 is 9.8 m^3/sec which is sufficient to command the area located in the southern part of the Tonle Bati area. It is served by an extension of the Main Canal M1. The eastern area will be commanded with the

extension of the Main Canal M3 and the northern area will be supplied from the Main Canal M1 after improvement of the main canal.

(2) Drainage Plan

The drainage system of Tonle Bati area is broadly divided into three drainage systems. The eastern part of the Tonle Bati area is drained to the Bueng Cheung Luong Lake through the old Pol Pot canals running in an eastwest direction. The southern area will be drained to the Haknuman (NS 85) canal. While, the northern area is directly drained in the downstream reaches of the Tonle Bati River. The drainage canal system to be constructed consists of major drainage canals, tertiary and quaternary canals, and their related structures.

(3) General Features of Irrigation and Drainage Facilities

The following are the general features of the Project facilities. The preliminary layout of the irrigation and drainage system is shown in Fig.18.

i) Irrigation Canals

a. Main canals

Improvement to the existing main canal will be the following:

- Slope protection by means of concrete lining, and sod facing,
- Re-shaping of canal's cross sections with the excavation of canal sections or earthfill for the embankment,
- Provision of an inspection road for the main canal with gravel metalling.

b. Laterals and tertiary canals

- Re-shaping of canal's cross sections with the excavation of canal sections or earthfill for the embankment,
- Provision of tertiary canals to suit the appropriate tertiary block size.

c. Provision of quaternary canals

- Provision of a field ditch will be needed to ensure equitable water delivery in the tertiary service area.

d. Related structures

- Installation of gates,
- Repair of canal sections downstream of the structures, and
- Provision of required structures or structure parts where not yet provided.

ii) Activation of the Tonle Bati Lake Related Structures

The water levels of Tonle Bati Lake are lowered in the dry season even though the irrigation water is augmented from the Prek Thnot River through a connection canal. Lifting water from the lake will be required in the dry season to supplement the gravity irrigation supply. A pumping station will be improved. An intake will be provided with slide gates together with improvement to the inlet and outlet structures.

a. Improvement of the intake

b. Improvement of the Pumping Station

c Improvement of the Spillway of Tonle Bati Lake

d. Improvement of the Lake Dike

iii) Improvement of the Connection Canal (NS 78 canal)

a. Improvement of NS 78 Canal

The re-constructed canal does not function due to its high bottom level and lack of a diversion structure in the Stung Toch River. In order to augment the storage water of the Tonle Bati Lake, the 4.6 km connection canal up to the Tonle Bati River needs to be rehabilitated. To prevent erosion of the damaged canal section in dispersive soils, a self-retaining 2-phase canal lining will be provided, together with sodding.

b. Stung Toch Regulator

In order to divert water in the Stung Toch River which is conveyed from the Prek Thnot River, a regulator will be constructed in the Stung Toch River about 2 km downstream of the crossing point of National Road No. 2.

c. Kandal Stung Regulator

The existing Kandal Stung regulator, located west of the National Road No. 3 near to the Kandal Stung intake, will be replaced, to regulate the discharge from the Prek Thnot River to the Stung Toch River.

iv) Improvement of Drainage Canals and Related Structures

The following drainage works will be required :

a. Clearing of the canal sections,

b. Removal of sediment and obstructions,

c. Enlargement of canal capacity,

d. Improvement of canal embankment,

e. Construction of inspection roads,

f. Replacement of some drainage crossing structures.

(2) Proposed Project Works

The general features of the proposed project works of the irrigation and drainage system are as follows:

Description		First Stage Work	Second Stage Work
Main canal			
- Improvement of main canal	(km)	8.3	-
- Construction of main canal	(km)	-	5.5
Lateral			
- Improvement of existing lateral	(km)	6.9	-
- Construction of lateral	(km)	3.1	16.3
Tertiary canal			
- Improvement of existing tertiary canal	(km)	15.0	-
- Construction of tertiary canal	(km)	33.1	78.2
Quaternary canal system	(ha)	1,600	2,600
Improvement of Tonle Bati Lake Related Structures			
- Intake	(nos)	1	-
- Pumping Station	(nos)	1	-
- Spillway of Lake	(nos)	1	-
- Lake Dike	(km)	L.S	-
Improvement of Connection Canal			
- Connection canal	(km)	4.6	-
- Stung Toch regulator	(nos)	1	-
- Kandal Stung regulator	(nos)	1	-
Drainage works			
- Major drainage canals	(km)	24.1	39.2
- Tertiary canal	(km)	41.8	66.6

6.3.6 Operation and Maintenance

As mentioned above, the river water of the Prek Thnot, a main water source of the Project, is taken from the existing irrigation intakes by the related provincial offices, therefore, the overall water management is not carried out. Since the river flows in the dry season reduce extremely, the available water to the Project is largely affected in the dry season, and the flood waves arrives to the downstream without information under the present operation of the upstream intake gates. This condition implies the less effective water use of the limited dry season water source and flood damages in the high water season. To this end, Ministry of Agriculture and Forestry will carry out the water management.

The irrigation and drainage system of the Kandal Stung and Tonle Bati Irrigation Projects covers head regulators such as the Tuk Thla and Kompong Tuol regulators up to the outlets of drains at the boundaries of the Project.

The responsibility of operation and maintenance of the irrigation and drainage systems will be divided into two types of administrative bodies, i.e., a Project operation body, responsible for the head regulator to the lateral systems, and a water users groups responsible for tertiary irrigation and the drainage system.

The Department of Hydrology, Water Management Office will be responsible for the operation, maintenance, and management of the head regulators and localized reservoirs in order to ensure the equitable water management and safe operation of the large facilities. The local governments concerned will be responsible for the operation, maintenance and management of the main canal up to the lateral systems. The government operation bodies should have sufficient sections to perform their functions, such as operation, maintenance, and administration sections.

Each tertiary block will have a water user's association which will manage water distribution, operate and maintain the irrigation and drainage canal system, and manage contribution fees for the water user's association.

At the provincial and district government levels, the provincial and district irrigation committees will be organized to co-ordinate the smooth operation and maintenance of the irrigation system and water management of the Project. They will be constituted from

representatives of the provincial or district government offices, such as the agriculture office, the public works office, the rural development office, and the police/military office.

O&M section will prepare a seasonal water distribution schedule including rotational blocks for dry and rainy season cropping, respectively. It will submit the prepared irrigation schedule to the chairman of the Irrigation Committee for its approval. After the approval, the irrigation schedule will be announced to the water user's association before starting crop cultivation.

Maintenance works of the irrigation system will be divided into two categories, i.e. routine maintenance and periodical maintenance. Routine maintenance works will be made within a short interval and on a small scale throughout a year. Periodical maintenance will be made rather intensively on a large scale during a water cut period. The water cut will be made from the end of irrigation for the second cropping, to the irrigation start of the rainy season cropping.

6.4 Rural Life Improvement Plan

In order to overcome problems and constraints in the living conditions of the Study Area, the formulated improvement plans are as follows:

(1) Improvement in Food and Nutrition

The proposed measures in improving food and nutrition of the people are categorized into the promotion of crop and livestock production, and the educational extension of life improvement:

i) Promotion of crop and livestock production:

Attainment of food and balanced nutrition by the intensification and increase of the staple food crop (rice), secondary crops, livestock raising, and vegetables for home consumption.

ii) Educational life improvement extension:

Improvement of knowledge on nutrition, hygiene and health management, improvement in effective cooking methods including the modernization of cooking facilities and the saving of energy, improvement of knowledge on safety and hygiene in food and domestic water.

(2) Improvement of the Living Environment:

Improvement of the living environment consists of the construction of rural infrastructures for the domestic water supply, the application of improved methods of livestock raising especially in relation to the living conditions, and educational life improvement extension work:

i) Infrastructure:

Improvement of domestic water supply system and facilities.

ii) Livestock raising method:

Improvement of animal raising methods concerned with hygiene.

iii) Educational extension:

Improvement of toilet facilities and establishment of a regulation to control the living

environment.

(3) Increase in Employment Opportunities

The measures proposed are mostly the promotion of agricultural production by diversifying to cash crops for market, and vocational training on such activities as handicrafts, weaving, and sewing. The key point envisaged to carry out these measures is to formulate leading groups to initiate practices of these activities.

(4) Improvement of Farm Household Management

The main items to be covered by this measure are 1) education on the role clothing plays in promoting a safe, healthy life and practical training on achieving this, 2) training on basic accounts and record keeping of home life activities such as income and expenses, and 3) training and guidance on improvement of kitchen and cooking stove.

(5) Community Development

Community development is the most important element to in improving life conditions of the people in the area. The proposed measures for this development are as follows:

a. Promotion of people's participation at the planning stage of the programs.

b. Organizing grass roots communities by function, such as a water users' association, a small farmers' credit group, and life improvement leading groups.

c. Establishment of community hall as a base for community activities such as self-help group, day-care center, etc.

d. FHH /women's group formulation, and conducting basic studies on home life improvement in the area.

(6) Strenthening of Support Services

The measures required for this element are to strengthen the support services by reactivating and improving the Agricultural Development Centers and to carry out almost all services and programmes for life improvement extension work in cooperation with the agricultural support services.

The proposed staffing of the life improvement extension work is summarized as follows:

Agricultural Development Center	Gross Area	Covered Communes	No. of Village	No. of Family	No. of life improvement extension worker
	(ha)	(No.)			
1. Kandal Stung No. 1 (Existing)	5,600	5	19	2,245	3
2. Kandal Stung No. 2 (Newly proposed)	5,700	8	48	3,614	5
3. Tonle Bati (Existing)	6,900	5	34	4,380	6
Total	18,200	18	101	10,239	14

The proposed facilities and equipment for life improvement extension work is described in the Plan of Establishment of Agricultural Development Centers.

(7) Improvement of Transportation System

This element is to facilitate and improve the transportation system by improving the provincial and district roads from farm to market and home, especially those impassable in the wet season.

The problems and constraints on the home life of the people in the Study Area, elements to be considered, and measures proposed for life improvement, are summarized in Fig.20.

Even though all of the practical measures proposed are necessary for the life improvement plan, on the practical possibility of the plan implementation capacity of the concerned agencies, necessity and urgency, and requirement by the peoples, should be considered. The priority components taken at the initial stage of the project are to strengthen the support services concerned with the stabilization of the economic base by the promotion of agricultural production and life improvement extension work in the area. And after, the practical measures proposed would be implemented and extended as programmes and services to the peoples.

6.5 Rural Infrastructure Improvement Plan

Existing rural infrastructures such as rural road networks, rural water supply, health facilities, schools, and community facilities are proposed to be improved. Proposed infrastructure improvements are explained respectively.

6.5.1 Rural Road Networks

Rural people face difficulties in their daily transport on existing roads at present, especially in the rainy season, due to insufficient maintenance of the existing road networks caused by budgetary constraints. For example, present difficulties are observed in shopping, treatment of urgent patients, transport of crops to market, and rural communication. Therefore, the main purpose of the road network improvement is to establish sufficient transportation routes to improve the daily transportation conditions and to promote regional and agricultural development in Study Area.

The road network to be provided will consist of the national roads, the provincial roads and feeder roads, including the district roads. Existing roads will be upgraded to asphalt-paved or gravel-metalled with widening or additional related structures provided. The following existing roads are proposed to be improved, and the location of the road works is shown in Fig. 21.

Proposed Road Improvement Works

Roads	Route No	Length	Pavement
Trunk Roads			
Provincial Roads	No. 104 & No.105	15.9 km	Asphalt
Others Roads	District Rd: 1 & Khum Rd: 1	15.9 km	Gravel
Feeder Roads	District Rd: 1 & Khum Rd: 20	62.3 km	Gravel
Total		97.6 km	

6.5.2 Rural Water Supply

In the Study Area, ground water in dug wells and tubewells is the main source of drinking water and other domestic use. Dug wells have a depth ranging from around 5 to

10 m, while tubewells range at around 30 to 40 m. There are 149 dug wells and 97 tubewells under UNICEF and two foreign NGOs in the Kandal Stung Study area and 17 dug wells and 35 tubewells in the Tonle Bati Study area. Most of these dug wells use buckets, and the tubewells are equipped with manual operating pumps. A number of the wells, however, dry up in the dry season compelling villagers to depend upon other water sources such as lakes, canals, or ponds.

From a view-point of basic human needs, it is essential to provide a reliable water source for drinking and domestic purposes, to stabilize the livelihood of rural people in the Study Area. Additional tubewells are proposed to be provided where existing wells are insufficient. The number of the proposed wells is given below , and the locations of the works of the rural water supply facilities are shown in Fig. 22.

Proposed Tubewell

Description	Depth	Proposed Number
Deep Tubewell & Manual Pump	> 50 m	67
Shallow Tubewell & Manual Pump	< 50 m	196
Deep Tubewell, Submerged Pump and Distribution Pipeline	> 50 m	2
Total		263 wells & 2 systems

6.5.3 Social Infrastructures

(1) Improvement of Khum Clinic

There are 11 Khum clinics and a main hospital in Khum Anlong Remeath in the Kandal Stung area, and two Khum clinics in the Tonle Bati area. A Khum clinic is basically provided for each Khum, except the Khum Preah Puth where the clinic facility was severely destroyed during the Pol Pot regime. The existing condition of the clinic buildings are, 4 under good conditions, 6 under fair conditions and 3 only bad conditions out of 13 Khum clinics in the Study Area.

According to the Director of the District hospital, the minimum size required for a Khum clinic are 8 m by 12 m house, needing three rooms for a dispensary, ward, and medicine stock room. The improvement works for the proposed clinics are given below, and the locations are shown in Fig. 23.

Proposed Improvement of Khum Clinic

Study Area	Building Area	Related Facility
Kandal Stung (Trea,Preah Puth, Bakou,Tbeng)	4 sites, 384 m^2	4 set
Tonle Bati (Kreing Thnoung, Cham Pei, Kandoeung, Puth Sar)	4 sites, 384 m^2	4 set
Total (8 places)	8 sites, 768 m^2	8 set

(2) Community Facility

At present, Khum community facilities are not available in the Study Area. They are useful for communication and socio-economic activities of the rural people and are expected to be utilized further for the farmer's training, establishment of farmers' organizations, and agricultural extension services. Construction of the community facilities is one of the essential components for the success of the agricultural/rural development as well as for rural life improvement.

Community halls with staff quarters are proposed to be constructed in the respective

Khums and will be utilized as multi-purposes facilities for community development in the Study Area. The proposed works are given below, of which the locations are shown in Fig. 23.

Proposed Community Hall

Facility	Proposed Number
Community Hall	18 places
Staff Quarter	41 houses
Total	59 buildings

(3) Additional Classroom for Existing Schools

The present condition of primary school facilities in the Study Area is very poor, and some buildings are very dilapidated. In order to overcome the shortage of class rooms for enrolled pupils, schools are compelled to apply a rotation system. In total 58 class rooms are proposed to be constructed, and their locations are shown in Fig. 23.

6.6 Environmental Assessment

6.6.1 Environmental Assessment of Irrigation and Agricultural Development

It has been long regarded that economic development and environmental conservation are incompatible and many believe that the degradation of environmental quality is justified to achieve certain economic objectives. Generally, irrigation and agriculatural development are associated with dams, resorvoirs and causing drastic ecological changes in the command areas. However, in the case of this project, major environmental changes are not going to take place. There will not be a loss of forests, wetlands or any other natural systems as these do not exist at the present time.

Previous sections and the annexes at the back of this report describe in detail the status at present. Therefore, the project attempts to improve the economy of the Study Area by providing water through a rehabilitated irrigation network, improving infrasturcture such as schools, health centers, and roads, and bringing about an all round improvement in lifestyles. As it is somewhat difficult to quantify all identified effects, they are presented in a qualitative manner.

The Study Area is already utilized for farming. Efforts will be taken to build into the project design various measures through which environmental protection and management can be enhanced. Constraints identified during the course of the study will be eliminated. The proposals for environmental conservation are made with the objective of introducing sustainable growth, thereby maintaining the ability of the resource base to yeild continuously over a long period of time. The proposals also aim to provide better incomes to the rural people and thereby improve living standards.

6.6.2 Environmental Management

In chapter four of the annex, recommendations for rational environmental management have been discussed. In chapter five an environmental action plan has been presented. The recommendations range from land use to environmental education and include a variety of fields, where a little extra knowledge and attention can lead to long-term sustainable resources.

The Brundtland Commission defined sustainable development as: "a process of change

in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations".

Sustainable development also concerns the transformation of degraded and unsustainable systems into productive sustainable units. The proposals for the use of the unirrigable uplands is an example of this. The proposal to reduce pesticide use in favour of non-chemical methods, is a means of introducing a sustainable method of farming that will preserve not only the farming resource base but also those systems physically unrelated, such as the aquatic environment which can become polluted by the chemicals. Some of the chemical pollutants also can be picked up by lower forms of life and through a process of biomagnification, find a pathway into the human body.

Another proposal that can bring about a better environment is an increased tree cover. The benefits included are more firewood and timber, more food items and fodder, improved hydrology, more material for green manuring, more organic matter in the top soil, greater infiltration and less runoff, nutrient cycling from the deep soil layers, miscellaneous materials such as poles for farm use, habitat for species that are beneficial to crop husbandry, eg., snakes and birds, windbreaks and the modifying of micro-climates.

Reforesting the Phnum Thma reserve can create hydrological benefits for the Tonle Bati lake. It will provide the above benefits and also provide opportunities for recreation.

Rehabilitating the canal network will prevent erosion, sedimentation, and also provide healthier plant and animal ecosystems. It will prevent seepage losses and delivering more water to allow a larger area to be cultivated.

Government institutions will be primarily responsible for initiating the field application of the environmental recommendations. The people will be active participants in implementation, and the assistance of the NGO community will be sought where specialist skills are required. Environmental education is considered an important segment of the proposals and the transfer of knowledge and technology will be undertaken at appropriate times through the farmers' and women's organisations.

6.7 Cost Estimate

(1) General

The preliminary costs of the implementation of the Project are estimated on the basis of the following conditions:

a. The exchange rate used is

US$ 1.00 = Riel 2,200 = Yen 100

b. The main construction works will be carried out by the contractor(s) selected through competitive bidding. The on-farm works will be executed by the farmers associations concerned.

c. The unit prices of the works will be divided into foreign currency portion and local currency portion. Local currency portion is estimated with reference to current market prices in the middle of 1994, and the cost data obtained from the similar works around the Study Area. Foreign currency portion is estimated on the basis of CIF Phnom Penh.

d. Contingency allowed in the cost estimate is 10 % of the construction cost.

(2) Cost Estimate

The project cost will consist of construction cost, procurement of machinery, land acquisition cost, engineering and administration cost, and contingency. The total cost is estimated to be US$ 101.3 million, consisting of the foreign currency portion of US$ 59.5 million and the local currency portion of US$ 41.8 million. The cost required for implementation of the first stage works,which are shown in Table 7, will be US$66.8 million,consisting of the foreign currency portion of US$ 43.6million and the local currency portion of US$ 23.2million. The detail are shown in Table 8, and the summary is shown below.

Description	Total cost			First Stage		
	Foreign Currency	Local Currency	Total	Foreign Currency	Local Currency	Total
1. Construction cost						
1.1 Irrigation and drainage	33.61	17.74	51.35	27.76	10.72	33.48
1.2 Rural development center	2.96	2.33	5.29	1.45	1.14	2.59
1.3 Rural road network	4.79	4.42	9.21	3.40	3.13	6.53
1.4 Rural water supply system	2.56	1.32	3.88	0.71	0.36	1.07
1.5 Village clinic	0.19	0.19	0.38	0.07	0.07	0.14
1.6 School building	0.69	0.69	1.37	0.46	0.46	0.92
1.7 Community hall	1.61	1.61	3.23	0.63	0.63	1.26
1.8 On-farm development	0	5.30	5.30	0	2.20	2.20
Sub-total	46.42	33.60	80.02	34.47	18.73	53.20
2. Procurement of O/M equipment	1.90	0.10	2.00	0.95	0.05	1.00
3. Engineering services and administration	5.80	4.04	9.84	4.25	2.25	6.50
4. Land acquisition	0	0.23	0.23	0	0.03	0.03
5. Contingencies	5.41	3.80	9.21	3.96	2.11	6.07
Total	59.53	41.77	101.30	43.64	23.16	66.81

VII. PROJECT IMPLEMENTATION AND SELECTION OF PRIORITY DEVELOPMENT AREAS

7.1 Basic Approach to Project Implementation

The integrated agricultural and rural development project includes various schemes for development and consolidation of infrastructure facilities as well as for reinforcement and/or activation of supporting functions. In order to effectively implement the various components, and taking into account the technical and managerial capacity of the staff concerned, the implementation of the schemes should be made under well designed development in stages. It could be divided into the following two stages:

(1) Priority Development

The first stage development aims to establish the technical and implementing base as a model area which will be the core to demonstrate the effects of the integrated agricultural and rural development and function as a base for the future expansion of the whole area. Selection of the priority development areas as model development can be made according to the physical and socio-economic conditions of the Study Areas and the following selection criteria:

a. Benefit will accrue quickly with investment.
b. The priority area will function as a model exhibition to the surrounding area.
c. Project components will be easily applied to other areas extensively.
d. Land productivity is high.
e. The area is located near a water source and it is possible to introduce double cropping and crop diversification.
f. Accessibility of farm products to market is good.
g. Security condition is good.

As a result, 1,950 ha in the Kandal Stung area and 1,600 ha in the Tonle Bati area were selected as a priority development area, where reliable irrigation could be ensured under "without Prek Thnot reservoir" conditions.

(2) Second Stage Development

The remaining area will be covered in the second stage development. The implementation and operation of the model area would provide various information on intensive farming and life improvement measures, and opportunity to gain experience in the execution of large-scale project implementation. On the basis of the accumulated results and institutional set-up during the first stage development, the second stage could successfully be implemented. Commencement of the irrigation works, however, will be subject to the schedule of the realization of the Prek Thnot multipurpose dam.

The area belonging to the older terraces is not suitable for intensive development, as already suggested in chapter 6. For this area, pasture and fodder crops or fuelwood production are proposed. Thus the sufficient provision of extension support should be ensured as well as special measures for rural life improvement .

The implementation schedule of the Project is shown in Fig. 2.4.

7.2 Priority Development Area

The implementation of the first stage will be concentrated in the Kandal Stung area of 1,950 ha and the Tonle Bati area of 1,600 ha where reliable irrigation will be ensured under the run-of-river water of the Prek Thnot River. The implementation program will include the following:

i) Agricultural Development
   a. Improvement and strengthening of agricultural support services
   b. Establishment of a Rural Development Center, including demonstration farm

ii) Development of Irrigation and Drainage Development
   a. Urgent work for the improvement of the Kompong Tuol irrigation intake
   b. Improvement of irrigation and drainage facilities of the Kandal Stung Irrigation Project of 1,950 ha
   c. Improvement of irrigation and drainage facilities of the Tonle Bati Irrigation Project of 1,600 ha

iii) Development of Rural Infrastructures
   a. Improvement of the rural road network,
   b. Construction of rural water supply facilities,
   c. Improvement of village clinics
   d. Improvement of school buildings
   e. Construction of community halls

iv) Measures to rural life improvement

v) Support services to Women's groups

vi) Measures for environmental problems

VIII. PROJECT IMPACTS AND PRELIMINARY EVALUATION

The evaluation of the development plan in this chapter deals with mainly qualitative evaluation but quantitative preliminary evaluation has also been made for reference.

8.1 Agricultural Impacts

(1) Increase in Crop Production

The main agricultural impact expected will be the increase in rice production. The major increase will be expected in both rainy and dry season rice through the use of improved irrigation, inputs, and extension services under the plan implementation. To evaluate the increase in rice production, the following forecast has been set :

i) Harvested Area

it is assumed that suitable areas for irrigated rice farming will be developed at maximum levels after the implementation of the plan. As a result, irrigated rice fields will finally reach 8,400 ha. The change in harvested areas for each stage would be expected as follows :

Increase in Irrigation Area

(Unit : ha)

Crops	Present	Without Dam*	With Dam*
Rainfed Wet Season Rice	8,400	4,850	-
Irrigated Wet Season Rice	-	3,550	8,400
Irrigated Dry Season Rice	-	1,700	4,200
Dry Season Maize & Soybeans	-	510	3,192
Dry Season Vegetables	-	510	1,008

Remarks ; Dam* means the planned Prek Thnot dam

ii) Yield

With the implementation of the plan, the yield of irrigated rice will significantly increase by the stable supply of irrigation water and improved farming practices provided by proper agricultural support services. In addition, the yield of rainfed rice will also increase due to the improvement of the farming system to be introduced by the extension services. Anticipated yields of crops at each development stage are explained in Chapter 6.

Based on the above forecast given in Section 6.2.1, the crop production and the incremental production in each stage have been estimated and are summarized below :

Crop Production

(Unit : ton)

Crops	Without-project	Without Dam*	With Dam*
Rice	15,598	43,550	59,240
Maize	-#	1,530	9,576
Soybeans	-#	765	4,788
Vegetables	-#	5,100	10,080

Remarks ; -# The production is assumed as the same condition as present. Dam* means the planned Prek Thnot dam

Incremental Crop Production

(Unit : ton)

Crops	Without Dam*	With Dam*
Rice	27,952	43,642
Maize	1,530	9,576
Soybeans	765	4,788
Vegetables	5,100	10,080

Remarks ; Dam* means the planned Prek Thnot dam

From the above tables, rice production will increase 280 % without the planned Prek Thnot dam or 380 % after the dam's completion, if the proposed master plan is implemented. In addition is, the production of the upland crops grown in the dry season will drastically increase. These crop production increases, as a result of the plan implementation, will bring about not only the upgrading of rural living standards in the Study Area, but also an improvement in nutrition in and around the Capital, Phnom Penh.

(2) Increase in Livestock Production

The livestock production will also increase through more extension of veterinary services and strengthening of marketing system. Incremental coarse grains such as maize and soybeans grown in the Study Area can be converted to meat, which can be regarded as a form of value-added farm activities. In addition, crop residuals after harvest and by-products from processing of crops will also improve the fertility of livestock. The increased livestock production will contribute not only to increase the farmers' cash income through markets but also to improve nutrition conditions in and around the Capital, Phnom Penh.

The incremental production of livestock has been estimated by use of a unit of pig head which are summarized as follows :

Incremental Livestock Production

(Unit : head)

Description	Without Dam*	With Dam*
Incremental Livestock in Pig	2,720	17,200
Increment per Typical Family	0.8	2.5

Remarks ; Dam* means the planned Prek Thnot dam

(3) Demonstration Effects

With the implementation of the plan, farmers in the priority areas and also in other agricultural areas, especially the suburbs of the Capital, Phnom Penh, will become familiar with modern irrigation farming practices and value-added livestock raising, and the incentive for adopting improved irrigation farming practices will be greatly enhanced. Enthusiasm generated from this success may even shorten the development period of other projects.

In addition to the farmers living in the suburbs, lots of other Cambodian farmers and government officials engaged in agricultural or rural development will have opportunities to visit, since the study area is close to the Capital of the country.

8.2 Impacts on Improvement of Rural Infrastructures

(1) Improvement of Rural Water Supply

Drinking and domestic water in the priority areas mainly depends upon ground water sources from dug wells or tubewells, however, some of the wells dry up in the dry season compelling people to bring water from remote wells or nearby rivers and ponds. By providing additional tubewells, the present conditions will be much improved.

(2) Improvement of Rural Transportation

Some reaches of existing national, provincial and regional roads are narrow and not well-maintained and are muddy during the rainy season. By upgrading these reaches, rural transportation will be much improved. The improved road system will not only enhance economic activities such as agricultural products, inputs, livestock and other commodities through the improvement of market access but will also contribute to inter-regional accessibility and communication.

(3) Provision of Community Facility

Community facilities are not available in the study area at present. With the provision of a proposed community hall with staff quarters, demonstration cooking facilities, toilet facilities, day care facilities, and multi-purposes facilities, the hall will enhance agricultural activities such as farmers' training, establishment of farmers' organization, and agricultural extensions, and will also provide social activities for life improvement, primary health care, rural communication, women's activities, day care, social education to rural adult people, and entertainments the study area. The proposed hall will provide various opportunities to rural people for their development.

(4) Improvement of Other Rural Infrastructures

Four (4) existing Khum clinics out of a total of 14 clinics are not in acceptable condition at present. By improving the clinics, rural health services will be much improved in the proposed four Khum, especially in Khum Preah Puth whose clinic was destroyed by bombing.

The number of classrooms is in sufficient for the enrolled pupils at present. With the provision of additional classrooms, the pupils' education circumstances will be much improved and more pupils will be able to receive primary education in the rural area.

8.3 Socio-economic Impacts

(1) Increase of Farmer's Income

Farmers have to live upon limited as well as unstable agricultural outputs which are dependant on endowed rainfall at present, however, with implementation of the plan the farmer's income will be improved considerably due to the increase in crop and livestock production. The increase of the net farm income will function to provide motive power in the improvement of the living standards of the farmers as well as rural economic development. In addition, farmers' increased purchasing power will activate the stagnated rural markets.

(2) Rural Life Improvement

With the implementation of the proposed plan, the rural people will receive knowledge and know-how to improve their life from education received from the community halls, and schools. The proposed major life improvements cover:

a. Food and Nutrition,
b. Heal Management and Primary Health Care,
c. Cooking and House Work,
d. Livestock Raising Methods,
e. Farm Household Management,
f. Community Life and Organization,
g. Communal Activities, and
h. Public Services,

It is recommended to monitor and evaluate the above effects for further life improvement in future.

(3) Expansion of Women's Activity

The plan would improve/expand women's activities in the study area through the establishment of community halls, an improved water supply, roads, clinics, and schools. An increase in the farmers' income will also improve women's activities in the farm families of the study area and also other families throughout the economic chain as housewives in many cases are said to manage family budgets.

(4) Expansion of Business Chance

With an increase in the farmers' income, the farmer's purchasing power would rise in the rural markets. Markets for farm inputs and equipment/tools will be particularly more active, and subsequently would make other markets more active , which will expand business opportunities indirectly to local non-farmers.

(5) Increase in Employment Opportunities

Employment opportunities for unskilled laborers will be generated during the construction period. Most of the manpower will be supplied from the farmers in and around the study area. Furthermore, employees will be able to gain more experience and skills in the various working fields. The accumulation of experience and skills will be very useful for O&M work and will provide the motivation for future development in the Takeo and Bati Provinces and for Cambodia.

8.4 Environmental Impacts

(1) Sustainability

The need is increasing to adjust the land use system and to improve efficiency of land use, so that natural resources may be managed for the benefit of successive generations. From this point of view, the proposed integrated agricultural and rural development will achieve suitable, economical and sustainable land use which may be expected to in definitely produce sustainable benefits.

(2) Improvement of Living Environment

The living environment problems in the study area are insufficient employment opportunities, poor road condition, poor rural water supply system, and insufficient social facilities both in quality and in quantity, and these issues cause inconvenience and disadvantages to the rural people in the study area. The implementation of the proposed plans

will contribute to mitigate the living environmental issues by the improvement of social infrastructures and several extension services for the improvement in rural living standards.

8.5 Preliminary Economic Evaluation

Preliminary economic evaluation of the proposed development plan has been made in order to confirm viability of the plans.

8.5.1 Evaluation of Economic Factors

(1) Standard Conversion Factor (SCF)

Traffic and trade restrictions create distortion in the price relationship between trade goods and non-trade goods. A Standard Conversion Factor (SCF) of 0.70 is applied to the price of non-trade goods and services in evaluating the project costs and benefits.

(2) Transfer Payment

Transfer payments including tax, duty, subsidy, and interest are considered as domestic movements without having any direct productivity, in regard to the international economy. These transfer payments are excluded from the project cost as far as the economic analysis is concerned.

(3) Construction Conversion Factor (CCF)

The individual financial construction costs for the major project facilities are categorised into four items; transfer payment, unskilled labour, traded foreign costs, and others, and an economic / financial conversion factor is applied for each. The construction conversion factor (CCF), which is the weighted average of the above components, is adopted in estimating the economic cost.

8.5.2 Economic Cost

The economic cost for this evaluation consists of the costs for civil works, tertiary development, O&M equipment, engineering services, administration, O&M, and replacement costs.

The financial construction cost is converted by adopting CCF to the economic construction cost. The cost for social and rural infrastructures has not been counted, since the social and rural benefits of the infrastructures have not been included as a direct project benefit. The costs for the improvement of the Tuk Thla & Kompong Tuol Regulators and the main canal of the Kandal Stung and Tonle Bati areas have been divided on the basis of the proportion of irrigable area between "with-Prek Thnot Dam" and "without-Prek Thnot Dam" conditions. The life of the project works is assumed at 50 years.

The operation and maintenance cost (O&M cost) is converted by applying the CCF. O&M cost will be accrued according to the implementation schedule of the irrigation water supply.

The replacement term of the pumping systems for both areas is estimated at 20 years in the Kandal Stung area and 30 years in the Tonle Bati area, taking into account the frequency of use. The frequency of use was estimated at about 260 days/year/machine for the Kandal Stung area and 60 days/year/machine for the Tonle Bati area. The useful life of the gates was set up at 20 years.

The estimated economic costs are given below :

Economic Costs

(unit : US$)

Cost Component	Economic Cost
1. Construction cost	
(1) Kompong Tuol	6,309,000
(2) Irrigation and Drainage	11,018,000
(3) On-farm development	1,386,000
2. O&M equipments	950,000
3. Engineering Services & Administration	2,880,000
4. Contingency	2,254,000
Total Initial Investment	24,797,000
5. Annual O&M Cost	134,000
6. Replacement Cost	11,678,000

8.5.3 Economic Benefits

On the other hand, net incremental benefits are the direct benefits to be derived from an increase in crop and livestock production, which can be estimated as the difference between the benefits under "without-project" conditions and under "with-project" condition. The estimated economic benefits will increase gradually year by year and reach the final target five (5) years after the short of operation. The estimated economic benefits are US$ 3.9 million and the breakdown is given below :

Economic Benefits ($/ha)

(unit : US$/ha)

Benefit Component	With-project		Without-project	
	Kandal Stung	Tonle Bati	Kandal Stung	Tonle Bati
1. Rice (150 %)	773	798	145	148
2. Vegetables (15 %)	347	376	0	0
3. Maize & Soybeans (15 %)	50	54	0	0
4. Livestock	100	129	59	85
Total Benefit	1,270	1,358	204	233
Net Incremental Benefit	in Kandal Stung Area			1,066 $/ha
	in Tonle Bati Area			1,125 $/ha

Net Incremental Economic Benefits

Area	Unit ($/ha)	Area (ha)	Total (1,000 $)
1. Kandal Stung Area	1,066	1,950	2,078
2. Tonle Bati Area	1,125	1,600	1,800
Total	-	3,550	3,878

8.5.4 Economic Evaluation

On the basis of the economic project costs and benefits thus estimated, EIRR has been calculated for the economic evaluation which is about 12 %. It is understood that the proposed development plan will be viable from an economic point of view.

8.6 Financial Analysis

A financial analysis of the project was made by analyzing typical farm budgets and farmers capacity to pay.

8.6.1 Farm Budget Analysis

In order to evaluate the project in terms of farmer's economy, typical averaged size farm budgets in each priority development area were made under the "with" and "without" conditions.

(unit : US$/year)

	Without project		With project		Incremental benefit	
	Kandal Stung	Tonle Bati	Kandal Stung	Tonle Bati	Kandal Stung	Tonle Bati
Gross income	530	600	1,635	2,640	1,105	2,040
Production cost	50	80	158	233	108	153
Net income	480	520	1,477	2,407	997	1,887
Living expenses	480	520	1,364	1,364	884	844
Net reserve	0	0	113	1,043	113	1,043

As seen form the above table, the net income of a typical farmer is expected to increase by 3.1 to 4.6 times, from US$ 480 and US$ 520 under without project condition up to US$ 1,477 and US$ 2,407 under with project condition, for the Kandal Stung and the Tonle Bati area respectively. The economic situations are sure to improve.

8.6.2 Capacity to Pay

After the implementation of the project, the operation and maintenance cost of the irrigation and drainage facilities as well as on-farm facilities is shouldered by benefiting farmers. O&M cost for the main system will be recovered from the water charge while costs for the on-farm facilities will be in the form of labour. If the government shares half the annual O&M cost, estimated at US$ 181,000, the water charge to be paid by the farmers is estimated at US$ 27 per hectare. Consequently, the water charge of an average farmer is calculated at US$ 24 ha in the Kandal Stung area and US$ 38 ha in the Tonle Bati area based on the average holding size for each area.

On the other hand, the incremental net savings of an average farmer are estimated at US$ 113 and US$ 1,043 for the Kandal Stung and Tonle Bati areas, respectively. On the above assumption, farmers could pay the water charges.

8.7 Conclusion and Recommendation

The Master Plan has identified the priority projects in the Kandal Stung area of 1,950 ha and the Tonle Bati area of 1,600 ha where infrastructure improvement as well as agricultural development and rural life improvement plans will be implemented as a core for future large scale development.

It is concluded that the priority projects are justified, because the projects will significantly contribute to the economic development of the Study Area as well as to rural life improvement, in addition to the numerous direct and indirect benefits already described.

After the accumulation of the technical and administrative kow-how for the further development and realization of the Prek Thnot dam, it is recommended to carry out a detailed investigation and study for the second stage development plan herein formulated.

In order to smoothly implement the project the following are recommended to be undertaken by the Government:

(1) Early implementation of the improvement of the Kompong Tuol irrigation intake,

(2) Actual participation of beneficiaries in the project implementation and O&M,

(3) Organization of water user's associations and government guidance for it,

(4) Establishment of a water management system for the Prek Thnot River inclusive of a radio communication system and institutional set up,

(5) Set up of a demonstration farm for the purpose of demonstrating irrigated agriculture and to provide a base for the further extension of the Project area,

(6) Promotion of training for the government staff and leading farmers involved in the Project implementation and O&M.

Tables

Table 1 List of Existing Irrigation Canals of the Kandal Stung Irrigation Project Area

No.	Canal	Abbre-viation	Length	Canal property at head								Construction	Improvement/ New
				Q	v	i	B	H	b1	b2	h		
			(m)	(m3/sec)	(m/sec)		(m)	(m)	(m)	(m)	(m)		
1. Main canal		M	5,300	NA	NA	NA	NA	NA	NA	NA	NA		Imp
		Sub-total	5,300										
2. Lateral													
2.1	Lateral 1	L1	4,000	NA	NA	NA	NA	NA	NA	NA	NA		New
2.2	Lateral 2	L2	500	NA	NA	NA	NA	NA	NA	NA	NA		Imp
2.3	Lateral 3	L3	850	NA	NA	NA	NA	NA	NA	NA	1.20		Imp
2.4	Lateral 4	L4	1,520	1.316	0.56	0.0005	1.50	2.00	1.00	1.00	1.23	MCC	New
	Lateral 4	L4	3,240	1.316	0.56	0.0005	1.50	1.75	1.00	1.00	1.07	MCC	Imp
2.5	Lateral 5	L5	855	1.084	0.44	0.0002	1.50	1.57	1.00	1.00	1.02	MCC	New
	Lateral 5	L5	2,260	1.084	0.39	0.0002	1.50	1.57	1.00	1.00	-	MCC	Imp
		Sub-total	13,225										
3. Tertiary canal											0.35		
3.1	Tertiary 1.0	T1.0	900	0.079	0.22	0.0003	0.50	0.60	0.50	0.50	0.65	MCC	New
3.2	Tertiary 1.1.0	T1.0	1,000	0.294	0.31	0.0003	0.50	1.00	0.50	0.50	0.58	1990MCC	New
3.3	Tertiary 1.2.1	T1.1.0	1,000	0.294	0.29	0.0003	0.50	0.93	0.50	0.50	0.54	1990MCC	New
3.4	Tertiary 1.2.2	T1.2.2	1,000	0.196	0.28	0.0003	0.50	0.84	0.50	0.50	-	1990MCC	New
3.5	Tertiary 1.3.1	T1.3.1				not constructed yet							
3.6	Tertiary 1.4	T1.4	1,000	0.089	0.23	0.0003	0.50	0.68	0.50	0.50	0.57	MCC	New
3.7	Tertiary 1.5	T1.5	1,200	0.220	0.28	0.0003	0.50	0.87	0.50	0.50	0.54	1990MCC	New
3.8	Tertiary 2.1.0	T2.1.0	994	0.193	0.28	0.0003	0.50	0.84	0.50	0.50	0.51	1990MCC	Imp
3.9	Tertiary 2.2.0	T2.2.0	1,264	0.164	0.26	0.0004	0.50	0.81	0.50	0.50	0.53	1990MCC	Imp
3.10	Tertiary 2.3.0	T2.3.0	1,416	0.185	0.27	0.0002	0.50	0.83	0.50	0.50	0.53	1990MCC	New
3.11	Tertiary 2.4.0	T2.4.0	1,480	0.188	0.27	0.0003	0.50	0.83	0.50	0.50	-	1990MCC	Imp
3.12	Tertiary 3.1.0	T3.1.0				not constructed yet							
3.13	Tertiary 3.2.0	T3.2.0	850	0.156	0.26	0.0002	0.50	0.79	0.50	0.50	0.63	1989MCC	Imp
3.14	Tertiary 3.3.0	T3.3.0	1,900	0.269	0.30	0.0002	0.50	0.98	0.50	0.50	0.61	1989MCC	Imp
3.15	Tertiary 3.4.0	T3.4.0	1,900	0.260	0.30	0.0003	0.50	0.96	0.50	0.50	0.70	1989MCC	New
3.16	Tertiary 3.5.0	T3.5.0	1,900	0.339	0.32	0.0002	0.50	1.05	0.50	0.50	0.36	1989MCC	Imp
3.17	Tertiary 4.1.1	T4.1.1	600	0.081	0.22	0.0003	0.50	0.61	0.50	0.50	-	1990MCC	Imp
3.18	Tertiary 4.1.2	T4.1.2				not constructed yet							
3.19	Tertiary 4.2.1	T4.2.1	600	0.069	0.21	0.0003	0.50	0.58	0.50	0.50	0.38	1990MCC	New
3.20	Tertiary 4.2.2	T4.2.2	800	0.089	0.23	0.0003	0.50	0.68	0.50	0.50	0.29	1990MCC	New
3.21	Tertiary 4.3.1	T4.3.1	600	0.051	0.20	0.0003	0.50	0.54	0.50	0.50	0.38	1990MCC	Imp
3.22	Tertiary 4.3.2	T4.3.2	900	0.089	0.23	0.0002	0.50	0.68	0.50	0.50	0.32	1990MCC	Imp
3.23	Tertiary 4.4	T4.4	600	0.690	0.23	0.0003	0.50	0.57	0.50	0.50	0.35	1990MCC	Imp
3.24	Tertiary 4.5.1	T4.5.1	600	0.075	0.22	0.0003	0.50	0.60	0.50	0.50	0.40	1990MCC	New
3.25	Tertiary 4.5.2	T4.5.2	942	0.098	0.23	0.0002	0.50	0.70	0.50	0.50	0.35	1990MCC	New
3.26	Tertiary 4.6.1	T4.6.1	600	0.075	0.22	0.0003	0.50	0.60	0.50	0.50	0.44	1990MCC	Imp
3.27	Tertiary 4.6.2	T4.6.2	1,000	0.125	0.24	0.0002	0.50	0.74	0.50	0.50	0.53	1990MCC	Imp
3.28	Tertiary 5.1.1	T5.1.1	1,350	0.187	0.27	0.0003	0.50	0.83	0.50	0.50	0.30	1990MCC	Imp
3.29	Tertiary 5.1.2	T4.1.2	585	0.063	0.24	0.0003	0.50	0.55	0.50	0.50	0.42	1990MCC	Imp
3.30	Tertiary 5.2.1	T5.2.1	900	0.111	0.24	0.0002	0.50	0.72	0.50	0.50	0.33	1990MCC	New
3.31	Tertiary 5.2.2	T5.2.2	900	0.066	0.21	0.0002	0.50	0.58	0.50	0.50	0.43	1990MCC	New
3.32	Tertiary 5.3.1	T5.3.1	1,000	0.117	0.24	0.0002	0.50	0.73	0.50	0.50	0.37	1990MCC	Imp
3.33	Tertiary 5.3.2	T5.3.2	1,000	0.084	0.23	0.0003	0.50	0.62	0.50	0.50	0.42	1990MCC	Imp
3.34	Tertiary 5.4.1	T5.4.1	1,000	0.110	0.24	0.0003	0.50	0.72	0.50	0.50	0.34	1990MCC	Imp
3.35	Tertiary 5.4.2	T5.4.2	900	0.072	0.21	0.0002	0.50	0.59	0.50	0.50	0.31	1990MCC	Imp
3.36	Tertiary 5.5.1	T5.5.1	950	0.058	0.20	0.0002	0.50	0.56	0.50	0.50	0.42	1990MCC	New
3.37	Tertiary 5.5.2	T5.2.2	900	0.115	0.24	0.0003	0.50	0.72	0.50	0.50	-	1990MCC	New
3.38	Tertiary 5.6	T5.6				not constructed yet							
3.39	Tertiary 6.0	T6.0	3,502	0.468	0.32	0.0002	0.50	1.14	0.50	0.50		1989MCC	New
		Sub-total	38,033										

Note:

NA : No data

Canal	Improvement	New	Total	Number
	(m)	(m)	(m)	(m)
Main canal	5,300	0	5,300	1
Lateral	6,850	6,375	13,225	5
Tertiary canal	19,939	18,094	38,033	35
Total	32,089	24,469	56,558	-

Table 2 Present Conditions of Canal Related Structures of the Kandal Stung Irrigation Project Area

No.	Structure	Abbreviation	Constructed (year)	Constructed (by)	Present condition	
	Main canal					
1.	Control	COM-M1	1989	MCC	leakage from gate	
2.	Divisor	DIV-M2	1987	-	no gate	riprup : damaged
3.	Check	CI-M3.1	1989	-	no gate	wing wall : damaged
4.	Check	CI-M3.2	Pre .existing	1978	no gate	riprup : damaged
5.	Check	CI-M3.3	1989		no gate	riprup : damaged
6.	Divisor	DIV-M3.4	1987	-	no gate	riprup : damaged
	Lateral L1					
7.	Intake	I-L1.0	1989	MCC	no gate	
8.	Crossing	X-1.0	1989	-		riprup : damaged
9.	Check	CI-L1.1	1989	-	no gate	
10.	Check	CI-L1.3	1990	-	no gate	riprup : damaged
11.	Check	CI-L1.4	Pre . existing	1978	no gate	
12.	Check	CI-L1.5	1990	1992	no gate	
	Lateral L4					
13.	Check	C-L4.2	1988	MCC	no gate	riprup : damaged
14.	Check	CDI-L4.2	1988	-	no gate	
15.	Check	CDI-L4.3	1988	-	no gate	
16.	Check	CI-L4.4	1990		no gate	riprup : damaged
17.	Check	CDI-L4.6	1990		no gate	riprup : damaged
18.	Check	CT-L4.7.1	1990	-	no gate	
19.	Check	CT-L4.7.2	1990	-	no gate	
	Lateral L4					
20.	Check	CD-L5.1	1988	MCC	no gate	
21.	Check	CDI-L5.1	1988	-	no gate	
22.	Drop	D-L5.2	1988	-	no gate	
23.	Check	CDI-L5.2	1988	-	no gate	
24.	Check	CI-L5.3	1988	-	no gate	
25.	Check	CI-L5.4	1988	-	no gate	riprup : damaged
26.	Check	CI-L5.5	1988	-	no gate	riprup : damaged
27.	Check	CI-L5.6	Pre. existing		no gate	
	Drain					
28.	Check	CI-D3	Pre . existing		no gate	

No.	Structure	Abbreviation	Constructed (year)	Constructed (by)	Present condition	
	Block 1					
1.	Turnout	T1.0	1990	MCC	filled by farmers	
2.	Turnout	T1.1		-	no gate	
3.	Turnout	T1.2.1	1990	-	no gate	
4.	Turnout	T1.2.2	1990	-	no gate	
5.	Turnout	T1.3	not constructed yet			
6.	Turnout	T1.5	not constructed yet			
	Block 2					
7.	Turnout	T2.1.0	Pre.existing	1977	no gate	
8.	Turnout	T2.2.0	1990	-	no gate	
9.	Turnout	T2.3.0	1990	-	no gate	
10.	Turnout	T2.4.0	1990	-	no gate	
	Block 3					
11.	Turnout	T3.1.0			no gate	
12.	Turnout	T3.2.0	1990	MCC	no gate	
13.	Turnout	T3.3.0	1990	-	no gate	
14.	Turnout	T3.4.0	1990	-	no gate	
15.	Turnout	T3.5.0	1990	-	no gate	
	Block 4					
16.	Turnout	T4.1.1	n.a.	MCC	no gate	
17.	Turnout	T4.1.2	n.a.	-	no gate	
18.	Turnout	T4.2.1	1988	-	no gate	inlet crest : damaged
19.	Turnout	T4.2.2	1988	-	no gate	inlet crest : damaged
20.	Turnout	T4.3.1	1988	-	no gate	
21.	Turnout	T4.3.2	1988	-	no gate	inlet crest : damaged
22.	Turnout	T4.4	1990	-	no gate	inlet crest : damaged
23.	Turnout	T4.5.1	1990	-	no gate	inlet crest : damaged
24.	Turnout	T4.5.2	1990	-	no gate	inlet crest : damaged
25.	Turnout	T4.6.1	1990	-	no gate	
26.	Turnout	T4.6.2	1990	-	no gate	
	Block 5					
27.	Turnout	T5.1.1	1988	MCC	no gate	inlet crest : damaged
28.	Turnout	T5.1.2	1988	-	no gate	wing wall : damaged
29.	Turnout	T5.2.1	1988	-	no gate	
30.	Turnout	T5.2.2	1988	-	no gate	
31.	Turnout	T5.3.1	1988	-	no gate	
32.	Turnout	T5.3.2	1988	-	no gate	
33.	Turnout	T5.4.1	1988	-	no gate	
34.	Turnout	T5.4.2	1988	-	no gate	
35.	Turnout	T5.5.1	1988	-	no gate	
36.	Turnout	T.5.5.2	1988	-	no gate	riprup : damaged
37.	Turnout	T5.6		-	no gate	inlet crest : damaged
	Block 6					
38.	Turnout	T6.0	1989	MCC	no gate	

Table 3 List of Existing Irrigation Canals of the Tonle Bati Irrigation Project Area

No.	Canal	Abbre-viation	Length	Canal property at head								Construction	Improvement/ New
				Q	v	i	B	H	b1	b2	h		
			(m)	(m3/sec)	(m/sec)		(m)	(m)	(m)	(m)	(m)		
1.	Haknuman canal		2,800	NA	NA	NA	NA	NA	NA	NA	NA		Imp
		Sub-total	2,800										
2.	Main canal	M1	3,500	9.780	NA	0.00020	3.50	4.00	3.80	3.80	3.50	1990 DOH	New
	Main canal	M2	550	NA	NA	NA	NA	NA	NA	NA	NA	1987 WCC	New
	Main canal	M3	2,850	NA	NA	NA	2.00	2.44	3.50	2.00	NA	1987 WCC	Imp
		Sub-total	6,900										
3.	Lateral	L											
3.1	Lateral 1	L1	1,000	2.500	0.41	0.00010	2.00	1.75	3.50	1.50	1.45	1987 WCC	New
3.2	Lateral 2	L2	1,650	0.350	0.24	0.00010	1.00	1.38	2.50	0.40	0.98	1987 WCC	New
3.3	Lateral 3	L3	960	1.600	0.30	0.00010	1.50	1.85	2.00	3.00	1.45	1988 WCC	New
		L3	590	0.36	NA	0.00010	1.00	1.29	2.00	2.00	0.99	1988 WCC	Imp
3.4	Lateral 4	L4	775	0.720	0.21	0.00010	1.25	1.45	3.00	1.00	1.14	1988 WCC	New
3.5	Lateral 5	L5	1,030	NA	NA	0.00030	5.80	1.84	2.40	2.40	1.42	1989 DOH	Imp
3.6	Lateral 5.5	L55	1,250	0.166	NA	0.00020	0.60	1.65	2.40	1.20	1.15	1990 DOH	New
3.7	Lateral 7	L7	1,850	0.521	NA	0.00030	2.00	1.41	3.80	2.40	0.79	1990 DOH	Imp
		Sub-total	9,105										
4	Tertiary canal												
4.1	Tertiary 3.1	T3.1.0	1,450	0.225	0.14	0.00010	0.85	1.20	0.40	0.40	0.90	1988 WCC	New
4.2	Tertiary 3.2	T3.2.0	650	0.090	0.10	0.00010	0.85	0.90	0.40	0.40	0.60	1988 WCC	New
4.3	Tertiary 3.3	T3.3.0	800	0.180	0.13	0.00010	0.85	1.10	0.40	0.40	0.80	1988 WCC	New
3.9	Tertiary 3.4	T3.4.0	1,300	0.225	0.14	0.00010	0.85	1.20	0.40	0.40	0.90	1988 WCC	New
4.50	Tertiary 3.5	T3.5.0	1,050	0.135	0.12	0.00010	0.85	1.00	0.40	0.40	0.70	1988 WCC	New
4.60	Tertiary 3.6	T3.6.0	1,000	0.180	0.13	0.00010	0.85	1.10	0.40	0.40	0.80	1988 WCC	New
4.70	Tertiary 3.7	T3.7.0	600	0.180	0.13	0.00010	0.85	1.10	0.40	0.40	0.80	1988 WCC	New
4.80	Tertiary 3.8	T3.8.0	975	0.135	0.10	0.00010	0.85	1.10	0.40	0.40	0.79	1988 WCC	New
4.90	Tertiary 3.9	T3.9.0	1,000	0.090	0.11	0.00010	0.70	0.90	0.40	0.40	0.80	1988 WCC	New
4.10	Tertiary 3.10	T3.10.0	975	0.135	0.12	0.00010	0.85	1.00	0.40	0.40	0.60	1988 WCC	New
4.11	Tertiary 4.C	T4.0	1,450	0.315	NA	NA	1.00	1.51	0.40	0.40	1.19	1988 WCC	Imp
4.12	Tertiary 4.1	T4.1.0	1,250	0.225	0.13	0.00010	0.85	1.20	0.40	0.40	0.87	1988 WCC	New
4.13	Tertiary 4.2	T4.2.0	1250	0.180	0.12	0.00010	0.40	1.15	0.40	0.40	0.84	1988 WCC	New
4.14	Tertiary 5.1	T5.1.0	800	NA	NA	0.00020	0.40	1.31	2.40	3.00	0.79	1989 DOH	New
4.15	Tertiary 5.2	T5.2.0	1,050	NA	NA	0.00020	0.40	1.48	1.20	2.40	1.01	1989 DOH	New
4.16	Tertiary 5.3	T5.3.0	800	NA	NA	0.00020	0.40	1.26	2.40	1.20	0.76	1989 DOH	New
4.17	Tertiary 5.4	T5.4.0	1,050	NA	NA	0.00020	0.40	1.41	2.40	2.40	0.65	1989 DOH	New
4.18	Tertiary 55.1	T55.1.0	300	0.038	NA	0.00020	0.40	1.33	2.40	1.20	0.83	1990 DOH	New
4.19	Tertiary 55.2	T55.2.0	600	0.037	NA	0.00020	0.40	1.27	2.40	1.20	0.75	1990 DOH	New
4.20	Tertiary 55.3	T55.3.0	750	0.042	NA	0.00020	0.40	1.40	2.40	1.20	0.90	1990 DOH	New
4.21	Tertiary 55.4	T55.4.0	900	0.049	NA	0.00020	NA	1.36	2.40	1.20	0.87	1990 DOH	New
4.22	Tertiary 7.1	T7.1.0				not constructed yet							
4.23	Tertiary 7.2	T7.2.0				not constructed yet							
4.24	Tertiary 7.3	T7.3.0				not constructed yet							
4.25	Tertiary 7.4	T7.4.0				not constructed yet							
4.26	Tertiary 7.5	T7.5.0				not constructed yet							
4.27	Tertiary 7.6	T7.6.0				not constructed yet							
		Sub-total	20,000										

Note:

NA : No data

Canal	Improvement	New	Total	Number
	(m)	(m)	(m)	(m)
Haknuman canal	2,800	0	2,800	1
Main canal	2,850	4,050	6,900	3
Lateral	3,470	5,635	9,105	7
Tertiary canal	1,450	18,550	20,000	21
Total	10,570	28,235	38,805	

Table 4 Present Conditions of Canal Related Structures of the Tonle Bati Irrigation Project Area

No.	Structure	Abbreviation	Constructed (year)	Present condition (by)		
	Main canal					
1.	concrete bridge	C.B.M1	1991	DOH		
2.	concrete bridge	C.B.M2	1991	DOH		
	Lateral L1					
3.	check	CI-L1	1987	WCC	no gate	riprup : damaged
	Lateral L2					
4.	crossing	X-2-0	1987	WCC		riprup : damaged
	Lateral L3					
5.	intake	I-L3	1988	WCC	no gate	riprup : damaged
6.	check	CI-L3-1	1988	WCC	no gate	riprup : damaged
7.	check	CI-L3-2	1988	WCC	no gate	riprup : damaged
8.	check	CI-L3-3	1988	WCC	no gate	riprup : damaged
9.	check	CI-L3-4	1988	WCC	no gate	riprup : damaged
10.	check	CI-L3-5	1988	WCC	no gate	riprup : damaged
11.	wooden bridge	W-B-L3	1988	WCC	no gate	riprup : damaged
	Lateral L4					
12.	intake	I-L4	1988	WCC		
13.	check	CI-L4	1988	WCC		
14.	Wooden bridge	W-B-L4	1988	WCC		
	Lateral L5					
15.	intake	I-L5	1989	DOH	no gate	riprup : damaged
16.	check	CI-L5	1989	DOH	no gate	riprup : damaged
	Lateral L55					
17.	intake	I-L55		DOH	no gate	riprup : damaged
	Lateral L6					
18.	intake	I-L6				
	Lateral L7					
19.	check	CI-L7		DOH		

No.	Structure	Abbreviation	Constructed (year)	Present condition (by)		
	Block 1					
	no related structure					
	Block 2					
	no related structure					
	Block 3					
1.	Turnout	T3.2.0	1988	WCC	no gate	riprup : damaged
2.	Turnout	T3.3.0	1988	WCC	no gate	riprup : damaged
3.	Turnout	T3.4.0	1988	WCC	no gate	
4.	Turnout	T3.5.0	1988	WCC	no gate	riprup : damaged
5.	Turnout	T3.6.0	1988	WCC	no gate	riprup : damaged
6.	Turnout	T3.7.0	1988	WCC	no gate	
7.	Turnout	T3.8.0	1988	WCC	no gate	
8.	Turnout	T3.9.0	1988	WCC	no gate	
9.	Turnout	T3.10.0	1988	WCC	no gate	
	Block 4					
10.	Turnout	T4.0	1988	WCC		
11.	Turnout	T4.1.0	1988	WCC		
12.	Turnout	T4.2.0	1988	WCC		
	Block 5					
13.	Turnout	T5.1.0	1989	DOH	no gate	
14.	Turnout	T5.2.0	1989	DOH	no gate	
15.	Turnout	T5.3.0		DOH	no gate	
	Block 55					
16.	Turnout	T55.1.0	1990	DOH	no gate	
17.	Turnout	T55.2.0			no gate	
	Block 7					
18.	Turnout	T7.2.0		DOH	no gate	
19.	Turnout	T7.3.0		DOH	no gate	
20.	Turnout	T7.4.0		DOH	no gate	
21.	Turnout	T7.5.0		DOH	no gate	
22.	Turnout	T7.6.0		DOH	no gate	

Table 5 Proposed Farming Practices for Each Crop

Inputs	Unit	Maize & soybeans*	Rice	Groundnut	Sweet potato	Greengrams	Sesame	Chilli(dry)	Vegetables
(Yield projected)**	ton/ha	Maize 3, Soybeans 1.5	4.0	2.0	15	1.0	0.5	2	10 (Chinese cabbage)
1. Seed	kg	15(maize) 20(beans)	50	90	30,000 (seed cuttings)	20	10	0.3	0.3
2. Fertilizers									
Urea	kg	100	70	50	100			250	250
Compound(15:15:15)	kg	400	200	300	200		200	300	300
3. Agro-chemicals***									
Seed dress	gram	90	90	90					
Insecticide	litre	2	2	4	2	2		2	2
Fungicide	litre	2	2	3	2	2		2	2
4. Labour input	man/day	150	130	110	90	90	90	110	110
5. Animal power	oxen/day	20	28	20	25	3	3	20	20
6. Machinery									
Sprayer	hr	2	2	2	2	2		2	2
Thresher/sheller	hr								
7. Miscellaneous (About 15 % of item 1 to 6)									

* Maize and soybeans are grown as a mixed crop.

** Yield for rice is in paddy, maize and groundnut are shelled grain.

*** These pesticides are planned to be applied only to avoid disastrous damages by pests, but not for general usage.
Recommended insecticides and fungicides are Fenithrothion, Buprofezin, Dithiocarbamate (Polycarbamate), Benomyl, etc.

Table 6 Proposed Staffing and Facilities of the Agricultural Development Centres

Items	Kandal Stung No. 1	Kandal Stung No. 2	Tonle Bati	Total
Staffing				
Administration				
General manager	1	1	1	3
Section chief	1	1	1	3
Clerk	1	1	1	3
Accountant	1	1	1	3
Typist	1	1	1	3
Vehicle driver	5	5	5	15
Office boy	3	3	3	9
Agricultural extension				
Section chief*	1	1	1	3
Subject matter specialist	3	3	3	9
Field extension worker	7	10	10	27
Life improvement extension				
Section chief**	1	1	1	3
Life improvement worker	3	5	6	14
Supply and marketing				
Section chief	1	1	1	3
Storehouse manager	1	2	3	6
Clerk	2	4	6	12
Store keeper	2	4	6	12
Operation and maintenance				
Assistant civil engineer	1	1	1	3
Maintenance work supervisor	2	2	2	6
Farm machinery mechanic	1	1	1	3
Farm machinery operator	2	2	2	6
Ditch tender	0	2	2	4
Buildings				
Main office	550 m^2	550 m^2	(550) m^2	1,100 m^2
Staff quarters	2,220 m^2	2,640 m^2	3,060 m^2	7,920 m^2
Store house	1,000 m^2	1,500 m^2	2,000 m^2	4,500 m^2
Garage	75 m^2	75 m^2	75 m^2	225 m^2
Generator house & others	70 m^2	70 m^2	20 m^2	160 m^2
Community hall				
Office	1,000 m^2	1,500 m^2	1,630 m^2	4,130 m^2
Quarters	1,400 m^2	2,100 m^2	2,240 m^2	5,740 m^2
Trial/demonstration farm				
Centre	1 ha	1 ha	1 ha	3 ha
Community hall	0.1 ha	0.1 ha	0.1 ha	0.3 ha
Equipment				
4WD vehicle	4 units	4 units	4 units	12 units
Minibus (20 persons)	1 unit	1 unit	1 unit	3 units
Mobile extension unit	1 unit	1 unit	1 unit	3 units
Cold vaccine storage (solar energy type)	1 set	1 set	1 set	3 sets
Copy/printing machine	1 set	1 set	1 set	3 sets
Personal computer	2 sets	2 sets	2 sets	6 sets
Generator	1 set	1 set	1 set	3 sets
Portable generator	2 sets	2 sets	2 sets	6 sets
Mrtor cycle for worker	16 units	24 units	28 units	68 units
Farm machinery***	1 set	1 set	1 set	3 sets

Note: * The section chief is one of the specialists.
** The section chief is the life improvement specialist.
*** Including tractor, trailor,plow,harrow,sprayer, thresher,etc.

Table 7 Implementation of the Project Works

Overall Development Plan

1. Irrigation and Drainage

	(Unit : ha)
Kandal Stung area	4,200
Tonle Bati area	4,200

2. On-farm Development 8,400 ha

3. Agricultural Development Center
   - Kandal Stung No.1 Center
   - Kandal Stung No.2 Center
   - Tonle Bati Center

4. Rural Road Network

	(Unit : km)
Trunk Road	31.8
Feeder Road	62.3

5. Rural Water Supply Facilities

	(Unit : set)
Type I (manual pump)	263
Type II (pipeline system)	2

6. Other Rural Infrastructure

	(Unit : nos.)
Commune Clinic	8
Classroom	58
Community Hall	18

First Stage Development Plan

1. Irrigation and Drainage

	(Unit : ha)
Kandal Stung area	1,950
Tonle Bati area	1,600

2. On-farm Development 3,550 ha

3. Agricultural Development Center
   - Kandal Stung No.2 Center
   - Tonle Bati Center

4. Rural Road Network

	(Unit : km)
Trunk Road	15.9
Feeder Road	22.6

5. Rural Water Supply Facilities

	(Unit : set)
Type I (manual pump)	157
Type II (pipeline system)	1

6. Other Rural Infrastructure

	(Unit : nos.)
Commune Clinic	3
Classroom	39
Community Hall	7

Table 8 Summary of Project Cost

(Unit : 1,000 US$)

Construction Work Items	First Stage Works			Second Stage Works			Total			Remarks
	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	
I. CONSTRUCTION COST										
1 Irrigation and Drainage Systems										
1).Improvement of Tuk Thla and Kompong Tuol Regulators	12,277	4,483	16,760	0	0	0	12,277	4,483	16,760	
2).Irrigation and drainag system										
- Kandal Stung System	5,201	2,549	7,751	3,823	4,218	8,041	9,025	11,968	15,791	
- Tonle Bati System	10,281	3,692	13,972	2,030	2,803	4,833	12,311	6,494	18,805	Include' Demon Station Farm 265 ha
Sub-Total	27,759	10,724	38,483	5,853	7,020	12,873	33,612	17,744	51,356	Include' Demon Station Farm 259 ha
2 On-Farm Development										
- Kandal Stung Area	0	1,299	1,299	0	1,349	1,349	0	2,648	2,648	
- Tonle Bati Area	0	901	901	0	1,748	1,748	0	2,649	2,649	
Sub-Total	0	2,200	2,200	0	3,096	3,096	0	5,297	5,297	
3 Social / Rural Infrastructures										
1). Rural Development Center	1,450	1,139	2,589	1,515	1,190	2,705	2,965	2,329	5,294	
2). Rural Road Network	3,397	3,136	6,533	1,390	1,284	2,674	4,787	4,420	9,207	
3).Rural Water Supply Facilities	706	364	1,070	1,857	957	2,814	2,563	1,321	3,884	
4).Village Clinic	71	71	142	119	119	238	190	190	380	
5).School Building	460	460	920	225	225	450	685	685	1,370	
6).Community hall	631	631	1,262	983	983	1,966	1,614	1,614	3,228	
Sub-Total	6,715	5,801	12,516	6,089	4,758	10,847	12,804	10,559	23,363	
Total (Item - I)	34,474	18,725	53,199	11,942	14,875	26,817	46,416	33,600	80,016	
II. Procurement of O/M.Equipment	950	50	1,000	950	50	1,000	1,900	100	2,000	
III.Engineering / Administration (12%)	4,251	2,253	6,504	1,547	1,791	3,338	5,798	4,044	9,842	
IV.Land Acquisition	0	30	30	0	200	200	0	230	230	
Total (Item - II.III.IV)	5,201	2,333	7,534	2,497	2,041	4,538	7,698	4,374	12,072	
V. Physical Contingency (10%)	3,967	2,106	6,073	1,444	1,692	3,135	5,411	3,797	9,209	
Total (Item - I+II+II+IV+V)	43,642	23,164	66,806	15,883	18,607	34,490	59,525	41,771	101,296	

Figures

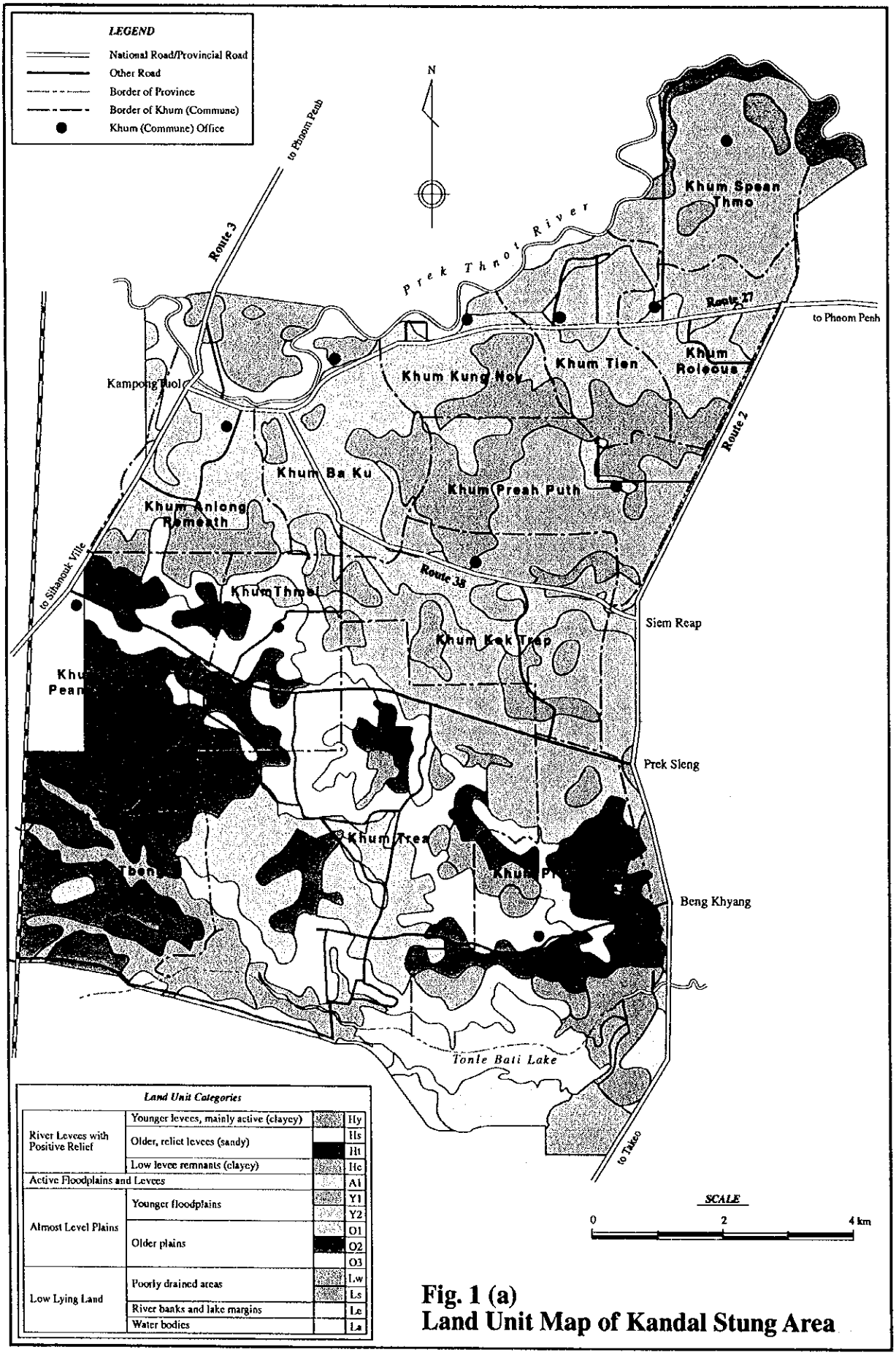

Fig. 1 (a)
Land Unit Map of Kandal Stung Area

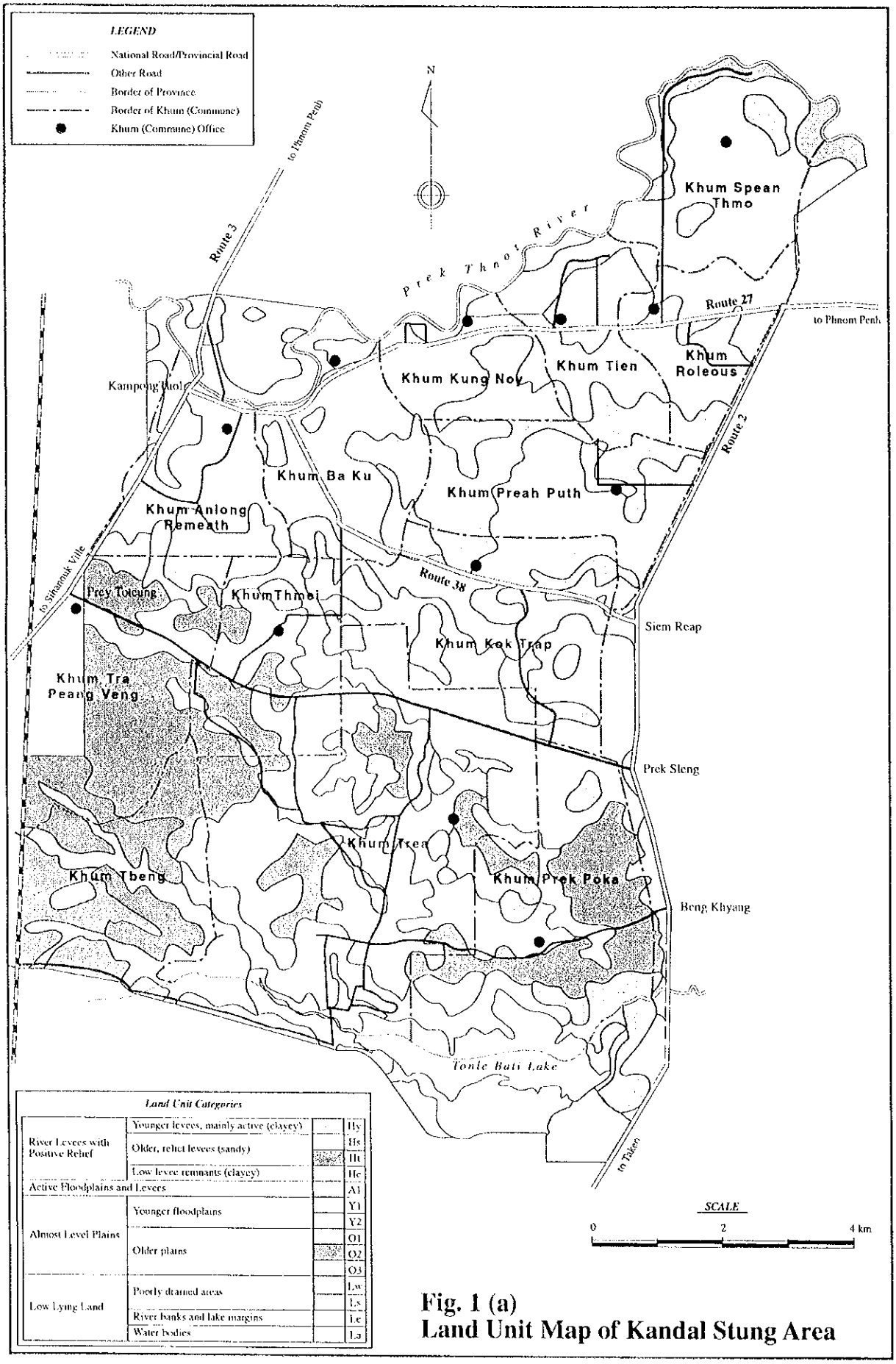

Fig. 1 (a)
Land Unit Map of Kandal Stung Area

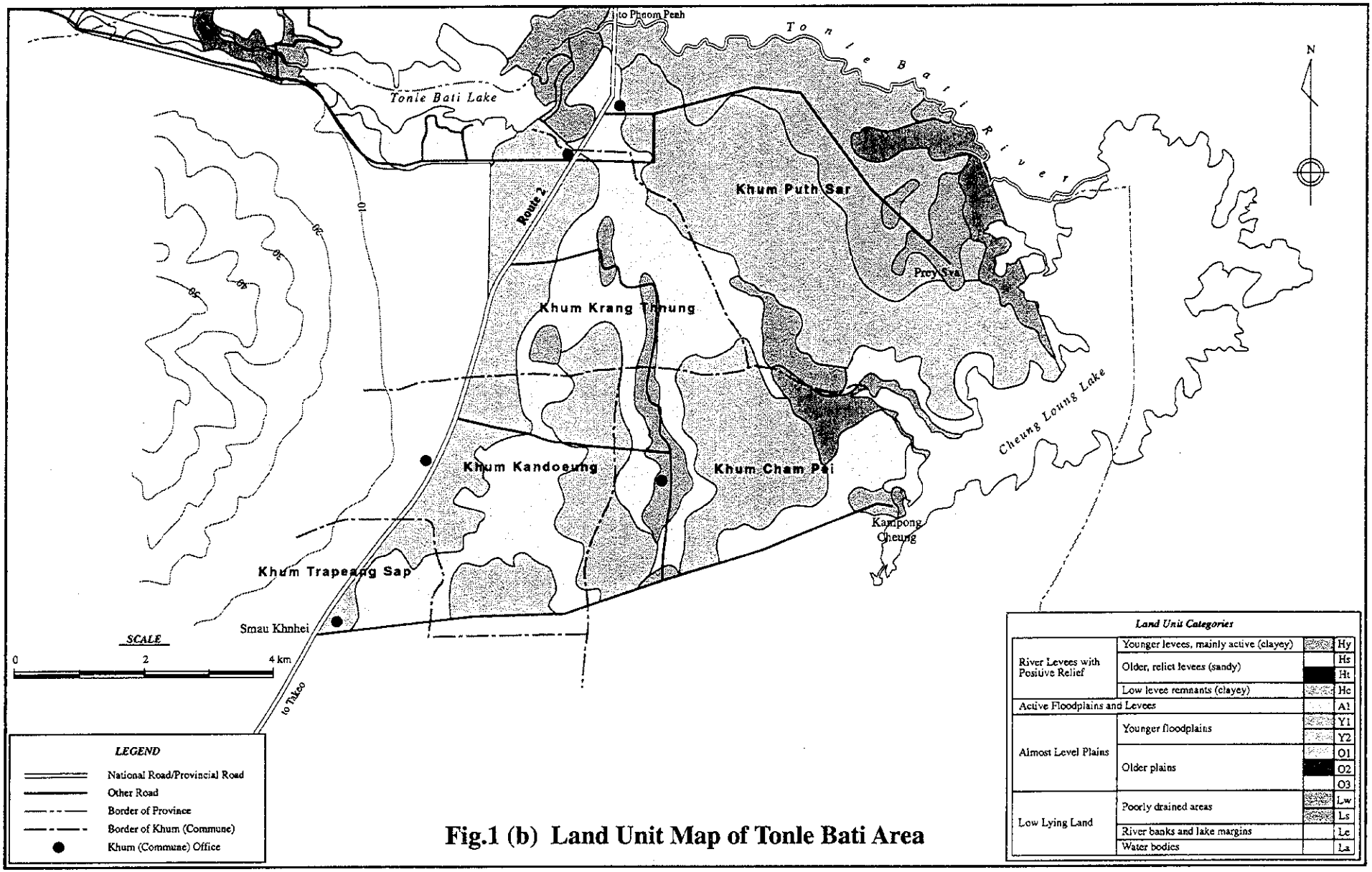

Fig.1 (b) Land Unit Map of Tonle Bati Area

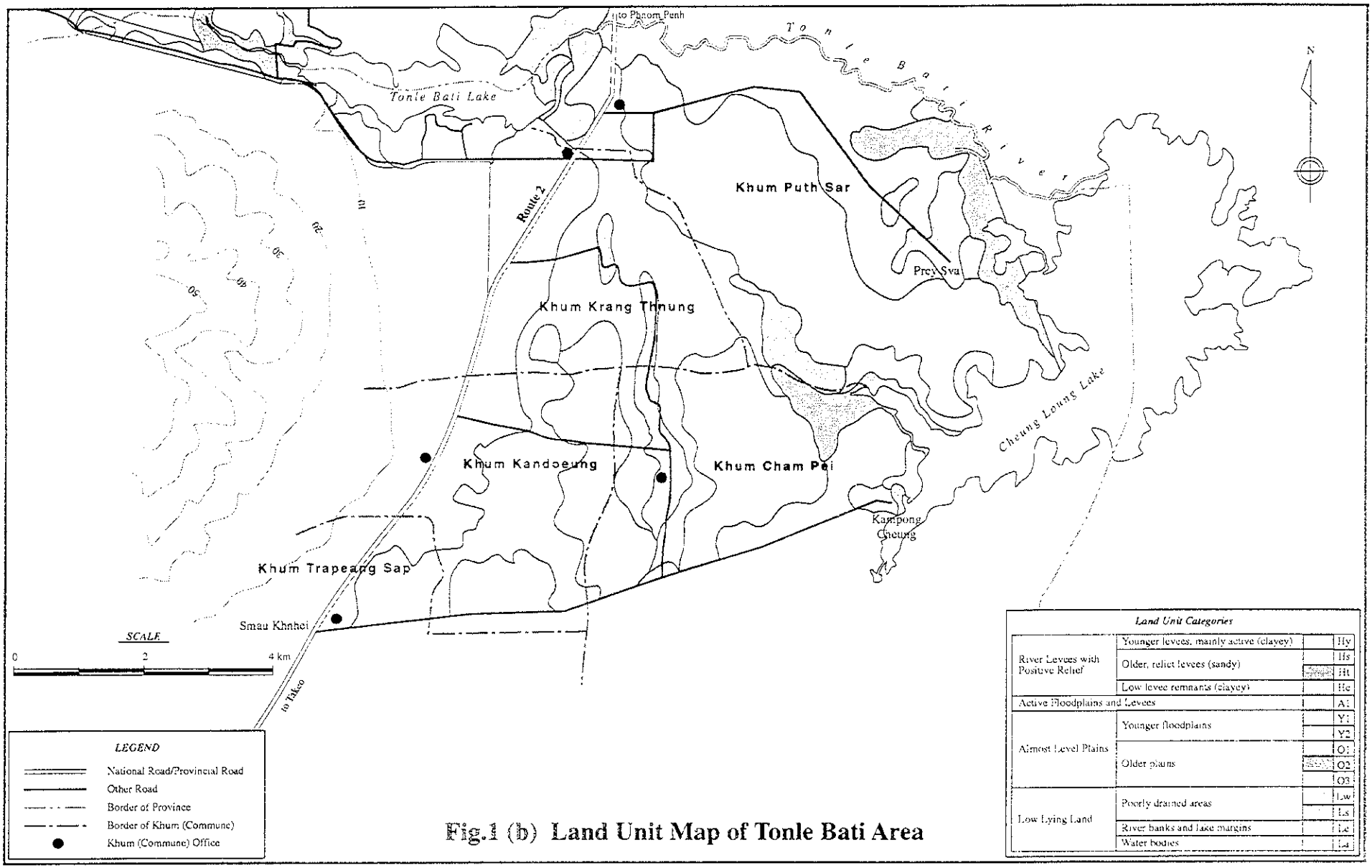

Fig.1 (b) Land Unit Map of Tonle Bati Area