and other productive activities and, to some extent, to domestic activities, hygiene and sanitation.

3.4 Present Agricultural Setting in Priority Development Area

3.4.1 Present Land Tenure System and Land Holding Size

The registration of land titles has commenced under MAFF and is planned to be completed within a 2-year development phase, from 1994 to 1995. The land title registration in the Development Priority Areas is also being undertaken.

The average area of rice field per farm household is 0.9 ha in the Kandal Stung and 1.4 ha in the Tonle Bati Priority Development Areas. According to the farm household survey, most of the farmers in the Priority Development Area own their land even though the land title registration is not yet complete. Tenant farmers who are renting farmland were not be observed in the survey. The holding area of rice fields by farmers in the Kandal Stung Priority Development Area is rather small, 65 % are less than 1.0 ha, while in the Tonle Bati area, 63 % are between 1.0 and 2.0 ha.

3.4.2 Crops and Cropping Pattern

(1) Land use and crops

The agriculture in the Priority Development Area is dominated by rice cultivation and most of the farm land is rainfed lowland rice fields. A typical pattern is single cropping in the wet season by rain-fed, however, double cropping in a year with irrigation is made in a very limited area. In addition to rice cultivation, farmers grow vegetables, sugar palm, bananas, mangoes and guava in a limited area during the dry season. According to the land use data of the district offices, the land used for rice cultivation is about 70 % and 80 % , while land used for upland crops is 1.8 % and 0.5 % in and around the Kandal Stung and Tonle Bati Development Areas, respectively.

The upland crops including green beans, leafy vegetables, cucumbers, sweet potatoes, maize, and cassava are grown in the home garden or on the slightly higher land which is unsuitable for rice cultivation.

(2) Cropping pattern

Farmers try to grow as much rice as they can, even in marginally suitable soil conditions. Rice production is affected by an unstable distribution of rainfall and the unit yield of rice is still at a very low level. Farmers do this in order to attain domestic self-sufficiency in food and also rice cultivation is still the most reliable job in the area. Despite efforts of the farmers, most fields do not have a stable irrigation water supply and are often affected by drought and floods.

The varieties of rice cultivated in the area are highly related to the seasons. The main types of rice in the area are early, medium, and late. The present cropping pattern in the Priority Development Area is clarified on the present land use and by data on the ratio of planted areas by season, obtained from the district offices. The total rice fields in the Priority Development Areas are 1,950 ha in the Kandal Stung and 1,600 ha in the Tonle Bati areas. The clarified present cropping pattern is illustrated in Fig. 8 and summarized as follows.

(Unit : ha)

Season	Kandal Stung Priority Development Area	Tonle Bati Priority Development Area
Early*	120	130
Medium	1,170	1,120
Late	780	480
Dry season	0	0
Total planted area	2,070	1,730
Total rice field area	1,950	1,600
Cropping intensity	106 %	108 %

3.4.3 Farming Practices

Rice cultivation is rather extensively practised at the family farm level. The prevailing farming practices in the Priority Development Area are basically the same as in the Master Plan Area. Transplanting using the wet nursery method is common for growing rice in the area. The farmers use farmyard manure as a basal dose and chemical fertilizers such as Urea averaging 20 kg/ha and Compound (16:20:0) averaging 80 kg/ha. Plant protection is usually not required because of low damages by insects and disease. Farmers rarely use chemicals, especially for brown plant hoppers in March to April. Harvesting and threshing is done manually. The threshed paddy is well dried under the sun and stored in a granary at each farm household.

3.4.4 Crop Yield and Production

(1) Yield and production of rice

The yield of rice is still very low, about 1.4 t/ha on average. The yield varies depending on the varieties, application rate of fertilizers, planting seasons, and condition of irrigation and soils. Irrigation water shortages, floods, and the availability of fertilizers are the most influential factors in production. Where irrigation water is available in the dry season, more than 2.5 t/ha of yield is realized.

The rice production by season in the Priority Development Areas is roughly estimated based on the cultivated area and the average unit yield of 1.4 t/ha for rainfed lowland rice as follows:

Season	Kandal Stung Area		Tonle Bati Area	
	Area (ha)	Production (t)	Area (ha)	Production (t)
Early	120	170	130	180
Medium	1,170	1,640	1,120	1,570
Late	780	1,090	480	670
Total	2,070	2,900	1,730	2,420

The total production of rice (paddy) for 1993-1994 is estimated at 2,900 tons in the Kandal Stung Area and 2,420 tons in the Tonle Bati Area.

(2) Other crops

Crops grown in the Priority Development Areas other than rice are sugar palm, maize, cassava, sweet potato, vegetables, and some perennial crops. Almost all farmers grow bananas, mangoes, guava, and cocos in their home gardens. The planted area of upland crops is very small compared to rice, less than 2 % of agricultural land. The number of sugar palm trees in the Priority Development Area is 1.8 and 0.2 tree/household in Kandal Stung and Tonle Bati Priority Development Areas, respectively. The majority of palm trees are concentrated outside the Kandal Stung Development Area, and recently there are very few farmers producing palm sugar in the Priority Development Area, due mainly to the low price of sugar and the high risk of accidents in collecting sugar sap from the tree. Vegetables were not commonly grown in the area but recently some farmers have started to grow them, and mushrooms for marketing. Other crops are mostly consumed within the area.

3.4.5 Livestock and Fisheries

Livestock raising is quite important for the farmers in and around the Priority Development Areas. Most farmers keep cattle as draught animals, and pigs and poultry mainly for cash income. The estimated number of cattle is around 3,000 and 3,400 heads in Kandal Stung and Tonle Bati Priority Development Areas, respectively.

The number of cattle to prepare rice fields in the Kandal Stung Priority Development Area is still inadequate in more than half the number of communes at present, while the Tonle Bati Priority Development Area has enough draught animals. However in a few years, the Kandal Stung Priority Development Area will have sufficient power after the present cattle grow. The raising method is still primitive and they are fed on grass, crop residues, and household leftovers. Farmers store rice straw at harvesting time for feed throughout the year. Disease control in livestock raising is a great concern for farmers.

Inland fishery is a common source for domestic consumption in the area, and is mostly done by cast net, traps, or scoop nets in rivers, canals, ponds, and lakes. The precise data concerning the amount of fish caught in the study area are not available. The average consumption of fish is said to be about 18 kg/capita/year in the area. Fish culture is not observed in and around the Priority Development Areas at present except naturally propagated fishing .

3.4.6 Agro-processing

The most important agro-processing activity in the Priority Development Areas is rice milling. About 90 % of villages have rice mills to polish their rice for their own consumption. Most rice mills were installed in the last 2 to 3 years, due to the free rice market system introduced recently. The recovery rate of the milling is about 60-62 % and the milling charge is about 45 US$/t (paddy).

Two types of rice mills, with milling capacity of 400 kg/hr and 150 kg/hr, are popular in the area. The 400 kg/hr type is composed of one dehuller with a steel whitening system, and the 150 kg/hr type is composed of only a one steel huller one-pass model. Some milling machines are manufactured in Phnom Penh, and spare parts are available locally.

3.4.7 Marketing of Agricultural Products and Inputs

At present the marketing of farm products in the area is under a free marketing system. Usually farmers sell their products, especially paddy, pigs and poultry whenever cash is required, to the middlemen who visit individual farmers. No organization has been established to trade farm products in and around the Priority Development Areas. The most important

product in the areas is rice. The farmers usually sell the rice (paddy) to the middle men for cash, or barter for daily necessities such as salt and sugar.

There are two market channels for farm inputs supply, the Government operated CCAM and the private market. The constraints on the input supply system is a shortage and delay of supply. This is due to inappropriate storage capacity for inputs, and a lack of credit sale system for fertilizers.

3.4.8 Agricultural Production Value

The estimated production of rice, and palm sugar and the number of livestock in the Priority Development Areas for 1993-94 crop year are shown below:

Items	Kandal Stung Area	Tonle Bati area
Rice (t)	2,900	2,400
Sugar (t)	100	10
Cattle (head)	3,000	3,400
Pig (head)	1,100	1,400
Poultry (head)	9,100	8,900

The gross production value of the above agricultural production at farm gate is estimated as follows:

Items	Production		Unit	Value					
	Kandal Stung	Tonle Bati	Price	Kandal Stung			Tonle Bati		
			(1,000R)	(MR)	(1000US$)	(%)	(MR)	(1000US$)	(%)
Rice(t)	2,900	2,400	400	1,160	468	(77)	960	384	(74)
Sugar(t)	100	10	600	60	24	(4)	6	2	(0)
Cattle(head)	450	510	260	117	47	(8)	133	53	(10)
Pig(head)	1,650	2,100	80	132	53	(9)	168	67	(13)
Poultry(head)	13,700	13,400	3	41	16	(3)	40	16	(3)
Total				1,510	608	(100)	1,307	522	(100)

Note; The annual production of animals is estimated as an assumption based on the total number of animals, applying 15 %, 150 % and 150 % for cattle, pig and poultry, respectively.

As seen in the above table, 77 % of annual farm production value is derived from rice cultivation, while livestock contributes about 20 %, in the Kandal Stung Priority Development Area. In the Tonle Bati Priority Development Area rice cultivation contributes to 74 % , and livestock 26 %.

3.4.9 Farm Household Economy

According to the household survey , the average farm size and family size in both Kandal Stung and Tonle Bati Priority Development Areas are 0.9 ha and 1.4 ha per household and 5.6 and 6.0 persons per families, respectively. The average available labour force for families is estimated at 2.5 persons. According to the food balance analysis for individual households, about 80 % and 70 % of households in the Kandal Stung and the Tonle Bati area, respectively suffer from a shortage of rice for their own consumption.

The main economic base in the Priority Development Areas is rice cultivation , but the production is not high enough due to an irrigation water deficit and a shortage of inputs and improved techniques. A majority of farmers supplement their living by other income, livestock, sugar, wages, etc. as shown in the following table. In the Kandal Stung area, only 31 % of farmers are full-time, while 66 % in the Tonle Bati area.

Farmer's Income Distribution

Income source category	Kandal Stung Study Area		Tone Bati Study Area	
	(No.)	(%)	(No.)	(%)
1. Rice cultivation	7	6	5	11
2. Rice and livestock	16	14	24	55
3. Rice, livestock, and other crops	13	11	0	0
4. Rice, livestock, and other off-farm income	57	48	13	30
5. Rice and other off-farm income	25	21	2	5
Total	118	100	44	101

The gross income in the Kandal Stung area is estimated at about US$ 370 for farming, and US$ 190 for farming and off-farm activities, totalling about US$ 560. The gross farm household income in the Tonle Bati area is estimated at about US$ 570 for farming activities, and US$ 30 for off-farm activities. About 33 % of the gross income in the Kandal Stung area is derived from off-farm work consisting of salaries, wages earned by labour, and remittance from family members working in Phnom Penh or abroad. About 95 % of the gross farm income is derived from farming activities in the Tonle Bati area.

The total annual living expenses of the average farm household in the Kandal Stung and the Tonle Bati Study areas are estimated at about US$ 480 and US$ 520, respectively. The study on farm budgets makes it clear that the farm economy for typical farmers in both the Kandal Stung and Tonle Bati areas remains at a subsistence level.

3.5 Agricultural Supporting Services in Priority Development Area

3.5.1 Government Organizations

There are two channels of agricultural supporting services in the Government organizations with some support from NGO's. One is from each central department passing through the provincial level to the district agricultural office, and is mostly used for services including FFP program, cattle vaccination program, and general information from MAFF. The other is through agricultural or rural development centres operated by DOA, mainly for agricultural support services including technical demonstrations and guidance, input supplies, rural credit, and community development, but the area covered by the centres is very limited to several villages belonging to a few communes. The Government institution directly concerned with the Kandal Stung Priority Development Area is the agricultural office of the Kandal Stung District of Kandal Province. The Kandal Stung Rural Development Centre (KSRDC) does not cover the Area: The Tonle Bati Priority Development Area receives support services from the agricultural office of Bati District of Takeo Province, and the Tonle Bati Agricultural Development Centre (TBADC). Qualified staff and budget are not sufficient to execute effective agricultural extension work in both offices and centres.

3.5.2 Agricultural Extension and Input Supply

(1) Kandal Stung Priority Development Area

At present any noteworthy agricultural extension work is executed in the Kandal Stung Priority Development Area, other than by the district agricultural office. In May 1994, MCC (NGO) reduced by one worker their rural credit which covers three villages in the Roluos commune. In 1991, KSRDC was established under the Department of Agronomy with the cooperation of WVI: Their activity covers 375 families in 12 villages belonging to 3 communes in the South-west part of the district, outside the Priority Development Area and is concentrated on community mobilization through small scale agricultural credit and income generation activities. Agricultural support services are not extended to the Priority Development Area by NGOs at present.

(2) Tonle Bati Priority Development Area

The main work by TBADC is to distribute irrigation water and farm inputs to an area of about 6,000 ha (including the Priority Development Area) in cooperation with the District Agricultural Office. Agricultural extension work was started in 1992 as a pilot village project including such activities as rural credit, operation of a demonstration plot to show farming techniques for fertilizer application and use of improved varieties, as well as community mobilization such as repairing rural roads, digging wells, and educating primary school teachers. At the end of 1993, HEKS took over the operation and is continuing at present. The centre with 4 workers, has to cover extension work for 4,400 households in 34 villages belonging to 5 communes totalling about 6,000 ha. At present, due to a shortage of staff and budget, it is limited to covering the 4 selected pilot villages belonging to 4 communes.

(3) Input Supply

The Kandal Province branch of CCAM is supplying fertilizers and chemicals to the whole Kandal Stung district area through a store house located in the Siem Reap village, just out side the southeast end of Kandal Stung Priority Development Area. The capacity of the store is only about 140 t, and inefficient to supply inputs to the Priority Area. Kandal Stung district does not have a store facility. Fertilizers and chemicals are also privately sold in the Svay Minh market in the Kandal Stung Priority Development Area and at some small retail shops along Road No.2. The Tonle Bati Agricultural Development Centre sells fertilizers and chemicals for the Government for the Tonle Bati Priority Development Area. Fertilizers are also available in the Samrang Yang market located 4 km south of the Tonle Bati Priority Development Area. The Bati district office does not have a store to keep fertilizers and chemicals.

3.5.3 Agricultural Credit Services

KSRDC started small rural credit schemes by formulating credit-use groups through which credits are disbursed and repaid. The area covered by the scheme during 1990 to 1993 totalled 616 families from 6 villages. The main items covered by credit are rice for home consumption, materials for palm sugar production, initial funds for livestock raising, and home vegetable gardens. TBADC started credit services in 1992 for 2 villages and 120 families. According to data from TBADC, the major items requested were for home vegetable gardens, home yard pig raising, and the operation of small shops in the villages. No significant differences of credit purposes between male and female members were observed. The observed constraints of the Centres in carrying out the credit services are a shortage of well trained extension staff, a shortage of veterinary care for pigs and poultry, and a shortage of planting materials. There are the only credit systems available for farmers.

3.5.4 Agricultural Support Activities by NGOs

The Family Food Programme (FFP), sponsored by UNICEF and implemented with the assistance of WFP and the Khmer Women Association, specifically targets poor families with children under five, female-headed-households, and widows.

At the more general level of overall health status of the population in the Study area it should be noted that, apart from government services, NGOs in both districts are active in the Primary Health Care (PHC) field (:WVI and 24 Hour TV in Kandal Stung District; JOCS in Bati District). This includes such activities as the improvement of the domestic water supply, sanitation, vegetable gardening, and vaccinations.

3.6 Irrigation and Drainage System

3.6.1 Existing Irrigation and Drainage Facilities

(1) 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.

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.

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.

During the flood of August 3, 1994, the gates could not be fully opened. The discharge through the gates is estimated to be 177 m^3/sec, while the maximum flow capacity is estimated to be 260 m^3/sec, if the gates are fully opened. The present capacity of the Tuk Thla regulator reduces the maximum capacity to 68 %.

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.

(2) Kandal Stung Irrigation Project

During the Pol Pot regime 1975-79, an irrigation canal system was constructed in the Kandal Stung area, together with the Tuk Thla regulator and the Kompong Tuol regulator. Distribution canals for irrigation were constructed, following latitudinal and longitudinal grid lines, regardless of the topographic conditions. Intake and canal related structures were constructed together with canal works. Major canals were located 1 km by 1 km, and distribution canals and field borders were provided, in principle, at 100 m intervals.

From 1987 to 1991, the rehabilitation/construction of the irrigation facilities of the Kandar Stung Irrigation Project was executed by the Department of Hydrology with the assistance of Mennonite Central Committee (MCC). The primary objective of the rehabilitation of the Kandal Stung facilities is to provide irrigation water and drainage to about 2,000 ha of agricultural land. In addition during the design stage in 1986, an area of 1,100 ha located north of Road No.104 was included in the project area, and the Kandal Stung Irrigation Project was implemented to cover an area of 3,100 ha.

In August 1991 when the National Road No.3 dike between Kompong Tuol and Tuk Thla regulators was washed out, the irrigation facilities of the Kandal Stung Project were also severely damaged by the flood. 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 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.

i) Irrigation System

Rehabilitation of the Pol Pot canal and related structures was executed from 1987 to 1991 by the Department of Hydrology, with a joint effort of the Kandal Stung District, Kandal Province, and MCC.

The Kandal Stung Irrigation Project was planned to irrigate 3,100 ha. Irrigation water to the Kandal Stung area was diverted from the right bank opening in front of the Kompong Tuol regulator. A shallow and wide borrow area, adjacent to the National Road No.3, conveyed water to the intake of the Kandal Stung Irrigation Project. No irrigation water is diverted at present to Kandal Stung area due to repeated damage to the road dike.

The irrigation canal system consists of main, lateral and tertiary canals with related structures. The rehabilitation of the distribution canal system was basically based on the Pol Pot layout, although some new canals and structures were added during the rehabilitation works.

Description	Length			Number
	Total(km)	New (km)	Rehabilitation (nos)	
Irrigation Canal				
Main Canal	5.30	0	5.30	1
Lateral Canal	13.23	6.38	6.85	5
Tertiary Canal	38.03	18.09	19.94	35
Related Structure				
Structures related to main and lateral canal	-	-	-	28
Turnout for tertiary canals	-	-	-	38

The present conditions of canals and structures constructed so far are described hereunder.

a. Irrigation Canals

- Main Canal:

The capacity of the main irrigation canal at its head is 9.73 m^3/sec for an area of 3,100 ha inclusive of the future extension area. The canal is the Pol Pot canal EW63, which is large and deep.

The canal runs on the ground surface slope of approximately 1:2,000. It crosses the high-elevated area with excavated sections upstream, and it runs in the low-lying area with embankment sections downstream. Canal base levels are not appropriate, in some places too deep, in other places shallow. Heavy erosion occurs on the inside and outside slopes in some places. Embankment appears erosible and dispersive soils embankments. To prevent erosion on the canal slopes, slope protection by means of lining and sod facing will be needed as well as reshaping of the canal embankment.

The water level of the main canal was set to be 12.00 m (LBKS). However, the main canal water levels never reached this except during high floods. According to the operation sequence of the Tuk Thla regulator, when the water surface of the main canal reached El. 12.0 m (LBKS), all gates of the Tuk Thla regulator are opened. In those cases, the water surface at the Tuk Thla regulator is considered to be about 1 m above the crest of the gate. It is understood the main canal received waters with a surface level at about 11.0 m under normal operation conditions. This caused the upstream area, lying 12 to 11 m in elevation, to suffer a lack of water.

- Lateral:

Five Laterals branch from the main canal. Pol Pot canals are used for some of the Laterals (Lateral-1, Lateral-2, Lateral-3, and Lateral-5) which are level-crossed with other Pol Pot canals. The canal sections in these reaches are wide and deep against their small command areas. Irrigation water diverted from the main canal goes out to the drainage canals or drain water enters the laterals at the level-crossed locations. Water losses are great and it is difficult to convey water sufficiently to the tail end. A distinctly separate system of irrigation and drainage canals enables to improve irrigation water management as well as to attain reliable water supply at the tail end.

Heavy erosion occurs on the inside and outside canal slopes in some places. The embankment is likely to be constructed using erosible and dispersive soils. Most lateral

canals require the reshaping of the canal cross sections and improvement of the embankments.

- Tertiary Canals:

Tertiary canals do not receive water from the main canal and lateral canals, and some are served with water from drains. Before the regulators were damaged, the amount of the water was scarce and the water levels in the canals were low so that gravity irrigation was difficult. Most of the tertiary canals are levelled by farmers or filled with eroded soils due to a longterm lack of water supplies. Almost all tertiary canals require reshaping of the canal section and improvement of the embankment.

Tertiary canals in the upstream area are provided at about 1 km interval with lengths of about 1 to 2 km, creating command areas that are too large. Whereas, the tertiary blocks downstream are small, inducing a large number of turnouts on the Lateral canals. The present tertiary system makes it difficult to attain an efficient water management of the distribution system and on-farm system, as well as sustainable O&M of on-farm facilities by water users.

b. Structures

The present conditions of the structures are as shown below;

- Lack of gates on many turnouts and check structures,
- Erosion of canal sections downstream of some check structures in the main and lateral canals,
- No provision of platform covers on the structures
- Turnout barrels are filled with sediment

Most of the existing structures need repair or desiltation.

ii) Drainage System

Drain water in the Project area discharges to the Cheung Loung lake through the Pol Pot canals. There are many obstacles in these drainage canals preventing a smooth flow of water. During construction of the irrigation canals smooth drain flow is disturbed. Therefore inundation or flooding has often occurred in low-lying areas.

Many fish fences, bushes or earth bunds for irrigation intake are seen, and due to the lack of road crossing culverts, the inundation on the paddy fields always occurred on the west side of Road No.2. Pol Pot canals used as drainage canals in the Project area supply irrigation water to the downstream areas and Pol Pot diversion structures are located downstream, resulting in poor drainage conditions in the Project area. The main drainage canal needs to be connected to the major drainage canals to field the drainage canals from the above-mentioned lake.

(3) Tonle Bati Irrigation 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.

i) Irrigation System

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	Length			Number
	Total	New	Rehabilitation	
Irrigation Canal	(km)	(km)	(km)	(nos)
Main Canal	9.70	4.05	5.65	3
Lateral Canal	9.11	5.64	3.47	7
Tertiary Canal	20.00	18.55	1.45	21
Related Structure				
Structures related to main and lateral canal	-	-	-	19
Turnout for tertiary canals	-	-	-	22

a. Tonle Bati Lake

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 7.8 m. The catchment area is very small, causing the lake water to lower quickly after the rainy season. An intake and spillway are located at the southeast and east end, respectively. The lake is surrounded with embankments on the north and east, with crest levels ranging from 8 m to 10 m. The Pol Pot canals discharge to the lake from the north, having regulating gates at the crossing with the embankment.

There is a Pagoda and a recreation centre adjacent to the southern coast. The intake water level for the Tonle Bati area will be required to be 7.8 m. The Pagoda's northern ground slopes toward the lake with ground elevations of 7 to 8 m. The embankment will be extended to protect the Pagoda from intrusion of the lake water. 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. A water level of 5.5 m will be required, of which the water front will be 100 to 150 m inward from the rainy season water front.

b. Pumping Station and Spillway

- Pump Station and Intake:

The pumping station is provided with three sets of diesel engine driven pumping equipment having capacities of 8 m3/min (one set) and 5 m3/min (other two sets). The pumping capacity is not sufficient to supply irrigation water to the whole Project area. It is used only to supply supplemental water during the cropping season. The intake structure is of concrete box barrels, 1.5 m wide and 3.75 m high. The culvert bottom is located at an elevation of 4.7 m. Regulation gates are not provided.

- Spillway:

A spillway with a bridge for the National Road No.2 is located at the outlet of the lake. In August 1991, the floodwater spilled over the lower part of the National Road No.2. In 1992, 4 slide gates were provided by the Department of Hydrology in front of the stoplog gates of the Pol Pot structure, but the bridge still remains heavily damaged.

c. Irrigation Canals

- Main Canal:

The capacity of the main irrigation canal (M1) at its head is 9.78 m^3/sec which covers about 4,000 ha of land including the future extension area. The M1 canal was newly excavated to run through the central part of the Project area, branching from the Pol Pot canal (Haknuman canal). The central part of the project area is higher elevated, having the ground elevations of 7 to 7.5 m. To serve this area, a large canal size was adopted with mild sloping. The excavated canal berm encountered erosive heavy clay layers in the older plains. This caused the canal banks and slopes to be heavily eroded and the inspection road to be impassable. To prevent erosion on the canal slopes, slope protection using ining and sod facing will be needed as well as reshaping of the canal embankment.

The water level at the head of the main canal was set to be 7.80 m (LBTB). However, the lake water levels reduce below the required water level throughout the year except for half or one month during high floods. With augmented water from the Prek Thnot River, the water level and volume of the lake have to be maintained to ensure reliable irrigation to the Tonle Bati area.

- Lateral:

Five Laterals were constructed in the priority area, with some (Lateral-5 and Lateral-7) being reconstructed from Pol Pot canals. Heavy erosion occurred in the canal and on the embankment slopes in Lateral-4 and Lateral-5. Most lateral canals require reshaping of the canal cross sections and improvement of the embankments.

- Tertiary Canals:

Most tertiary canals are filled with eroded soils due to a longterm lack of water supplies. Almost all of the tertiary canals require reshaping of the canal sections and improvement of the embankments.

d. Canal Structures

The present conditions of the structures are shown below.

- Lack of gates on many turnouts and check structures,

- Erosion of canal sections downstream of some check structures in the main and lateral canals,
- No provision of platform covers on the structures,
- Turnout barrels are filled with sediment.

Most of the existing structures need repair or desiltation.

e. Connection Canal NS78

A connection canal was constructed on the north-south No.78 during the Pol Pot regime 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 Hydrology Department, but it does not function due to a rather high bottom level and an absence of a diversion structure in the Stung Toch River. Since the canal runs 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.

ii) Drainage System

The drainage system of the Tonle Bati area is broadly divided into three drainage systems. The eastern part of the Tonle Bati area is drained to the Cheung Loung Lake through the old Pol Pot canals which run east-west. The southern area is drained to the Haknuman canal, one of the large Pol Pot canals in the area. The northern area is directly drained to the downstream reaches of the Tonle Bati River.

The drainage canals constructed in the Tonle Bati area tertiary and consist of the rehabilitated Pol Pot canals and the newly constructed drainage canals. These drainage canals are connected with Pol Pot canals. Some of the drainage canals are filled up with sediment and are not functioning at present. The drainage canals constructed so far are summarized below.

Tertiary Drainage Canal (km)	Length	Number
Improvement canal	1.08	1
Newly constructed drainage canal	10.58	10
Total	11.65	11

3.6.2 Irrigation Water Management

(1) Operation and Maintenance

The Kompong Tuol irrigation intake is located furthest downstream of the Prek Thnot River basin. The Roleng Chrey gates, which are located 40 km upstream of the Kompong Tuol irrigation intake, are operated by the Kompong Speu provincial office. The gates are intermittently opened without an operation manual according to the observed water levels. In the dry season the river discharges decrease drastically, and the release of a small amount of river water is difficult. The gate operator opens the gate when the upstream water levels reach a critical level to the embankments. The river flows at the Tuk Thla and Kompong Tuol regulators greatly fluctuate due to the intermittent gate operation at Roleng Chrey. No communication on water management practices is made between the upstream and downstream areas of the river basin. It results in a great loss of water source as well as a high risk of damage to the facilities. A water management system including a communication network has to be created on a river basin basis at the central government level.

O&M of the Kompong Tuol intake was carried out by two related Districts, Dangkor District office of the Phnom Penh municipality for Tuk Thla regulator and the Kandal Stung District of Kandal Province for the Kompong Tuol regulator. Gate operators were appointed from the two Districts, 25 for the Tuk Thla regulator and 6 for the Kompong Tuol regulator. To coordinate the operation of the regulator gates, a coordinating committee was organized, constituted by representatives of the Hydrology Office of the two related Districts and Phnom Penh municipality. It always encountered operation conflict among the related districts. The farmers in the Kandal Stung irrigation area wanted to raise the water level to increase the irrigation area. Whereas, the farmers in both bank areas immediately upstream of the regulators tried to lower the water level to lessen inundation damage to their farm land. A sufficient institutional set-up for the operation of the regulators is required to solve these issues.

The Kandal Stung District Office is responsible for O&M of the main and lateral canal system of the Kandal Stung Irrigation Project. In fact, however, the communes are operating the gates of the canals in their area. Maintenance and repair of the canals and structures is not carried out due to the lack of a systematic O&M organization, O&M manual and O&M fund.

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.

(2) Irrigation Conditions

The rehabilitation of the Kandal Stung irrigation system covering 2,000 ha was completed in 1991. However, since the breach of the road dike at the Kompong Tuol irrigation intake in August 1991, the irrigation canals have been completely empty, because the water level in the Prek Thnot River is too low for the water to enter the main canal. Therefore irrigation from the canal system can not be carried out even in the rainy season. Farmers excavated the canal embankment to take rain water gathered in the canals, and to drain their farm land. This condition accelerated the damages of the irrigation facilities. Farmers are using small scale pumps to supplement rainwater for paddy cultivation, and the number of pumps tends to increase. The farmers are keen to rehabilitate/improve the irrigation canal system.

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 16.8 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 fuel for the pumps was supplied by WCC and Takeo Province, totalling 9,000 l 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 the canals to their fields, even in rainy season cropping. The dry season irrigation area is estimated to be 20 ha, and the rainy season supplemental irrigation is estimated to be 100 ha.

3.7 Rural Infrastructure

3.7.1 Rural Road Networks

Cang Dan, capital of Kandal Province is located about 8 km south of Phnom Penh along the National Road No.2 which connects Takeo, capital of Takeo Province, to Phnom Penh. The Kandal Stung Priority Development Area is located about 21 km south along the National Road No.2. The other direct access from Phnom Penh to the Kandal Stung Priority Development Area is the National Road No.3 which runs northwest of the Priority Area, through Kompong Tuol. Provincial Roads No.105 and No.104 connect the National Road No.3 to the National Road No.2. Although the condition of the No.105 is not good, it can be used in all weather and is much better than other local routes. The present road system in the Kandal Stung Priority Development Area and the Tonle Bati Priority Development Area are shown in ANNEX VI.

In the Priority Development Area, there is about 6.5 km of national roads and about 16.4 km of provincial roads in Kandal Province. The National Road No.3 located at the western extremity of the Kandal Stung Priority Development Area is paved with asphalt. The National Road No.2 located at the eastern extremity of the Kandal Stung Priority Development Area and the western extremity of the Tonle Bati Priority Development Area is mostly paved with asphalt. The National Road No.2 between Samrong Yong and Haknuman in the Tonle Bati Priority Development Area is still unpaved, and is under rehabilitation. The Provincial Road No.104 in the Kandal Stung Priority Development Area has been asphalt-paved, but is severely damaged, and is only passable by four wheel drive cars in the rainy season.

There is no district road in the Priority Development Area. The Village road (farm road) network is insufficient for the efficient operation of crop cultivation. In the rainy season, these roads are nearby impassable due to mud or serious erosion.

3.7.2 Rural Water Supply Facilities

(1) Present Water Use

In the Priority Development Area, ground water is the main water source for drinking and domestic use. A number of facilities in the Priority Development Area are summarized below:

	Priority Development Area	
Facility	Kandal Stung	Tonle Bati
Tubewell	29	9
Dug well	56	0
Artificial pond	2	10
Lake	0	1

In the dry season, many wells are dried up. In such villages, a large number of water users depend on other water sources, including lakes, canals, and ponds, and are faced with a severe shortage of domestic water supply facilities. The following table shows the number of functioning wells in each commune and the average number of people commanded by each well in the dry season and rainy season, respectively.

Name of Khum	Number of Functioning wells		Density of User *Per well	
	Rainy season	Dry season	Rainy season	Dry season
Kandal Stung Priority Development Area				
Roluos	15	8	92	173
Preah Puth	10	6	160	267
Tien	7	7	105	105
Bakou	15	15	178	178
Korng Nory	10	10	79	79
Anlung Romeat	28	28	62	62
Tonle Bati Priority Development Area				
Kreing Thnoung	4	3	919	1,225
Champey	3	3	462	462
Kandang	1	0	280	no well
Put Sar	1	1	472	472

The Tonle Bati Priority Development Area has a severe lack of water supply facilities. On the other hand, the western part of the Kandal Stung Priority Development Area is comparatively well served and less arid. It is desirable that the number of water users per well is approximately 40 families (5x40=200 persons). In this context, the number of wells in the Priority Development Area is extremely short, particularly in the Tonle Bati Priority Development Area.

(2) Present Condition of Tubewells

One tubewell per village is basically provided in the Priority Development Area. The existing tubewell depth ranges mostly from 30 to 40 m in the Kandal Stung Priority Development Area, and from 20 to 30 m in the Tonle Bati Priority Development Area. The tubewell facilities are equiped with a cylinder-type hand pump made in India. Though the maintenance of the tubewell facility is said to be conducted by village people, it is hardly possible for them to repair the pump facility when needed, and also the repair budget is extremely limited.

In the Kandal Stung Priority Development Area, the geological formation is comparatively sandy, and the ground water is sufficient to yield. In the Tonle Bati Priority Development Area, the geological formation consists of sand and gravel, but the ground water is not satisfactorily yielded in the dry season.

The iron content of the ground water is high, particularly in the western part of the Kandal Stung Priority Development Area. The people usually do not use the ground water for drinking and cooking due to its high iron content. Instead, they use dug well water available in the area. If they do not have a dug well, they use ground water from the tubewell after airing it for 2 to 3 days in a large jar.

In the rainy season, the entire area uses rainfall kept in the large jar for domestic water. In the dry season, they use tubewell water, dug well water, and artificial pond water. The priority of water use in the dry season is dug well, tubewell and/or pond in the Kandal Stung Priority Development Area, and tubewell and pond in the Tonle Bati Priority Development Area.

(3) Water Quality

The pH value of the sampled water ranges within the permissible limit of 6.5 to 8.5. According to the result of a chemical analysis, most water shows a high iron content. Coliform was detected in the dug well water and pond water by biological analysis. Basically tubewells are better at protecting the water from contamination by seepage water, and also for yielding excellent water.

3.7.3 Other Rural Infrastructure Facilities

(1) Health Facilities

Both the Priority Development Areas, have similar public health service facilities. The Kandal Stung Priority Development Area has 5 Khum clinics and the Kandal Stung District Hospital in the Khum Anlong Remeath. A Khum clinic is basically provided for each Khum except the Khum Preah Puth. This clinic was severely destroyed during the Pol Pot regime. Out of the 5 clinics, 3 are in fairly good condition, but 2 are rather deteriorated. The Tonle Bati Priority Development Area has 4 Khum clinics and the existing buildings are quite deteriorated.

(2) School Facilities

There are 8 primary schools and 1 middle school in the Kandal Stung Priority Development Area and 4 primary schools and 1 middle school in the Tonle Bati Priority Development Area. School facilities such as buildings, books, and science equipment are inadequate. In order to overcome the shortage of classrooms for enrolling students, the schools are managed by a rotation system, changing the class by school hours. Some wooden schools are so dilapdated that replacement or additional buildings are indispensable in improving the quality of education.

(3) Community Hall

There are no community halls in any of the khums. People are sometimes utilizing temples to hold meetings.

3.8 Environment

3.8.1 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.

3.8.2 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 Physical Constraints

The major physical constraints observed in the Priority Development Areas are summarized below.

(1) Soils

i) Low fertility soils lie in the Tonle Bati Priority Development 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.

4.2 Agricultural Development Constraints in Priority Development Areas

Most of the constraints which are crucial to profitable and sustainable agricultural development in the Priority Development Area are due to insufficient agricultural services, irrigation water deficits, and floods. The major constraints to further the development of agriculture are summarized as follows:

(1) Irrigation water deficit

The farmers are suffering from a shortage of irrigation water for cultivating rice even the beginning of the wet season. The farmers in the area are eager to grow at least two crops of rice a year but due to the irrigation deficit , at present, two crops of rice cultivation is possible in a very limited area. It is essential to improve the irrigation water supply and to control floods to develop and stabilize the agriculture in the area.

(2) Insufficient agricultural inputs supply

The availability of certified seeds is very limited. Farmers are using their own local variety seeds. Most of these varieties are low yielding, but are adaptable to the local micro-environments and alleviate risks because of their tolerance to adverse conditions such as drought. Photoperiod sensitive varieties with different flowering stages are also used to lengthen the transplanting and harvesting periods in order to mitigate the labour shortage. The shortage of improved seeds is the major constraint for increasing rice production.

A shortage of agricultural inputs such as fertilizers and chemicals are also major constraints at present in the area. The timely and stable supply of farm inputs with reasonable prices is required to attain stabilized and sustainable agricultural production.

(3) Lack of supporting services and improved techniques

Despite the fact that the existing rice fields in the area have a large potential to increase crop yields, packages of farming techniques have not been developed, these should include field trials of rice varieties, appropriate planting times, and fertilizer practices suited to the different physical conditions. Since there is no basis of researched techniques, credible extension services to increase crop production as well as life improve the farmers could not be sufficiently provided by the offices concerned.

The present support services including agricultural extensions, rural credit, inputs supply system, and marketing of agricultural products, are not functioning due to the lack of qualified manpower, facilities, appropriate techniques and budget. Effective extension and support services are inevitable in attaining full exploitation of agricultural development in the area. It is necessary to improve the present complicated extension systems, and strengthen manpower, techniques and facilities. It is also necessary to introduce a formal credit system to enable farmers access to a stable availability of farm inputs.

4.3 Socio-economic and Institutional Constraints

4.3.1 Socio-Economic Constraints

The study area seems to be relatively homogeneous in terms of the socio-economic position of the families living in it: no great differences have been discovered, either in size of land holdings, assets, income, or type of houses. Most families can be classified as poor while the difference between 'poor' and 'poorer/poorest' appears to be only marginal. Nevertheless, a specifically vulnerable group in the area includes the FHHs who have small dependent children and no adult male members in the family. They are estimated at about 10 % of the total number of families. It is, however, felt that their needs can be covered through

programmes aimed at all households in the area, but with a special emphasis on the women. It is important though to closely monitor the situation to see if land is being sold by this group - or other poor families for that matter - possibly reducing them to tenants, sharecroppers or agricultural labourers, contributing to a further decline in their already weak socio-economic position. On the other hand, without sufficient support, FHHs may already be far too stretched to work the land. With the proposed increase in production and diversification (see Chapter 5), the time a FHH would need to spend on agricultural activities would only increase further, thus creating an additional problem. One solution proposed here - during implementation - is to carefully study the situation in each village in this respect and, if deemed necessary to facilitate optimal participation of the poor families, and to establish day care centres for children between 2-6 years of age to free up the parents time to fully reap the benefits of the envisaged project activities.

At a more general level it is conceivable that the small land holdings of approx 1.0 ha per family may pose a serious problem for farming to remain economically attractive. To some extent, this problem may be offset through the proposed intensification and crop diversification, but will need close scrutiny. At the same time, the proposed change in agricultural practices (i.e. from a single low yielding wet season rice crop to intensive and diversified cultivation) might be an obstacle in itself since it assumes a higher level of commitment and agricultural knowledge than currently the case and, simultaneously, requires a change in attitude/behaviour of the farmer who is now very much preoccupied with trying to grow more rice. This obsession will need careful attention during the implementation stage and may need to be satisfied before any other intervention such as crop diversification can be introduced. A phased introduction of new ideas and practices to allow internalisation, accompanied by explicit training components, would probably be an effective strategy to facilitate the required changes.

4.3.2 Institutional Constraints

As a result of its recent history, the government machinery in Cambodia is very weak, lacks, sufficiently skilled and adequately paid staff and, in general, is not functioning at a level required for the project under consideration. It is difficult to see how a weak bureaucracy will be able to support a fairly intensive, time consuming project and its longer term sustainability. The current development initiatives of NGOs (:the principal development agencies in the area) are supported by the government with - temporary - secondment of government staff (both district and national) to their projects. Although this provides a training opportunity for government staff, it also implies a progressive shortage of manpower at the government offices if more staff are not appointed. Ways and means will have to be found to overcome this problem.

At the grass roots level, an organisational structure of farmers/families is necessary for the successful and sustainable functioning of the envisaged irrigation system and indeed other developmental interventions. It has been observed though that families are quite self-centred and inward looking, rather than engaging in social or joint activities apart from the phenomenon known as 'provasdaya' or mutual help. This avenue has been researched further and in the next chapter a scenario for grass roots organisational development based on this principle is being proposed.

Another institutional constraint is the lack of credit opportunities at reasonable costs/interest rates. Current practices tend to disproportionately favour the money lenders leading to an increasing number of indebted families which, at a certain point in time, may be obliged to sell their land (see also above). Proper credit facilities (and savings schemes) are being envisaged to avoid this undesirable tendency.

V. AGRICULTURAL DEVELOPMENT PLAN IN PRIORITY DEVELOPMENT AREA

5.1 Development Concept

5.1.1 Basic Development Concept

The Priority Development Areas are 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 Priority Development Area is still low, 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 Priority Development 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 Priority Development 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 Priority Development 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.

5.1.2 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.

5.1.3 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 Priority Development 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 Priority Area, and the establishment of a new agricultural Development Centre in the Kandal Stung Priority Development Area,
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. Strengthening and establishment of agricultural development centres and their branches, including staff training programs , and

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

(7) Establishment of a Demonstration Farm

The main objective of the demonstration farm is to demonstrate and exhibit the effects of the proposed integrated agricultural and rural development to farmers in the surrounding area. The demonstration farm is planned for the selected Priority Development Area.

5.2 Land and Water Resources

5.2.1 Land Resources

(1) Land Resource Assessment

Development opportunities of each priority area are estimated from the existing land use and their land suitability for each crop. This result is summarized in the following table.

Kandal Stung Priority Area

	Present land use	Land Use	Suitability Classes (Wet season rice/Dry season rice/Upland/Pastures)	Area (ha)
1.	Rice field			
		Up	**S3sft** / S3sft / **S2ft** / S1f	389
	Almost flat	Pl & Pd	**S1** / **S1** / S2sd / S2sd (S1f / S1f / S3sfd / S3sfd)	1,465
	Deppressional	D	**S3sft** / S1d / N1 / S1d	194
	Sub-total			2,048*
2.	Upland field	U & V	S2st / S2st / **S1** / **S1**	344
3.	Un-used land	S		13

Remark: * Net area is 1,950 ha.
<1: Deficiency : s = soil physical condition, f = soil chemical condition, t = landscape, d = drainage condition.

Tonle Bati Priority Area

	Present land use	Land Use	Suitability Classes (Wet season rice/Dry season rice/Upland/Pastures)	Area (ha)
1.	Rice field			
	Gently sloping	Up	**S1** / **S1** / S2sd / S1s	449
	Almost flat - small -	Ps	**S1** / **S1** / S2sd / S1s (**S1f** / **S2ft** / S2sd / S1f)	767
	Almost flat - large -	Pl&Pd	**S1** / **S2ft** / S3sfd / S2sf (**S2sf** / **S3sft**/ N1 / S2sf)	464
	Sub-total			1,680*
2.	Upland field	U & V	S2ft / S2ft / **S1f** (**S2ft**) / **S1f**	127
3.	Un-used land	S & H		22

Remark: * Net area is 1,600 ha.
<1: Deficiency : s = soil physical condition, f = soil chemical condition, t = landscape, d = drainage condition.

Most rice fields in the areas have a good chance to introduce double cropping of rice. Gently sloping rice fields in the Kandal Stung priority area may be more suitable for upland cropping than for dry season rice cultivation. It is considered that the Upland and Village areas should be used for upland crops, pastures for cattle, community forests for fuel wood, etc. than for rice cropping, especially in the abandoned areas.

(2) Soil Improvement Plan

The soils and land units have been grouped into three categories for discussion of their improvement. Consideration of economics, land tenure, and sociological aspects is not taken into account.

i) Land Units L, Lf :

These areas have silty to sandy soil with moderately well drainability. These are presently used for villages with house gardens, grazing land for cattle feeding, and upland cropping areas. Due to the topographic conditions and permeability features, these are only marginally suitable for rice, but suitable for upland crops and pastures. The surface soils are low fertility, therefore organic matter such as rice straw, compost, green manure, etc. should be mixed with the soils and also chemical fertilizer should be applied to get good yields. As well, machinery tillage will be done for up to 30 cm below to retain soil nutrition and to expand the root zones for upland crops.

ii) Land Units P3 :

These are sandy-surfaced plains soils, presently used for wet season rice. Because of the low clay content, low organic matter content and low fertility of their topsoils, these

soils need additional organic matter, for which residual rice straw collected after the harvest is proposed to be mixed with the soils. Farmers willing to grow an early leguminous cover-crop should be encouraged. Leguminous shrubs could be grown on rice field bunds and other patches of high ground for both additional green manure, cattle fodder, and fuelwood. Green manure could also be purchased, possibly from farmers in land units Hs and Ht (see above). The application of mineral fertilizers probably including trace elements, would also help.

iii) Land Units P1, P21, P22, T1, T2, P2 :

These areas have good silty clay soils and are used extensively for wet season rice. The soils are suitable for dry season irrigation of both rice and upland crops. Soil improvement in these areas would include the use of post harvest rice straw and whatever other organic materials are available, leguminous or otherwise, plus mineral fertilizers. In addition, introducing blue-green nitrogen fixing algae into the rice field would be effective in the double cropping of the rice. In this case, lime and phosphate fertilizers would be quite effective for algae nitrogen fixing.

5.2.2 Water Resources

(1) Run-of-river resource from Prek Thnot

Euroconsult studied the potential for staged development proir to constructing the dam and concluded that a total of 4200 ha could be irrigated, 2500 ha of which would be in the JICA Project area. The residual flows at Tuk Thla are derived by assuming that 1700 ha upstream of Tuk Thla will be implemented.

The flow available at Tuk Thla is therefore the natural flow less the gross irrigation demand upstream, based on the Euroconsult cropping plan of double-cropped HYV rice. These upstream demands are recomputed using the revised potential transpiration figures and the net rainfall model described in Annexe I. The percolation rate (1mm/day), requirement for puddling water (two applications of 125mm) and overall efficiency of 65 % are used by Euroconsult. The average annual diversion requirement to irrigate 1700 ha, amounts to 34-mcm. A 15-day flow balance shows that small water shortages occur during five months in the 10-year series. These small deficiencies can be overcome using local storage such as the O Krang Ambel reservoir. The following table shows the monthly averages of the residual flow at Tuk Thla derived from the 10-year series.

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	8.0	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) Impact of Roleng Chrey

The Roleng Chrey regulator was completed in 1973. Its 6.7 m high gates can raise the water upstream to about bank-full level, holding back as much as 4mcm of water. Flows into the left bank main canal are controlled by 4m high radial gates. The diversion of water into two small canals on the right bank is not controlled other than by a general lowering of the upstream water level.

At present, the water level at Roleng Chrey is maintained at the top of the closed gates. When there is surplus flow upstream - in excess of that diverted and leaked - the operator opens one or more gates appropriately. This may follow a period when water is allowed to spill over the closed gates. Water is released until the upstream level has fallen several metres, and the gate(s) is closed, usually after a period of some hours. This results in the release of a substantial volume of water as the channel storage upstream of the gates is drawn

down. Following the gate closure, flow from the Prek Thnot catchment causes the upstream water level to return to the operating level, usually after a period of a few days. During the wet season, the operator tries to anticipate flood flows by simple observation of clouds over the headwaters of the basin. If rain-producing clouds are seen on several successive days, the gates are opened by an amount based on the operator's experience, and the season.

There may be some physical constraints for this method of operation. The gates are well counterbalanced, and it is understood that they cannot be closed when there is full hydrostatic pressure against them. This is probably the reason for the substantial drawdown of the upstream storage, a procedure that would not otherwise meet the simple objective of maintaining the upstream water level.

The operation of the regulator has a major impact on the river downstream. In the dry season, when river flows are naturally low, a substantial part of the flow can be diverted at Roleng Chrey, leaving only leakage flows in the river. Thus, the operation of Roleng Chrey affects the amount of water available at Kompong Tuol in the critical periods for irrigation. In the flood season, the timing of the gate opening can influence the peak discharge of moderate floods. The operator does not have the means to warn others (downstream of Roleng Chrey) that releases are being made, and whether these are made in anticipation of a significant flood from the headwaters. Consequently, the flood wave arrives at Tuk Thla / Kompong Tuol without warning. The rise in water level can be rapid, and can cause problems for the operators downstream, where the gates can be opened only slowly.

There has been no study of the impact of Roleng Chrey under the existing operating regime as there were few data on which to base such an analysis. Yet improved river management must take account of the existing distribution of water and the constraints under which the existing structures operate. Data from the hydrological stations established during this study, and from the operator's log, are used to describe the effects of some recent Roleng Chrey operations. From this work it is possible to define an operational strategy for the future that will allow the natural water resources to be shared between the irrigation areas along the river.

An analysis of the water balance in the dry season suggests that the present diversions are greater than the design assumptions based on the Euroconsult cropping plan for the upstream areas in some months, notably February, March, April and June. This comparison is subject to a wide margin of error as there are no firm data on the present diversions. Nevertheless, it strongly suggests that the water expected in the lower river will not be available unless there is a change of operating strategy at Roleng Chrey, and the control of releases for use downstream, is made a priority. Otherwise, only leaked water will be available downstream during the critical months, and the planned water sharing will not be realised.

It is possible to rule out a strategy of continuous operation, particularly in the dry season, as the gates are too insensitive to ensure a small constant discharge. Thus, a realistic strategy should be based on the dynamic operation of the gates. The following sequence is envisaged over a seven-day period:

a. the upstream water level is maintained for a few days (gates closed) while diversions are made to the existing canals feeding the upstream irrigation areas;

b. one gate is opened to send water downstream as a low flood wave, the upstream water level falls, and the upstream canal flows cease;

c. when sufficient water has been released downstream, the gate is closed, and the upstream water level slowly rises, allowing diversions upstream to recommence.

This cycle can be defined to share the water equitably. Variation in the timing and scale of releases downstream can be made for the changing demands for water through the

irrigation seasons, and in response to the different inflow regimes. The cycle could be interrupted at any time by the need to pass a flood, and the cycle would normally be suspended or modified during the main part of the wet season when the distribution of water for irrigation is not an issue. A typical dry period operating cycle is illustrated in Annexe I.

Inevitably, the introduction of planned water sharing in the dry season by the formal operation of the Roleng Chrey gate will require some changes in the irrigation regime in the areas currently benefitting from free water flowing in the canals. The water balance suggests that less water will be available in some periods than is presently distributed, resulting in some economic impact in those areas, attributable to the changed water regime. The institutional implications of a more formal operating policy are self evident and the needs for policy formation, technical support, measurement and communications are discussed elsewhere in this report.

While flood warning from the upstream basin of Prek Thnot would be a great benefit to the safe operation of structure on the river, it is recognised that it is infeasible at present. However, it should be given high priority when security conditions allow. Meanwhile, policies that imply advance knowledge of inflows should be avoided, and it must be accepted that moderate flood peaks can be fully attenuated by gate operations.

5.3 Proposed Agricultural Development Plan

5.3.1 Proposed Cropping Pattern

Irrigation development in the Priority Development Areas is based on the "without Prek Thnot Reservoir" condition. The proposed cropping patterns are formulated on the following basic principles which govern the selection of crops and cropping seasons to be introduced under the project condition:

a. In the wet season, 100 % of irrigable land would be cultivated with rice of which 20 % would be of local varieties.

b. In the dry season, 50 % of land would be for improved varieties of rice, 30 % for upland crops such as maize, soybeans and vegetables, and the remaining 20 % in fallow.

c. The cropping period is staggered in regard to the availability of labour and irrigation.

Since rice has been the basis of farming and economic activities and supplies the staple food, and the farmers have a lot of experience in rice cultivation, it will remain the main food crop. The rice varieties to be introduced are high-yielding varieties with an early to medium growth duration of about 120 to 150 days, and are photo period insensitive. Maize and soybeans are selected as the main secondary crops in the dry season, in connection with the nutrition improvement of the people, and the promotion of livestock production especially pigs and poultry. Some vegetables such as Chinese cabbages, cabbages, green string beans, and kale are considered to be introduced as cash crops in the dry season. Greengrams, groundnut, sesame, and sweet potato may also be introduced in the dry season.

The main aim of the proposed cropping pattern is to stabilize the wet season rice crop, and then to introduce a dry season rice crop of 50 % of the irrigated area, and also to introduce upland crops, especially for livestock promotion.

The proposed cropping pattern for the Kandal Stung Priority Development Area (1,950 ha) and the Tonle Bati Area (1,600 ha) are formulated based on the above mentioned concepts as shown in and Fig.- 9 and summarized as follows:

Kandal Stung area (1,950 ha)

Crops	Wet season		Dry season	
	(%)	(ha)	(%)	(ha)
Rice:	100	1,950	46	900
Early dry season rice			46	900
Early wet season rice	50	975		
Medium wet season rice	30	585		
Medium local var. of rice	20	390		
Maize & soybeans			14	270
Vegetables			14	270
Total crop intensity/area	100	1,950	74	1,440

The total area of the wet season rice would be 1,950 ha and dry season rice would be 900 ha. The upland crops area for maize and soybeans is about 270 ha and vegetables is also about 270 ha.

Tonle Bati area (1,600 ha)

Crops	Wet season		Dry season	
	(%)	(ha)	(%)	(ha)
Rice:	100	1,600	50	800
Early dry season rice			50	800
Early wet season rice	50	800		
Medium wet season rice	30	480		
Medium local var. of rice	20	320		
Maize & soybeans			15	240
Vegetables			15	240
Total crop intensity/area	100	1,600	80	1,280

The total area of the wet season rice would be 1,600 ha and dry season rice would be 800 ha. The upland crops area for maize and soybeans is about 240 ha and vegetables is also about 240 ha.

5.3.2 Proposed Farming Practices

It is proposed to introduce new high-yielding varieties or hybrid seeds with the appropriate use of fertilizers and agro-chemicals, along with the supply of irrigation water and institutional support services. The present farming practices prevailing in the project area can be basically applied to the proposed practices including animal power for soil preparation and transportation, manual operation for transplanting and harvesting, the wet nursery system, and the ordinary transplanting method. Some mechanization is necessary especially for chemical application, threshing rice, and shelling maize and groundnuts.

For plant protection, the proper application of chemicals will become necessary for the safe and effective control of insects and diseases. The minimum use of pesticides is recommended to avoid disastrous damage by pests together with the introduction of environmentally sound practices that use selected chemicals such as Fenitrothion, Buprofezin, Dithiocarbamate, Benomyl, if necessary. The farmers should choose the chemicals through consultation with the Agricultural Development Centres and their services. It is recommended to apply these under the guidance of an agricultural extension worker. It is also recommended to organize an Integrated Pest Management system for protection of the crops as well as the environment in the area.

The inputs and labour requirement for the proposed farming practices for each crop are summarized in Table -1. The staggering period for farm operation is determined based on the

balance between the requirement for the proposed practices and the available family labour especially at the peak seasons.

The proper management of livestock is essential in promoting livestock production in the area. It is recommended to produce secondary crops for feed and to construct proper houses for the animals to manage feeding effectively and for the better health condition of the animals. Besides improvement of feed and houses, it is also essential to promote disease control of the animals by an extension of the veterinary services and the breeding of healthy animals.

5.3.3 Anticipated Crop Yield and Production

The present yield of crops in the project area is rather low due mainly to the lack of irrigation water, a shortage of farm inputs, and the low level of supporting services to supply farming techniques and materials. After implementation of the project, the yield of crops would be substantially increased and stabilized after accustoming to the irrigation farming practices accompanied by the agricultural support services. The increase of yield without the project is considered to be insignificant. The research results obtained by the IRRI-Cambodia Project were carefully referred to in setting the target yield of rice. The target yield of crops at the full development stage is assumed below:

(Unit : t/ha)

Crop		Present	Without irrigation*	With irrigation
Rice	Local varieties	1.2	2.5	3.0
	High Yielding Var.	-	-	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 grain. 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.

In order to attain the projected target yield as early as possible by applying the proposed farming practices, it is essential to improve and strengthen the present agricultural supporting services to keep pace with the implementation of the infrastructural development. As some farmers in the area are rather familiar with the new varieties, it is assumed there will be about a 5 year build-up period after the completion of the project works and the starting of proper agricultural support services.

The anticipated rice production in the area at the full target stage is estimated at 11,010 t and 9,280 t for the Kandal Stung and Tonle Bati area, respectively. The present paddy production in each area is estimated at about 2,900 t and 2,400 t, respectively. The increment of rice production by the project is expected at about 8,100 t and 6,400 t for each area, respectively, as shown below:

Irrigation Development Area	Net area (ha)	Planted area (ha)	Production (t)
Kandal Stung	1,950	2,850	11,010
Tonle Bati	1,600	2,400	9,280

The expected production of secondary crops in the Kandal Stung area is estimated at about 810 t of maize, 405 t of soybeans, and about 2,700 t of vegetables. The expected production of secondary crops in the Tonle Bati area is estimated at 720 t of maize, 360 t of soybeans, and 2,400 t of vegetables, shown below:

	Kandal Stung		Tonle Bati	
	Planted area (ha)	Production (t)	Planted area (ha)	Production (t)
Maize	270	810	240	720
Soybeans	270	405	240	360
Vegetables	270	2,700	240	2,400

5.3.4 Anticipated Livestock Production

The anticipated production of livestock is estimated as the increased production of pigs which one a very common animal in the area. The requirement of feed to raise 50 kg of pigs is estimated at about 250 kg of coarse grains. The expected increased production of pigs in the area is estimated as follows:

Priority Development Area	Grains for feed*	Total no of pigs	pigs per household**
	(t)	(head)	(head)
Kandal Stung	360	1,440	0.7
Tonle Bati	320	1,280	1.1

* About 30 % of the production of maize and soybeans are fed to pigs.

** Number of households included in priority development area is about 2,170 and 1,140 in Kandal Stung and Tonle Bati area, respectively.

The increased number of pigs would be about 1,440 heads in the Kandal Stung Priority Development Area, and 1,280 heads in the Tonle Bati Priority Development Area. In the development area, the average increased number of pigs per household is counted at about 0.7 heads in Kandal Stung area, and about 1.1 heads in Tonle Bati area.

5.3.5 Market and Price Prospects

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:

Commodities	Present prices(US$/t)	Prospective prices(US$/t)
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
Pigs	68US$/head	82US$/head
Labour	0.8US$/day	0.8US$/day

5.3.6 Agricultural Benefit

The anticipated agricultural production value increased by the project is evaluated as the agricultural benefit of the project. The increased agricultural production value per ha is estimated as the unit incremental benefit by the project for the Priority Development Areas, as shown below:

	Incremental benefit	
Priority Development Area	Kandal Stung	Tonle Bati
Unit increment(US$/ha)	1,261	1,326
Project area(ha)	1,950	1,600
Total increment(1,000 US$)	2,459	2,122

The anticipated agricultural benefit is estimated at about US$ 2.5 million, and US$ 2.1 million for Kandal Stung and Tonle Bati Priority Development Area, respectively.

The economic agricultural benefit for the Priority Development Area under "without Prek Thnot Reservoir" conditions, the incremental benefit, is estimated at US$ 2.1 million and US$ 1.8 million for Kandal Stung and Tonle Bati areas, respectively.

5.3.7 Farm Household Economy

In order to evaluate the project feasibility in regard to the farmers' household economy, a typical household budget was prepared for the Priority Development Areas under "with and without" project conditions as shown below:

(Unit : US$)

Items	Kandal Stung		Tonle Bati	
	Without project	With project	Without project	With project
Gross income	530	1,635	600	2,640
Production cost	50	158	80	233
Net income	480	1,477	520	2,407
Living expenses	480	1,364	520	1,364
Net reserve	0	113	0	1,043

Without project conditions are referred to the present conditions.

Under "with project" conditions, the net income obtained by the farmer would be sufficient to pay more than 3 million Riel (US$ 1,364) of annual living expenses including food, welfare, and education.

5.4 Agricultural Supporting Services Development Plan

5.4.1 Development Concept

(1) Objectives of support services

The objectives of the agricultural support services in the project area are to extend necessary assistance on the following services in order to increase farm income and to enable the farmers to earn a living through raising crops and livestock production.

a. extension of agricultural technology and techniques
b. agricultural input and equipment supply, rural credit and agricultural insurance system services,
c. technical guidance on operation and maintenance of irrigation and drainage, and rural infrastructures, and
d. extension on life improvement.

(2) Organization strengthening

In order to cope with the prevailing constraints and problems, a comprehensive supporting service system achieved through the strengthening of provided staff and facilities is need. The activation of the existing Agricultural Development Centre in the Tonle Bati area, and the establishment of a new Agricultural Development Centre (Kandal Stung No. 2) in the Kandal Stung Priority Development Area are proposed.

(3) Operation of support services

An operation plan of the centres is formulated taking into consideration the cooperation and coordination of each district office, relevant research stations, development centres and other projects such as IRRI-Cambodia Project, and various activities regarding life improvement in the project area.

It is proposed that the agricultural supporting services initially, will be carried out by the Agricultural Development Centres, operated directly under the management of the Department of Extension. After establishing sufficient qualified extension workers and facilities, it will be transferred to the management under each district office. The proposed operation system of the Agricultural Development Centres for agricultural services are illustrated in Fig.-10.

5.4.2 Agricultural Extension

The proposed agricultural extension services will be provided mainly for food (rice) and some other secondary crops, and livestock raising mainly pigs, poultry and cattle (animal power), through the provision of trained extension personnel, vehicles and equipment, and nearly constructed office buildings.

(1) Extension activities

The key points of emphasis in agricultural extension are summarized as follows:

i) Introduction of improved varieties:

The introduction of improved and recommendable varieties selected by the experiments of the agricultural research stations and IRRI project activities.

The execution of simple trials and a demonstration cultivation of the introduced varieties in the project area, to confirm their suitability to the conditions in the area.

ii) Supply of planting materials

Multiplication and supply of introduced crop varieties required by the farmers. The multiplication will be carried out by the contracted leading farmers in their field.

iii) Demonstration and guidance on cultivation techniques

Demonstration and guidance for the cultivation of crops including improved nursery management, type, rate, timing and methods of applying of fertilizers and pesticides, pest surveillance, communal rat control, and water management including irrigation and drainage.

iv) Extension on livestock production

Education on the potential and methods for increased production, improved nutrition and disease control, housing construction, and basic breeding guidelines,

v) Strengthening of vaccination service

Vaccination for the animals will be extended using animal health mobile units organized by the agricultural development centres, and the supply of facilities and equipment such as cold stores and veterinary appliances, and

vi) Monitoring and evaluation

Monitoring and evaluation of the results obtained through the agricultural services activities should be executed to obtain further feed back for the continued improvement of the agricultural support services.

(2) Proposed staffing for agricultural extension

The proposed Agricultural Development Centres will be the base for the agricultural extension work, and the number of extension workers is estimated at seven (7) and three (3) for the Kandal Stung No. 2 and the Tonle Bati Development Centre, respectively, as follows:

Agricultural Development Centre	Gross Area	Covered Communes	No.of Village	No. of Family	Proposed No. of Field worker
	(ha)	(No.)			
1.Kandal Stung No. 2 (Newly proposed)	2,400	7	26	2,170	7
2.Tonle Bati (Existing)	1,830	4	9	1,140	3

The required number of field extension workers is estimated on the following assumptions:

i) The number of families to be covered by one field extension worker is proposed to be about 300 to 400.

ii) The farmers groups to be covered by one field worker is assumed to be about 10 to 16, and each farmers group is composed of about 25 to 30 farm households.

iii) The working schedule for field workers is:

a. Visit one group twice a month,

b. Visit two groups a day,

c. 4 field working days per week,

d. 2 days a week training and study for the worker,

The proposed number of field extension workers to be assigned to each agricultural development centre and their specialities are summarized as follows:

Specialities	Kandal Stung No.2	Tonle Bati
Rice/Secondary crops	3	1
Horticultural crops	2	1
Livestock/Veterinary	2	1
Total	7	3

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

(3) Facilities and equipment

The Agricultural Development Centres will serve as a home base for the field extension workers. The community halls established in each commune will be used by the field offices for the training of farmers. A residence for the worker will be provided near the community hall. The training of the farmers groups will mostly be carried out at the community hall. The offices, buildings and facilities required are summarized in Table -2.

5.4.3 Agricultural Input Supply and Market

The key points for the improvement of the input supply system are:

a. to supply required inputs to the whole project area by CCAM through the Agricultural Development Centres, and
b. to strengthen the storage and handling capacity of the Agricultural Development Centres to meet the requirements,

The required capacity of storage is 700 t of fertilizers and 7.8 kl of chemicals for the Kandal Stung Priority Development Area and 600 t of fertilizers and 6.4 kl of chemicals for the Tonle Bati Priority Development Area. The proposed input supply system is one of section of the Agricultural Development Centre.

It is recommended to establish: farmer organizations similar to agricultural cooperatives for marketing, by transferring the input supply function and facilities of the Agricultural Development Centres to the farmers organizations, in the future.

5.4.4 Agricultural Credit and Insurance Services

(1) Credit Services

The MAFF(Department of Extension) is proposed to be the implementing institution of the credit program, and the Agricultural Development Centre will be the contact point for the borrowers. For implementing the credit program, it is important to motivate the farmers by informing and discussing the credit system with them. The program should be implemented and funded based on where the credit is really needed. The following kinds and categories of activities to be covered by the credit, taking into consideration the experiences observed by NGOs in the area, are proposed:

a. Rice for home consumption, especially from planting time to before harvesting,

b. A small amount of investment for income-generating activities such as livestock raising, home vegetable gardens, small businesses, etc. and

c. Inputs for farming especially for fertilizers and improved seed.

The proposed credit system is a kind of "small farmers development credit" or "credit for the poor". The borrowers should be limited to the poor, not relatively rich farmers. In the light of experiences by NGOs such as WVI and WCC in the area, the borrowers should be organized into solidarity groups that provide mutual support and are responsible for repayment. The size of one group will be about 10 to 15 members. The credit should be channelled through the groups for delivery and repayment, assisted by the agricultural and rural improvement extension workers of the Agricultural Development Centres.

For the sustainable and effective operation of the program, some strategies and activities by the implementing institution should be carefully considered; adequate and appropriate training and preparation of borrowers, assurance of subsequent loans upon repayment of old loans, and effective savings mobilization.

(2) Insurance

It is recommended to implement Government agricultural insurance system as a public policy measure to promote general welfare among the people and the sector, and as a kind of social insurance to ensure security and reduce risks. With the success of the proposed credit services and the development of the community through mutual aid, the effective mobilization of savings, the formation of a fund, and sufficient institutional capacity of implementation, the fund can also be used for mutual aid or mutual insurance when some members suffer from crop losses, etc.

5.4.5 Agro-processing

The main product under "with project "conditions will be rice. Rice milling will be the main processing activity in the future. The free marketing system has been applied and the processing and marketing of rice is handled mostly by the private sector. There are sufficient milling machine, in the area. Marketing of rice is usually directly from the paddy and the milling of rice is mainly for home consumption. Government intervention in these activities will not be necessary.

5.4.6 Farmers' Organization

The basic concept for the development of a farmers' organization is to carry out various supporting activities through the proposed Agricultural Development Centres, including the operation and management of irrigation facilities and rural infrastructures, rural life improvement, community development, and the promotion of agricultural production. There is no effective farmers' organization in the area at present. The following are the groups to be established:

a. Water users' association (irrigation water)

b. Drinking water supply group (wells)

c. Small farmers' credit group

d. Cultivation techniques study group

e. Life improvement leading group

f. FHH/women's group

(1) Water users' association (irrigation water)

Water users' group of beneficiaries will be established for the operation and management of on farm irrigation facilities and will be integrated with the water users' association. The formulation of the group is designed based on the proposed layout of the irrigation systems and water sources. Preferably, one group averaging 7-10 families will be formulated at the quaternary canal level. A water users' association will be instituted by organizing the groups of one (1) irrigation block which cover an average area of 400 ha..

The main activities of the association are the clearing and maintenance of irrigation and drainage canals below the tertiary irrigation blocks, and the scheduling of water deliveries within the control area. It is recommended to start organizing the groups at the planning stage of the project. The water users' association will receive technical guidance and instructions from the Agricultural Development Centres.

(2) Drinking water supply group

The principles for the formulation of drinking water supply groups are as follows:

a. One users' group for one well,
b. To prepare a proposal for well construction, and to implement the well with the assistance of the life improvement section of the Agricultural Centres,
c. To be responsible for the appropriate use and maintenance of the facilities.

(3) Small farmer's credit group

The principles for the formulation of small farmer's credit groups are as follows:

a. The group will be responsible for the disbursement and repayment of the credit,
b. To prepare a proposal for the formulation of the credit group in order to apply loans for farm inputs, pigs and poultry raising, materials for home gardening, retail shops and small business, etc.

The current system used by the existing Agricultural Centres in cooperation with NGOs, will be taken into account in organizing the credit groups. It is proposed that the credit services will be managed by the supply and marketing section of the Agricultural Development Centres.

(4) Cultivation techniques study group

For the effective extension of crop production techniques to the farmers, it is recommended to formulate a farmers' study group for cultivation techniques. The members of the group will be leading farmers and the main activities will be to introduce improved varieties and techniques, to demonstrate to other farmers under the guidance of the extension workers, and to help the extension workers as grass roots coordinators for the agricultural extension work in the area. It is recommended to organize one group per commune.

(5) Life improvement leading group

For the establishment of a better rural life, it is essential to motivate the co-operative activities of the people in a community. It is proposed to organize life improvement leading groups for effective life improvement extension work. The size of each group will be about 20 members, sharing common objectives to improve their rural life. The group will be formulated through meetings or participation in field workshops which are proposed to be organized for each commune.

(6) FHH/women's group

The Khmer Women Association wii be used as a vehicle to promote the grass roots organization of women. The activities of the women's organization will be effective, especially in regard to hygiene and health in the home life. The organization will be effective for the small farmers' credit scheme in the area of home gardening and the raising of pigs and poultry. The establishment of FHHs group is necessary for receiving special care from the Agricultural Development Centres for to improve life and to promote agricultural production.

5.4.7 Strengthening of the Agricultural Development Centre

All of the proposed agricultural support services will be extended through the proposed Agricultural Development Centre . The proposed organization of the Agricultural Development Centre is shown in Fig. 10. Each centre will be composed of 5 sections. Agricultural Extension, Supply and Marketing, Life Improvement, Operation and Maintenance, and Administration. Each section has a section chief supported by the staff and facilities proposed for each service activity in the Priority Development Area.

(1) Kandal Stung No.2 centre

This centre is proposed to be newly established and provided with staff and facilities to cover the Kandal Stung Priority Development Area. The proposed command area of farm land is about 1,950 ha (rice field), comprising of 7 communes. Anlong Romeat, Rolous, Preas Puth, Kong Noy, Teang, Bakou and Kok Trop, and 2,170 families.

(2) Tonle Bati Agricultural Development centre

The existing Centre has been operating for the Tonle Bati Study Area of about 5,700 ha. The proposed strengthening of this centre is for only 1,880 ha of the Priority Development Area. The proposed objective area comprises 4 communes. Champey, Put Sar, Kraing Thnung, and Kandeong, and 1,140 families. The proposed staffing includes the present staff.

The organization, staffing and facilities proposed for each Centre are summarized in Table -2.

5.5 Irrigation and Drainage Development Plan

5.5.1 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%

Design diversion water requirements calculated are shown below.

a. Unit design diversion water requirement with 80 % dependability for the main system

: 1.40 l/sec/ha

b. Unit design diversion water requirement for the tertiary system

: 1.72 l/sec/ha

(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 l/sec/ha.

5.5.2 Water Balance in the Prek Thnot Basin

(1) Kandal Stung Irrigation Project Area

The main irrigation water source of the Kandal Stung priority project is runoffs from the Prek Thnot River after sharing the irrigation demands of the existing irrigation schemes upstream. It is taken from the Kompong Tuol site on the right bank of the Prek Thnot river.

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 of 1,950 ha would be served 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 as it does not have a 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.

The following is a summary of the water balance of the basic year 1968, as shown in Fig.11.

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

(2) Tonle Bati Irrigation Project Area

The irrigation water source of the Tonle Bati area is the Tonle Bati River and lake storage, but the storage of the lake dramatically reduces in the dry season. To increase the irrigation area of the Tonle Bati area, augmentation of the irrigation water is inevitable. The Department of Hydrology has prepared an irrigation plan which will augment irrigation water to the Tonle Bati area using,

i) a localized multi-reservoir plan consisting of the Stung Toch, Saba and Kok Tel reservoirs, all of which are linked by a dike.

ii) a connection canal (NS 78) plan to make a direct connection from the Tonle Bati River to the Prek Thnot River through the Stung Toch River.

The augmentation plan was assessed in due consideration of the irrigation plan and environmental situation for each reservoir as follows:

a. *Stung Toch Reservoir :* the creation of a Stung Toch reservoir is not considered under the condition of a revised intake water level.

b. *Kok Tel Reservoir :* a Kok Tel reservoir water level would be 10.5 m, causing inundation of farm land.

The irrigable plan was examined using the water balance simulation of the alternatives of "without and with" the Kok Tel reservoir.

The water balance simulation indicates the following. The "without Kok Tel reservoir" case will supply irrigation to an area of 1,600 ha. Run-of-river water of the Prek Thnot, however, sharply reduces in the dry season, reducing the supply from the Prek Thnot River through the connection canals. It's necessary to pump 20 % of the annual water requirement for dry season irrigation. On the other hand, the "with Kok Tel reservoir" case will ensure gravity irrigation throughout the year for an area of 1,600 ha. However, if the Prek Thnot dam is completed quickly, the Kok Tel dam, which will be expensive to and will create construct environmental concerns, will not be justified.

The implementation schedule of the Prek Thnot Multipurpose Project is not formulated at present, and it is not clear when the Prek Thnot reservoir will become operational. In this context, the irrigation development "without the Kok Tel dam" using augmented water from a connection canal, was selected for the Tonle Bati Study area.

5.5.3 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) General Design Consideration

The rehabilitation plan of the Kompong Tuol irrigation intake consisting of the Tuk Thla regulator, the Kompong Tuol regulator, the National Road No. 3 dike, and other related facilities determined from five alternative cases, and the preliminary design, is conducted on the basis of the following considerations:

i) Uncertainty of Flood Flow Condition
ii) Design Flood Discharge without Prek Thnot Dam
iii) Flood Water Level (13.5 m) and Normal Water Level (11.5 m) at the Kompong Tuol Regulator
iv) Levee along the right and left banks of the Prek Thnot River

(3) Geological and Soil Mechanical Conditions at the Site

The geological conditions of the Tuk Thla regulator, the proposed Kompong Tuol regulator and the road dike sites are summarized as follows:

i) Tuk Thla Regulator Site

There are medium to fine dense sand layers up to an elevation of about 5 m. The sand layer is slightly permeable, and slightly dense, having an N-value of 20 to 30. Firm fine sandy layers underlie the pervious sand layers, which show N-values of 30 to 50.

ii) Kompong Tuol Regulator Site

The geology of the site consists of loose to soft sand layers with an N-value of 5 to 20 and are relatively high pervious. It exists above about +2.0 m in elevation. Firm sandy silt layers underlie the lose sand layers, having N-values of 30 to 50 and being less pervious. The thickness of the firm layer is about 3 m.

iii) National Road No. 3 Dike Site

This site is underlaid by a firm to solid sandy silt layer (less pervious), a dense silty sand layer (highly pervious), and a soft to loose sand layer (highly pervious). The highly pervious sand layers are continuous from upstream to downstream at the proposed embankment site and are susceptible to piping under a raised water level condition. The soils found in the high water channel near the site are fine grained. These soils are not suitable for embankment materials because they are highly dispersive, and less effective in compaction. So far as the results of the soil test on the mixture of in-situ materials with laterite or gravel soils is concerned, dispersiveness of the in-situ materials is not improved.

(4) General Features of the Proposed Works

i) Design Discharge and Water Levels

The design flood discharge and water levels for the rehabilitation of the Kompong Tuol intake is set as follows:

a. Flood Discharge at 100-year return period without Prek Thnot dam :1,900 m^3/sec
b. Normal operations water level :EL.11.50 m
c. Allowable maximum flood water level :EL.13.00 m

ii) Tuk Thla Regulator

The gate portion will be replaced with a new structure. The existing bridge for the National Road No. 3 and stilling basin are used, 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 discharge.

iii) Kompong Tuol Regulator

The existing regulator will be demolished and replaced with an embankment. The proposed site is selected near the original river course where the river flow is concentrated. The proposed regulator will consist of five motor driven roller gates, 6 m wide and 5 m high and a road crossing bridge. The piers and bridge are supported with concrete piles. Sheet piles under the piers will be needed to stop seepage. The base level of the gates is determined to be 6.6 m in elevation on the basis of the present river bed, which is 1 m below the bottom level of the existing Kompong Tuol regulator. This regulator will share the release of 650 m^3/sec of the design flood discharge.

iv) Overflow Type Spillway

This spillway is provided to release flood water exceeding the capacities of the two regulators. The required design capacity of the proposed spillway is 850 m^3/sec. The proposed spillway will be provided at the north side of the proposed Kompong Tuol regulator. The proposed cross section is of a trapezoidal earth embankment covered with thin concrete and sheet piling will be provided to stop seepage. A stilling basin will be provided downstream of the overflow section. The embankment will be constructed using selected soil materials transported from other areas.

v) National Road No. 3 Dike

The high embankment between the Kompong Tuol regulator and the old river channel is liable to fail when high reservoir levels are maintained. A new embankment is located directly upstream from the existing route. Sheet piling will be provided under the dike to stop seepage. The embankment will be constructed using selected soil materials transported from other areas.

vi) Flood Dikes along the Upstream Right and Left Bank

The present flood dike located on the right bank of the Prek Thnot River is improved by re-shaping of the embankment and covering with laterite. The left bank embankment will be extended to the village road. Lowered crest portions will be provided for both dikes to lessen flood damage in the areas.

vii) Radio Communication System

The present water management of the irrigation system including regulators on the Prek Thnot River was made by the respective provincial or district offices. To create an 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 at 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 initialed

vii) Improvement of Related Facilities

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

The general features of the rehabilitation of the Kompong Tuol intake are shown below. The general layout of the rehabilitation works is shown in Fig. 12.

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 Right Upstream Banks	Length of 4 km and 1 km for right and left banks dike crest width 4 m
f)	Radio Communication System	Main, branch and two site stations

5.5.4 Kandal Stung Irrigation Project

(1) General Design Considerations

In the design of the irrigation and drainage systems, the following design considerations are taken into account :

i) Available River Discharges to the Project Area
ii) Intake Water Level (11.5 m)
iii) Small Scale Pump-up Irrigation Area Upstream of the Main Canal
iv) Separate Irrigation and Drainage System
v) Irrigation Development Plan in consideration of the Future Development Area

(2) General Features of the Proposed Works

i) Irrigation System

The proposed irrigation and drainage systems are based on the existing irrigation system with modification, to the canal layout, canal sections, and discharge/water level control structures. The preliminary irrigation and drainage canal system layout is shown in Fig.13.

ii) Improvement of Canals

The following works are required for the respective canals:

- Main and Lateral Canals

  a. Slope protection for the existing main canal by means of a 2 phase concrete lining, and for the existing lateral canal by means of canal lining,

  b. Sod facing for canal and embankment slopes,

  c. Re-shaping of canals' cross sections with the removal of sediments and earthfill used for embankments,

  d. Improvement of inspection roads by using laterite pavement.

- Related Structures

  a. Installation of gates at check structures, diversion structures and turnouts,

  b. Repair of canal sections downstream of the structures' slope protection,

  c. Provision of required structures or structure parts where not yet provided,

  d. Replacement of severely damaged structures.

iii) Drainage System

The drainage canal system consists of major drains and tertiary drains. The function of the major drains is to transport water from tertiary drains and flood water from surrounding areas to the disposal points. The proposed drainage layout is based on the Pol Pot canal system. The drainage canal layout is based on the topographic maps at a scale of 1:5,000 which were prepared during this study period in 1994, and supplemented by the canal layout prepared by the DOH. The drainage layout of the Project is shown in Fig.13.

The structures related to the drainage canals are bridges, culverts, and closing bunds. Bridges are provided at the road crossing points.

iv) Tertiary Development

To ensure equitable water delivery to the tail end of the main and lateral canal system, unification or division of the existing tertiary blocks is needed. According to the proposed main and lateral canal system layout, tertiary blocks will command an average of 50 ha.

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 (basically 7 blocks). The quaternary block is served by its respective quaternary canals. The recommended size of one quaternary block is 7 to 10 ha.

The quaternary canal is a terminal system. Irrigation water to be carried by this canal is distributed directly to the fields. The end of a quaternary canal is connected to a nearby tertiary drainage canal in order to drain off excess water. The average interval of a quaternary canal is 100 m.

The structures required for the tertiary block will include: division boxes, measuring devices such as a Parshall flume type, and culverts.

v) Demonstration Farm

A demonstration farm is proposed for the purpose of demonstrating the effects of the improved irrigated agriculture and as a base for the further expansion of the development of the project area. The main objectives of the demonstration farm one as follows:

a. Establishment of a water users associations and the introduction of efficient on-farm water management

b. Demonstration and Guidance of Cultivation Techniques

The location of the 265 ha demonstration farm is upstream of the main canal command area in consideration of (a) a reliable water supply, (b) a high demonstration effect, and (c) efficient extension services. The demonstration farm will be provided with the tertiary canals and the quaternary canal system using land levelling.

The general features of the proposed project works of the irrigation and drainage system are summarized below.

Description		Work Quantity
Irrigation canal		
Main canal		
- Improvement of main canal	(km)	5.3
Lateral		
- Improvement of existing lateral	(km)	82
- Construction of lateral	(km)	40
Tertiary canal	(km)	56.8
Quaternary canal system	(ha)	1,950
Drainage canals		
Main canal	(km)	18.1
Tertiary canal	(km)	64.6

5.5.5 Tonle Bati Irrigation Project

(1) General Design Consideration

In the design of the irrigation and drainage systems, the following design considerations are taken into account :

a. Available River Discharges to the Study Area

b. Tonle Bati Lake Water Level (7.80 m)

c. Pump Irrigation in the Low Water Period of the Tonle Bati Lake

d. Priority Pump Irrigation in the Elevated Area in the Dry Season

e. Separate Irrigation and Drainage System

f. Future Development Area

(2) General Features of the Proposed Works

A. Irrigation System

The proposed irrigation systems are based on the existing irrigation system with modification to the canal layout, canal sections, and discharge/water level control structures. The preliminary irrigation canal system layout is shown in Fig.14.

i) Canal and Related Structures

The following works are required for respective canals:

a. Main and Lateral Canals

- Slope protection for the existing main canals by means of a 2 phase concrete lining, and for the existing lateral canals by means of concrete lining,
- Sod facing for canal and embankment slopes,
- Re-shaping of canals' cross sections with the removal of sediments and earthfill used for embankments,
- Improvement/provision of inspection roads by using gravel metalling.

b. Related Structures

- 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.

ii) Activation of the Tonle Bati Lake Related Structures

The water levels of the Tonle Bati Lake will be lowered in the dry season even if 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. The required pumping-up water will be about 20 % of the annual irrigation demand, as shown in Fig.15. The pumping station and intake will be improved. The intake will be provided with three slide gates and the improvement of the concrete structures.

a. Improvement of the Intake

Three slide gates, 2.0 m wide and 2.0 m high, will be installed, to enable adjusting of the discharges through the intake and to stop reverse flow from the canal to the lake during the pumping-up. The concrete structures will also be improved.

b. Improvement of the Pumping Station

Four sets (including one spare set) of horizontal volute type pumps will be installed with a capacity of 45 m^3/min, a total head of 4.5 m, and 30 kW at the existing pumping station. The pumps are driven by diesel engines.

c. Improvement of the Spillway of the Tonle Bati Lake

The bridge for the National Road No. 2, which is located immediately downstream of the spillway and is severely damaged, will be replaced.

d. Improvement of the Lake Dike

The existing dike surrounding the lake is insufficient in elevation and is eroded at places. Heightening and slope protection by sodding will be provided. The extension of the dike will be made to protect the Pagoda.

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

a. Improvement of NS 78 Canal

The flow capacity of the canal is determined to be 7 m^3/sec in consideration of the future extension of the Tonle Bati area. The 4.6 km canal concernd to the Tonle Bati River will be re-excavated and the spoil bank will be improved. An inspection road will be provided with laterite surfacing on the left bank. To prevent erosion of the damaged dispersive soils section, 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. 3. The regulator is a combined structure with a concrete weir and three gates. An intake with three slide gates for the connection canal to the Tonle Bati River will be constructed adjacent to the right bank wall. The total capacity of the intake will be 7 m^3/sec.

B. Drainage System

The drainage canal system consists of major drains and tertiary drains. The function of the major drains is to transport water from the tertiary drains and surrounding areas to the Cheung Loung lake or the Pol Pot drainage canals. The proposed drainage layout is principally based on the Pol Pot canal system. The drainage canal layout is based on the topographic maps at a scale of 1:10,000 which were prepared during this study period in 1993, supplemented by the canal layout prepared by the DOH. The structures related to the drainage canals are bridges, culverts, and closing bunds. The drainage layout of the Project is shown in Fig.14.

C. Tertiary Development

The commanding area of the existing tertiary canal range from 30 to 100 ha, and average 65 ha. Tertiary canals are provided in parallels at intervals of 500 m to 800 m. To ensure equitable water delivery to the tail end of the main and lateral canal system, unification or division of the existing tertiary blocks is needed According to the proposed main and lateral canal system layout, the tertiary block will command an average of 47 ha.

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 (basically 7 blocks). The quaternary block is served by their respective quaternary canals. The recommended size of one quaternary block is 7 to 10 ha.

The quaternary canal is a terminal system. Irrigation water to be carried by this canal is distributed directly to the fields. The end of a quaternary canal is connected to a nearby tertiary drainage canal in order to drain off excess water. The average interval of a quaternary canal is 100 m. All the quaternary canals, except the canals to be

constructed at the highest elevation of the respective areas are designed where possible to have a dual function, irrigation and drainage.

The structures required for the tertiary block will include division boxes, measuring devices such as a Parshall flume type, and culverts.

D. Demonstration Farm

A demonstration farm is proposed for the purpose of demonstrating the effects of the improved irrigated agriculture and as a base for the further expansion of the development of the project area. The main objectives of the demonstration farm are as follows:

a. Establishment of a water users associations and the introduction of efficient on-farm water management

b. Demonstration and Guidance of Cultivation Techniques

The location of the 259 ha demonstration farm of is in the command area of the M3 main canal at the following tertiary blocks in consideration of (a) a reliable water supply, (b) a high demonstration effect, and (c) efficient extension services. The demonstration farm will be provided with the tertiary canals and the quaternary canal system using land levelling.

The general features of the proposed project works of the irrigation and drainage system are shown in Table -3 and are summarized below.

Description		Project Work
Irrigation Canals		
- Main Canal	(km)	8.3
- Lateral	(km)	10.0
- Tertiary Canal	(km)	48.1
- Quaternary Canal System	(ha)	1,600
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 Canals		
- Main Canal	(km)	24.1
- Tertiary Canal	(km)	41.8

5.5.6 Operation and Maintenance of the System

(1) Organization for 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 to be operated and maintained includes the Tuk Thla and Kompong Tuol regulators, the irrigation canal system, and the drainage system up to the outlet of the drainage canals. Responsibilities for the operation and maintenance of the irrigation and drainage systems will be broadly divided into two types of administrative bodies, a government operation body responsible for the head regulator and lateral systems, and the water users associations responsible for on-farm irrigation and drainage systems within the tertiary blocks. The proposed O&M organization is shown in Fig.16.

The government body will be divided into two; the central government and the provincial government bodies. DOAHH will be responsible for the operation and maintenance of the Tuk Thla and Kompong Tuol regulators, and of the Tonle Bati lake related facilities, and the Provincial Offices of Agricultural Hydraulics and Hydrometeorology of Kandal and Takeo provinces will be responsible for the main and lateral canal system, in the Kandal Stung and Tonle Bati irrigation system.

The Water Management Office of DOAHH will carry out O&M of the Kompong Tuol intake. The Kandal and Bati district offices will carry out O&M of the main canal and the lateral canal systems in their administrative areas. Each government office will have to establish three units for the Project O&M; operation, maintenance and administration.

The operation unit will be responsible for operating the facilities and for delivering the water to their outlets in accordance with the irrigation schedules. The maintenance unit will be responsible for maintaining the facilities, and maintenance work will be done in close coordination with the operation schedule. The administrative unit will be responsible for applying the system's regulations and for billing water charges.

Prior to the implementation of the irrigation works, a water users association will be organized in each tertiary block, averaging a command area of 50 ha.

At the provincial and district government levels, provincial and district irrigation committees will be organized to co-ordinate the smooth operation and maintenance of the irrigation system and the water management of the Project. These will consist of representatives of the provincial or district government offices, including the Agriculture office, the Public Works office, and the Rural Development office.

(2) Irrigation Schedule and Supply

The O&M section will prepare a seasonal water distribution schedule including rotational blocks for dry and rainy season cropping. It will submit the prepared irrigation schedule to the chairman of the Irrigation Committee for its approval. After approval, the irrigation schedule will be announced to the water user' association before commencing crop cultivation. Continuous water distribution is employed at the peak requirement period of the Project canal. Two irrigation rotation blocks and a 15-day time lag will be adopted in the seasonal irrigation schedule for early rice cropping and local rice variety cropping. Four rotational blocks will be applied for the fully cropped season. Gate operation with intervals on a half month basis will be made by gate keepers principally in accordance with the irrigation schedule, and sometimes adjusting to the rainfall conditions. Irrigation supervisors of the O&M Office will check the gate operation in the field. The water management from the tertiary block is made up by the water users' association. The water supply in the tertiary system will be made principally on a rotational basis.

(3) Maintenance Plan

Maintenance works of the irrigation system will be divided into two categories routine maintenance, and periodical maintenance. Routine maintenance works will be frequent and on a small scale, throughout a year. Periodical maintenance will be more intensive, and on a large scale during the water cut period. The water cut will be made between the end of irrigation for the second cropping to the start of irrigation for the rainy season cropping.

Immediately after the irrigation cut, the staff of the O&M section will inspect the actual condition of the canals and structures under water, and judge the necessary repairs. Based on the result of the inspection, a periodic maintenance work program will be prepared, together with a budget estimate. The major periodical maintenance work will be desilting the canals and structures, canal embankment repairs, structure and gate repairs, and the greasing of gates. Routine maintenance works will be minor works such as grass cutting, and desilting work of the smaller structures. These periodical and routine maintenance works will be carried out directly or with hired labour under the supervision of the O&M section.

Urgent repair may be required when the canal system faces serious damage or unexpected forces are likely to lead to system failure.

5.6 Rural Life Improvement Plan

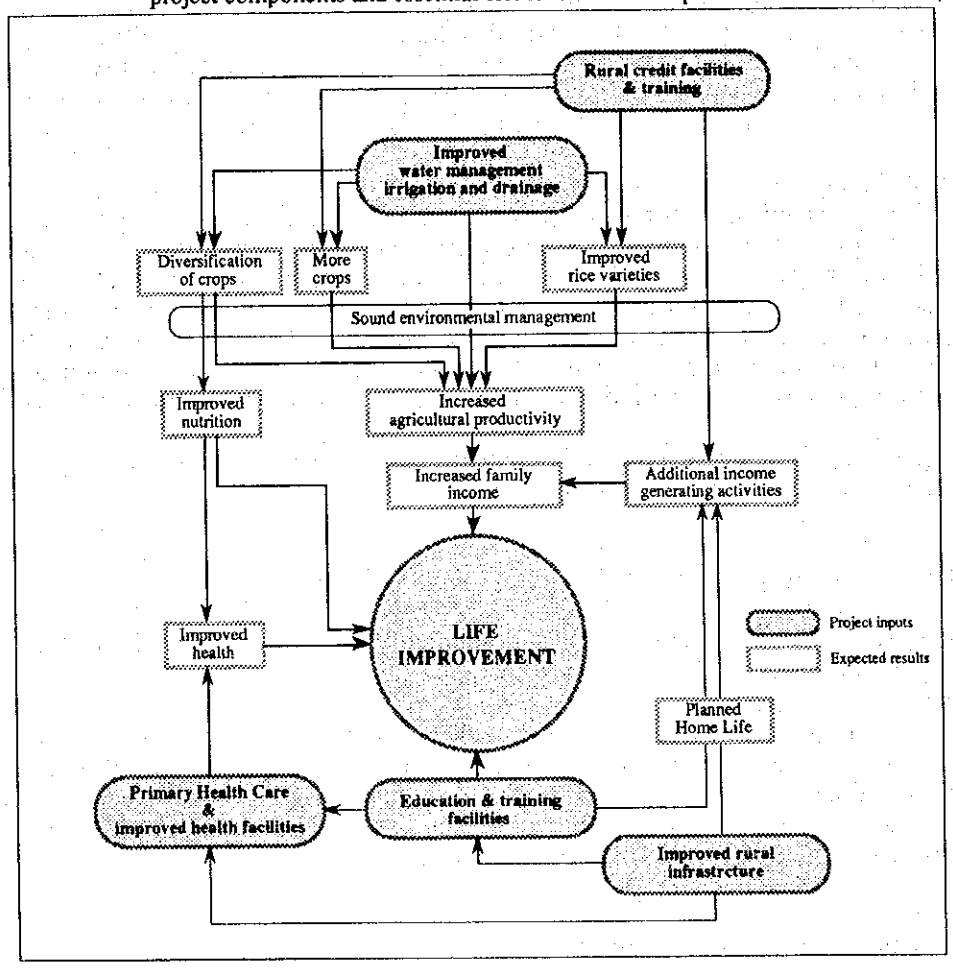
Increased income alone does not automatically mean an improved lifestyle. Other equally important factors must be considered.

In this envisaged project an attempt is made to balance these factors by investigating the potential of income generation through increasing and/or expanding agricultural and non-agricultural production and the services required to support this process, and implementing strategies in order to improve the level of nutrition, health, and education. In doing so, it is assumed that living conditions will improve more comprehensively.

5.6.1 Essential Elements of Life Improvement

A conceptual framework -in which the components of the envisaged project and the essential elements for life improvement are interrelated- is presented below:

Diagram 5.6.1: Conceptual framework:
project components and essential elements for life improvement



(1) Raising the Family Income

In the study area several ways in which the family income can be increased, are considered:

i) In view of the fact that most adults in the study area are farmers it is assumed that their income will increase substantially by an increasing agricultural productivity. Increased agricultural production in the area is largely dependent on the proper management of available water during the wet season. Unpredictable rainfall and flooding govern the success or failure of crops. In particular, the process of successful rice cultivation - the most dominant crop grown in the area - requires a reliable and timely availability of the right quantity of water in the right place. The proposed irrigation and drainage system (see elsewhere in this report) is designed in such a way that this can be achieved, thus optimising the conditions related to the current rice production capacity. This will have a positive impact on the family's position, particularly in relation to the uncertainties involved in rice production in the area; and, possibly, contribute to an increase or stabilisation in family income -at the lowest possible cost- since the risk of loosing valuable inputs (both in terms of labour and other resources) will be minimised.

ii) A next or simultaneous step requiring additional inputs is the introduction of improved varieties of rice (HYV: High Yielding Varieties) to increase the yield per ha of the cultivated land. This intervention needs to be carefully considered and prepared since it

involves a certain amount of risk-taking by the farmers. It is generally accepted that families who live on or below subsistence level (the majority of the population in the study area) are reluctant to change existing patterns and practices unless some form of guarantee is instituted. Setting up adequate and accessible credit facilities - including some training for farmers in basic accounts- is envisaged as a possible solution.

iii) Although the population in the study area is mainly pre-occupied with increasing the production of rice, a diversification of crops (including vegetables) would not only potentially contribute to the family's income, but also help in improving the nutritional status of the population. In the situation where there is a limited quantity of water available, it is recommended to consider concentrating on other, less water-demanding crops, particularly in the dry season and on soils which turn out very low yields of rice. And, although several families expressed interest in this proposition, this will need considerable awareness raising in the priority project area.

iv) Other income-generating activities such as pig and poultry raising, fruit trees, sugarpalms, kitchen gardening, and small businesses and rural industries (food/fruit processing, tile and brick making) will be promoted to provide additional sources of cash income. In particular where there is also a chronic lack of available manpower (such as in FHHs) this, combined with appropriate (vocational) training, credit, and other facilities, might prove feasible.

(2) Improving the Nutritional Status of the Population

The nutritional status of the population in the study area (and indeed in Cambodia) is of concern to most agencies involved in this field. The FFP (Family Food Programme, sponsored by UNICEF and implemented with the assistance of the WFP and the Khmer Women Association) specifically targets poor families with children under five and FHHs. The intended priority project would benefit from co-operation with these relevant organisations, particularly in reaching the most vulnerable groups. Most probably, the project could contribute to attaining food security and improved nutrition for those groups as an integral part of its activities.

(3) Improving the Health Status of the Population

At the more general level of the overall health status of the population in the study area it should be noted that, through the district hospitals, NGOs in both districts are active in the Primary Health Care (PHC) field (WVI and 24 Hour TV in the Kandal Stung District; JOCS in the Bati District). Their activities include improvement of the domestic water supply, sanitation, vegetable gardening, vaccinations, and family planning. In view of the deplorable situation existing in the area, the priority project envisages to support these interventions in close co-ordination with the concerned agencies.

(4) Literacy, Education and Vocational Training

Enrolment figures suggest that a large proportion of children go to primary school. In the adult population illiteracy has been observed in both men and women, affecting a larger proportion of women than men. However, according to the KWA officer in the Bati District who runs a small UNICEF supported literacy programme for women, interest in literacy training is not very high. At present it is assumed that literacy training will be carried out in the course of vocational training, particularly in relation to the income-generating activities envisaged in the priority project.

5.6.2 Proposed Life Improvement Plan

The ultimate target of the life improvement plan is to realize substantial and sustainable improvement of the living environment of the people. As mentioned in the preceding section, in order to overcome the problems and constraints in the living conditions of the project area, the improvement and adjustment of rural infrastructures including irrigation and drainage facilities, rural road networks, rural water supply facilities, school and community halls, and health services, would be carried out by firstly taking the socio-economic circumstances into account. Simultaneously, the improvement plan of the living environment is put forward. The essential elements of the life improvement plan and these concepts are illustrated in Fig. 5.6.1, and the practical improvement and extension plan is stated below.

(1) Life Improvement Plan and Activity

i) Improvement in Food and Nutrition

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

a. Promotion of Crop and Livestock Production

- attainment of food and balanced nutrition by the intensification and increase of the stable food crop, secondary crops, livestock raising and vegetables for home consumption.

b. Educational life improvement extension

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

ii) 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;

a. Infrastructure

- Improvement of domestic water supply system and facilities

b. Livestock raising method

- Improvement of animal raising methods concerned with hygiene.

c. Educational extension

- Improvement of toilet facilities.
- Establishment of a regulation to control the living environment.

iii) 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, sewing, mechanics, and hairdressing. The key point envisaged

to carry out these measures is to formulate leading groups to initiate practices of these activities.

iv) Improvement of Farm Household Management

The main items to be covered by this measure are the following;

a. Education on the role clothing in promoting a safe, healthy life and practical training on achieving this.

b. Training on basic account and record keeping of home life activities such as income and expenses.

v) Community Development

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

a. Promotion of people's participation at the planing stage of the programmes.

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

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

vi) Improvement of Supporting Services

The measure required for this element is;

a. to strengthen the support services by reactivating and improving the Agricultural Development Centre in the Tonle Bati area and by establishing an agricultural development centre in the Kandal Stung area, and

b. to carry out almost all services and programmes for life improvement extension work in co-operation with the agricultural support services.

It is essential that practical improvement activities are carefully executed in close contact with the people concerned in due consideration of their organizational and financial capabilities, necessity and priority, as well as the demand of the people. The essential element in the initial stage of the project implementation is the stabilization of an economic base through the promotion of agricultural productivity and the strengthening of support services in life improvement extension activities. After the, above plan and programme are to be concretely implemented. It is further proposed that a basic study on life improvement will be carried out to systematically grasp the life environment in the project area and to provide for a more effective life improvement.

(2) Strengthening of Support Services

i) Staffing

In order to implement and firmly sustain the social development organization, a life improvement/social development expert and local assistants will be assigned to the Agricultural Development Centre at the very beginning of the implementation stage. At the Khum level, a life improvement extension worker is to be assigned. In the initial phase it is essential that a detailed household survey in each village is to be carried out in close co-operation with the village chief, school teachers, leading farmers, etc. who will play an important role in the life improvement leading group. The life improvement expert and his assistants are required to be in close contact with staff from

the District Office, health services, agricultural extension services, irrigation/drainage offices, etc., as required. For specific technical consultations and workshops, each required specialist would be invited. The following table shows the proposed staff in the Agricultural Development Centre corresponding to the number of people commanded.

Agricultural Development Centre	Number of Communes	No. of Villages Covered	No. of Families	No. of Workers
Kandal Stung No. 2	7	26*	2,170	3
Tonle Bati	4	9	1,140	2

* including 2 villages in the Kok Trop commune.

Note: Basis of Expert estimated is as follows;

- No. of Families/workers----- 600 - 800
- No. of Groups/workers------- 20 - 30 (One group consists of 20 - 30 families)
- An expert visits a group once a month

ii) Facilities

A section of Life Improvement is set up in the Agricultural Development Centre. Each community hall is equiped with model kitchen facilities, water supply systems, and training apparatus for life improvement. The living accommodations for the experts will be provided within the compound.

Vehicles and audio-visual equipment and other required materials are provided in the Agricultural Development Centre, particularly motor-bikes will be adequately provided for the field extension workers (Details are shown in Section 5.4.7).

5.6.3 Participation of Beneficiaries

The project aims to achieve a substantial and sustainable improvement in the living conditions of the population in the area. It is assumed that increased agricultural and non-agricultural production, supported by improvements in the rural infrastructure, will directly contribute to an increase in the family's income. In turn, an improvement in the economic position will have a direct impact on living conditions in the area. To this end, major technical interventions such as rehabilitation and (re-)construction of the irrigation and drainage system, as well as related agricultural and infrastructural works and support services are envisaged. However, if the population in the concerned areas is to take full advantage of the facilities and potential benefits offered by the project, and indeed if the project activities and results should be sustainable, it is vital that the population is involved in planning, implementation and maintenance of those activities.

In particular, each intervention will have to be judged from the perspective of the potential beneficiaries and, to the maximum extent possible, will need to be discussed with them to incorporate their suggestions and to obtain their collaboration. For this purpose, the project includes a strong social development component which specifically aims at mobilising the population in the concerned areas to facilitate their participation and, simultaneously, act as a liaison between the population and the project to structure and articulate the suggestions of the beneficiaries until such time that sufficient confidence has developed and they are able to express and negotiate their own suggestions. As pointed out earlier this requires an organizational structure at the grass roots level which will facilitate the process of interaction, negotiation and collaboration.

(1) Starter Activity: Irrigation and Drainage Development

Without doubt the most important intervention in the envisaged project is the improvement of the water situation in the area through rehabilitation and construction of the irrigation and drainage system. This provides a reasonably ideal opportunity for social mobilisation since it requires a gradual build up of a grass roots organizational structure which is a condition for achieving effective, efficient and sustainable irrigation development.

i) Procedure

a. At the very beginning of the implementation phase a detailed household survey in each village in the priority project area is needed. Apart from the usual baseline data, and in view of the starter activity, particular attention should be paid to the cadastral survey and labour exchange groups.

b. The next step is to delineate the units of 10-15 families who have adjacent plots at the quaternary canal level and to reconfirm their willingness to help each other and themselves (*'provasdaya'*) in improving/constructing the quaternary irrigation and drainage system for their fields. It is important that all adult men and adult women of each family concerned are contacted and invited to take part in the deliberations. This because of the substantial contributions of both sexes in the particular stages of rice production in the area, and the need of sharing the responsibilities for appropriate water management, distribution, fee collection, operation and maintenance, once the system is operational.

c. These first rounds of discussions and negotiations should result in the final design of the tertiary and quaternary canals (in collaboration with the design engineers of the project), and the preliminary formation of groups of families. It is strongly recommended that these groups assume responsibility for the implementation of the rehabilitation and construction works of the tertiary and quaternary canals since (i): it will provide temporarily paid employment near the home - and thus generate much needed cash income in the area; (ii): it will instil a sense of ownership in the families concerned (particularly in relation to the proposed quaternary blocks which roughly cover 7-10 ha each) which is important in relation to operation, maintenance and, ultimately, long term sustainability.

d. The groups should be given clear instructions what they should do, when to start, when to complete the envisaged works, and what cost they can expect. This can only be done when the whole area affected by (parts of) the scheme has been visited and organized in the way suggested. At the final stages a design engineer should be present to judge the technical feasibility of the suggestions and, if necessary, make on the spot corrections.

e. The next issues to tackle will be the management, co-ordination and control of several aspects of the actual distribution of water at the village and district levels, operation and maintenance issues, and costs involved for each family. It will be necessary to establish a formal working relationship between the quaternary units and the government bodies responsible for the system, particularly the district offices (for an overview of the overall O&M organisation of the system see Annex V: 'Irrigation and Drainage. It is suggested that an irrigation management unit will be established in each tertiary irrigation block and then contact and negotiation with the government bodies on the above subjects will be made through representatives of the federal irrigation association.

f. On the basis of the directives from the 'higher levels of the system' each tertiary and quaternary block (respectively each village and sub-village groups) should prepare distribution and operation/maintenance plans as well as contribution collection systems in consultation with each other, and also collect irrigation fees.

g. The plans for the distribution of water should allow for some flexibility as it will be necessary to take into account the division of labour and related working hours

in the families particularly in respect of women and, if necessary, to make special arrangements to enable them to fully participate in the scheme.

h. The importance of solid operation and maintenance (O&M) procedures and responsibilities cannot be over-emphasised. Schemes often fail and, subsequently, large investments are lost, due to a lack of O&M. Although this issue cannot possibly be dealt with in this part of the report it needs to be pointed out that the beneficiaries should be made responsible for the quaternary and tertiary canals/blocks in this respect, in collaboration with the technicians of the overall structure. An appropriate O&M manual should be prepared and the quaternary units should receive training and further guidance in using it. This issue should be introduced in the start up period when the quaternary units are being established.

i. Intimately linked to the O&M issue is the water fees issue: it seems reasonable that water fees are set according to plot size, and the volume of harvest. Whether or not it is realistic to expect the investment costs of the scheme to be recovered through the contributions of the beneficiaries cannot be judged at present but will need to be considered in the future. In this respect a plan needs to be worked out between the government and representatives of the quaternary units for fixing the water fees at a reasonable and affordable level, whereby the level could gradually increase over time assuming the benefits of the scheme (higher yields) will increase. An O&M fund thus established will act as a safeguard and will protect the scheme, in particular in relation to major maintenance issues which cannot be dealt with on a local basis.

ii) Training of Water Management Groups

In this concept, the quaternary units are the core organisational entity of the scheme which, in collaboration with and supported by the government services, bear a substantial responsibility for the design, construction, operation and maintenance of the tertiary and quaternary parts of the envisaged scheme. A considerable amount of time and labour should therefore be spent on training and extension work in relation to the establishment and effective functioning of the quaternary units to facilitate their development into self-reliant water management groups.

(2) Agricultural Production, Rural Credit and Training/Extension

It is assumed that, by improving the management and control of available water for irrigation and by improving drainage, an increase in agricultural productivity can be achieved. The agricultural development plan emphasises the importance of (increased) rice (local and HYV varieties) and crop diversification such as vegetables, and maize and soybeans for the promotion of livestock production. Farming practices will gradually need to change and improve to maximise the benefits of the improved water system. It is suggested that some mechanisation, the application of fertilizers, and integrated pest management be introduced, and veterinary services to be instituted. A substantial technical training/extension component -taking full account of environmental consequences- is envisaged to introduce and guide the process, and credit facilities will be made available.

From the social development perspective it will be important to carefully distinguish between families who are able to participate in these interventions, and those who cannot or dare not take even a minimum risk. Specific interventions (such as special credit support to buy farm inputs, or small pumps for those who are not well situated to profit from the irrigation facilities) may need to be drawn up and implemented with these farmers (either male or female or both) to achieve a minimum of equity and maintain a certain social balance.

From the health and nutrition point of view it will be important to strongly promote the diversification of the diet. This will require close collaboration of agricultural extension workers with life improvement extension workers to not only promote growing more

vegetables and raising more livestock, but also to explain the concepts of a healthy diet and to organize short and simple training courses in each village. Life improvement leading groups established through the supporting services for life improvement will implement these suggestions.

(3) Additional Income Generating Activities

The extension/training and credit facilities envisaged to be established under the project are not only limited to supporting agricultural production, but also to stimulate non-agricultural income from activities such as handicrafts, weaving, and repair shops. It is, however, important that the families present ideas and, together with the project staff, further develop these into feasible and implementable plans for which credit can then be made available. These activities could be considered either on an individual or a group basis. Appropriate agreements with the borrowers need to be established covering repayment schedules, interest, and responsibilities.

(4) Rural Infrastructure

The rural infrastructure component of the envisaged project includes the improvement of the rural road network to facilitate transport and communications within the area and with other areas. It also includes the improvement of the drinking water supply and sanitation in the villages, and the rehabilitation/construction of schools, and health and community facilities including improvement of community halls with provision of toilets and day care rooms (see Annex VI for details).

From the social development perspective it is important that the population is involved in the planning and implementation of the proposed activities under this component. In particular the planning of roads, health, school, and community facilities requires the active involvement of the population to make sure that the facilities will actually conform to the wishes of the potential users. Road, clinics, schools, or community buildings which are not properly located or ill-designed will not be used or maintained.

In relation to the provision of drinking water it will be important that neighbourhoods sharing a well are fully engaged in their location and construction so as to understand the technology and to feel a sense of ownership/responsibility for its proper maintenance. It is furthermore worthwhile to consider establishing a committee for each well which should collect fees and, from these proceeds, maintain an O&M fund. Co-ordination with other agencies in the area (notably 24 HR TV and WVI in Kandal Stung District) would be opportune in avoiding duplication and also to exchange experiences.

Latrines are a much more family oriented affair. Although hardly any exist in the study area it has been noticed elsewhere in Cambodia that the sharing of latrines between families is very uncommon. As such, a programme to promote the construction and appropriate use of latrines should be geared at families rather than neighbourhoods. A combination with drinking water facilities should adopt a more overall approach to domestic hygiene and 'healthy living' in general. This would include such topics as environmental cleanliness, drinking water handling, hygienic cooking methods and facilities. These could be combined with issues of nutrition (see also ii above) and result in a more integrated concept of healthy family life. Primary health care staff will be needed occasionally to supplement the life improvement workers for specific advise and recommended procedures.

(5) Life Improvement: Summary

i) The project envisages to cover most needs identified by the families in the area: lack of water and its timely distribution; rice and food deficiency; lack of credit facilities; ill health; and a lack of roads, clinics, and schools. Gender sensitive strategies to improve

these problems have been suggested here, focusing strongly on the people themselves as the project is designed only to facilitate the process of their self development.

ii) This will require a major effort of the families who wish to be involved in the development interventions as most activities presented here and elsewhere in the report will increase the workload of every single man and woman in the area. But the benefits could be substantial if one is prepared to invest one's own time and labour.

iii) Although there is little difference between the socio-economic position of families in the household surveys, some families may not be able to fully participate in (the benefits of) the project. There are indications that particularly poor families including FHHs may simply not have the time and manpower available to meet the demands of the envisaged project. It will be important to distinguish these families and establish, if necessary, special facilities for them. One solution for this problem might be to establish day care centres for small children of these families to free up the time of the parents and adults. At the implementation phase it will be opportune to further study and intensify contacts with the organisations operating these centres (Care for Young Khmer, CYK) near the area. This could lead to intensive collaboration later on if and when the need for these centres becomes apparent in the priority project areas.

5.7 Rural Infrastructure Improvement Plan

The existing rural infrastructures such as rural road networks, rural water supply, health facilities, schools and community facilities are proposed to be improved substantially.

5.7.1 Rural Road Networks

The main purpose of road network development is to establish a sufficient transportation system to improve daily transportation conditions and to promote regional and agricultural development in Priority Development Area.

The road network will consist of the national road, the provincial road and feeder roads including district roads. The road condition will be upgraded with either asphalt pavement, or gravel metalling, and by construction of related structures, as required. Based on the inventory survey of commune roads, the improvement plan is set up to ensure the smooth communication of villages between the trunk roads and farmland. The improvement works of the roads consist of gravel metalling and widening, and the construction of related structures. A preliminary design is shown in ANNEX VI.

(1) Provincial road

The provincial roads No.104 and No.105 will be rehabilitated and improved. The following table shows the major improvement works for the provincial roads. The location of the provincial roads to be improved in the Priority Development Area are shown in Fig. 17.

Road Name	Length	Pavement (km)
Route No.104	9.1	Asphalt
Route No.105	6.8	Asphalt

(2) Village roads

The improvement works of the village roads consist of gravel metalling, widening, banking and construction of related structures. A 9 sections of a total length of 22.6 km will be improved. The location of the village roads to be improved are shown in Fig.18 and 19.

The length of road improvement works of the village road are summarized below:

Road Name	Sections	Pavement (km)
Kandal Stung	4	8.0
Tonle Bati	5	14.6
Total	9	22.6

5.7.2 Rural Water Supply Facilities

The present water supply conditions in the Priority Development Area are confronted with shortage, low quality, and long distance from the water source or well. In order to improve these conditions, additional rural water supply facilities will be provided.

The proposed water supply facilities are considered to be constructed in the following two categories :

Type I

a. To dig a tubewell of more than 30 m,
b. To provide manual pumps,
c. To provide a filter to remove oxidized iron if the ground water in iron is high,
d. To carry the well water to the residence bucket,
e. To store water in a large jar,
f. Number of beneficiaries should be about 25 to 50 households, and
g. Maximum distance from residence to well should be 250 m

Type II

a. To dig a tubewell of more than 50 m,
b. To provide a submergible motor pump,
c. To provide a filter to remove oxidized iron if the ground water in iron is high,
d. To pump up to an overhead tank,
e. To distribute water to a faucet which serves four to six households,
f. Number of beneficiaries should be about 50 to 100 households, and
g. Maximum command area should be 6 ha

The following rural water supply facilities are proposed to be constructed. The locations and number of the proposed rural water supply facilities are shown in Fig. 20 and Fig. 21.

Type of well	Kandal Stung area	Tonle Bati area	Total
Type I (Tubewell with manual pump)	42	32	74
Type II (Tubewell with submerged pump and pipeline)	1	1	2

5.7.3 Other Rural Infrastructure Facilities

(1) Improvement of Khum Clinic

Khum clinics are managed by the District Hospitals. The operation efficiency of some Khum clinics is substantially low due to the superannuating of medical equipment and there reduced functions. It is necessary to improve the Khum clinics to an appropriate level similar to the Khum clinic recently constructed at Themey in the Kandal Stung Study Area. A preliminary design of the facilities of Khum clinics is shown in ANNEX VI.

The improvement work of Khum clinic is based on the following criteria:

a. The Khum clinic building is dilapidated and not functioning.
b. The staff of clinic are continuing to conduct their tasks in spite of poor facilities, .

To improve the facilities, the following clinics are proposed to be constructed in the Priority Development Area.

Name of Khum	Building Area	Related Facility
Bakou	96 m^2	1 set
Preah Puth	96 m^2	1 set
Kreing Thnoung	96 m^2	1 set
Total	288 m^2	3 sets

The locations of the proposed Khum clinic facilities are shown in Fig. 22 and Fig. 23.

(2) Supplement Classrooms

The present condition of primary school facilities in the Priority Development Area is very poor. Some primary schools are confronted with a severe lack of classrooms for primary education where the rotation classroom system is applied. Those schools need supplement any classrooms. Therefore, the first priority is given to these schools. A preliminary design for the facilities is shown in ANNEX VI.

25 classroom facilities are proposed be for the Kandal Stung Priority Development Area and 14 for the Tonle Bati Priority Development Area, totalling 39 classrooms. The locations are shown in Fig. 22 and Fig. 23.

(3) Construction of Community Facilities

At present, Khum community facilities do not is exist in the Priority Development Area. Community facilities are useful for communication and socio-economic activities of the village people and are expected to be utilized further for the farmers' training, establishment of farmers' organization, agricultural extension services, and for vocational guidance. A preliminary design for the facilities of the community halls is shown in ANNEX VI.

Community halls with offices, staff quarters, a day care rooms, model cooking facilities and community latrines are proposed to be constructed in the following selected Khums and will be utilized as multi-purposes facilities for community development in the Priority Development Area.

The criteria for selecting Khum community halls for improvement are as follows:

a. Land for the construction site should be offered by the Khum office.

b. The proposed site should be accessible.

The locations of the proposed community facilities are shown in Fig.22 and Fig. 23. The following community facilities are proposed to be constructed in the Priority Development Area.

Buildings	Kandal Stung Priority Development Area	Tonle Bati Priority Development Area
Community Hall	5 places	2 places
Staff Quarter	10 houses	5 houses

VI. ENVIRONMENTAL ASSESSMENT

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 agricultural development are associated with dams, reservoirs 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.

The project attempts to improve the economy of the study area by providing water through a rehabilitated irrigation network, improving infrastructure such as schools, health centres, 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 yield continuously over a long period of time. The proposals also aim to provide better incomes to the rural people and thereby improve living standards.

6.2 Environmental Management

Recommendations for rational environmental management and an environmental action plan are presented in the attached Annex VIII. 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.

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 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, e.g., snakes and birds, windbreaks, and the modifying of micro-climates.

Reforesting the Phnom Tamao 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.

VII. IMPLEMENTATION SCHEDULE OF THE PROJECT

7.1 Implementation Plan

7.1.1 Construction Works

The construction works of the Project will consist of irrigation and drainage development works and rural infrastructure development works including agricultural development centres. The main works for each category are as follows:

(1) Irrigation and Drainage Development Works

i) Improvement of the Kompong Tuol Irrigation Intake
   a. Improvement of the Tuk Thla regulator
   b. Replacement of the Kompong Tuol regulators
   c. Construction of an emergency spillway
   d. Improvement of the National Road No.3 dike
   e. Improvement of the right and left bank dikes
   f. Establishment of a radio communication network for water management
   g. Improvement of related structures

ii) Kandal Stung Irrigation Project (1,950 ha)
   a. Irrigation canals and related structures
   b. Drainage canals and related structures
   c. Provision of on-farm facilities
   e. Establishment of a demonstration farm (265 ha)

iii) Tonle Bati Irrigation Project (1,600 ha)
   a. Irrigation works
      - Irrigation canals and related structures
      - Activation of Tonle Bati related facilities
      - Improvement of the connection canal
   b. Drainage canals and related structures
   c. Provision of on-farm facilities
   d. Establishment of a demonstration farm (259 ha)

(2) Rural Infrastructure Development Works

i) Road networks
   a. Trunk road with related structures (15.9 km)
   b. Feeder road with related structures (22.6 km)

ii) Rural Water Supply Facilities

a. Type I (manual pump type) (76 wells)

b. Type II (pipeline system) (2 systems)

iii) Other rural infrastructure

a. Commune clinic (3 nos)

b. Class room (39 nos)

c. Community hall (7 nos)

(3) Agricultural Development Centre 2 locations

7.1.2 Construction Schedule

The implementation schedule of the Project is shown in Fig.24. It includes the irrigation and drainage development works and rural infrastructure works. The preparatory works will last 9 months including the time necessary for detailed design, tendering, and project mobilization for implementation. The construction works will last 32 months for the main works and on-farm works. All the works will be completed in 41 months.

Irrigation and drainage works will be implemented under three work sections, the Improvement of the Kompong Tuol Irrigation Intake, the Kandal Stung Irrigation Project, and the Tonle Bati Irrigation Project. In order to serve irrigation water to the Project area, improvement of the Kompong Tuol Irrigation Intake will be implemented first. It will commence at the beginning of the first year, and will be completed including the preparatory works in 28 months. The Kandal Stung Project works will commence immediately after completing the design/tendering work of the Kompong Tuol intake. The works to be implemented first will be the main irrigation and drainage canal works, followed by the lateral and on-farm works. It will be completed including the preparatory works in 26 months. The Tonle Bati Project works will commence after completing the preparatory works of the Kandal Stung Project , and also will be completed in 26 months.

The rural development centre will be implemented in the middle of the first year and will be used as the construction office. Road works, rural water supply facilities, and other social infrastructures will also be executed in stages, parallel with the irrigation works in each area.

All the construction works from the main canals up to the tertiary canal facilities as well as rural infrastructures will be executed by contractors selected through competitive bidding. Whereas the on-farm facilities (quaternary facilities) will be implemented by the water users' associations under the guidance of the government.

7.1.3 Organization of the Project Implementation

The Ministry of Agriculture, Forestry and Fisheries (MAFF) shall primarily be responsible for the implementation of this project. MAFF shall prepare the implementation program and its budget for the execution of the development works.

To efficiently implement the project, close coordination among the related agencies for the integrated agricultural and rural development works, namely, the Ministries of Public

Works, Education, Health, State Secretariats of Rural Development, Environment, etc., will be essential and crucial.

In regard to the above, the following institutional set up is proposed:

(1) Project Management Committee

This committee will be composed of representatives of the Ministries of Agriculture, Forestry and Fisheries and other related ministries and agencies, and will control the implementation of the project, as follows:

- Decisions on matters/polices relating to the overall project implementation
- Action on recommendations relating to project management
- Approval of the project's annual operating budget
- Overall project planning and scheduling
- Review of the project performance

(2) Project Office

The Project Office for the Kandal Stung and Tonle Bati Projects will be principally based at the project site, while maintaining a project coordination desk at the Central Office. The Project Office will be administered by a chief who will be assisted by an Infrastructure Division and an Administrative/Finance Division.

a. Infrastructure Division: This is essentially an interagency group, composed of designated technical counterparts from the related ministries and agencies. It will generally assist in providing necessary counterpart assistance in the implementation of the various project components.

b. Administrative and Finance Unit: This will undertake all administrative, financial and legal services, including accounting, treasury, personnel, records, construction works supervision, other general services, and review the contracts for the Project.

(3) Agricultural Development Centre

This will have five distinct functional sections, further described below;

a. Administration section
b. Agricultural Extension Section
c. Supply and Marketing Section
d. Life Improvement Section
e. Operation and Maintenance Section

In the operation of the various activities of the project, NGOs presently operating in the Project areas will focus on providing consulting services and technical assistance, specifically in rural life improvement and community organizing.

7.2 Cost Estimate

(1) General

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

i) The exchange rate used is

US$ 1.00 = Riel 2,200 = Yen 100

ii) 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.

iii) The unit prices of the works will be divided into a foreign currency portion and a local currency portion. The local currency portion was estimated on the current market prices in the middle of 1994, and cost data obtained from similar works around the Study area. The Foreign currency portion was estimated on the basis of CIF Phnom Penh.

iv) 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$ 66.8 million, consisting of the foreign currency portion of US$ 43.6 million and the local currency portion of US$ 23.2 million. The details of each project work listed in Table 7 are shown in Table 8, and the summary is shown below.

Unit : US$ million

Description	Project Cost Foreign Currency	Local Currency	Total
1. Construction cost			
1.1 Irrigation and drainage	27.76	10.72	38.49
1.2 Rural development centre	1.45	1.14	2.59
1.3 Rural road network	3.40	3.13	6.53
1.4 Rural water supply system	0.71	0.36	1.07
1.5 Village clinic	0.07	0.07	0.14
1.6 School building	0.46	0.46	0.92
1.7 Community hall	0.63	0.63	1.26
1.8 On-farm development	0.00	2.20	2.20
Sub-total	34.47	18.73	53.20
2. Procurement of O/M equipment	0.95	0.05	1.00
3. Engineering services and administration	4.25	2.25	6.50
4. Land acquisition	0.00	0.03	0.03
5. Contingencies	3.96	2.11	6.07
Total	43.64	23.16	66.80

(3) Operation and Maintenance Cost

Annual operation and maintenance cost at the full development stage of the Project are estimated to be US$ 181 x 10^3, consisting of operation, maintenance, and repair of the irrigation facilities of the Project. The breakdown of the operation and maintenance cost is shown in Annex IX.

(4) Replacement Cost

Pumping equipment and metal works of the canal facilities are to be replaced periodically. Project life and replacement cost of the equipment used in the estimate are shown in Annex IX.

VIII. PROJECT EVALUATION

8.1 Agricultural Impacts

8.1.1 Increase in Crop Production

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

i) Cropping area: it is assumed that suitable areas for irrigated farming will be developed at maximum levels after the implementation of the development plan. As a result, planted rice fields under irrigation will finally reach 2,850 ha and 2,400 ha for Kandal Stung and Tonle Bati Priority Development Area, respectively. The change in cropping areas will be expected as follows :

Irrigation Cropping Area

(unit : ha)

Crops	Without Project		With Project	
	Kandal Stung	Tonle Bati	Kandal Stung	Tonle Bati
Rainfed Wet Season Rice	2,070*	1,730*	-	-
Irrigated Wet Season Rice	-	-	1,950	1,600
Irrigated Dry Season Rice	-	-	900	800
Dry Season Maize & Soybeans	-	-	270	240
Dry Season Vegetables	-	-	270	240
Total cropping area	2,070	1,730	3,390	2,880

Remarks ; i* including double cropping of rice in the early season.

ii) Yield: With the implementation of the development plan, the yield of each crop will significantly increase by the stable supply of irrigation water and improved farming practices provided by proper agricultural support services. The anticipated yields of crops at each development stage are explained in Section 5.3.

Based on the above forecast detailed in Sub-section 5.3.8, the crop production and the incremental production of each crop have been estimated and are summarized below :

Crop Production

(unit : ton)

Crops	Without Project		With Project		Incremental Production	
	Kandal Stung	Tonle Bati	Kandal Stung	Tonle Bati	Kandal Stung	Tonle Bati
Paddy	2,900	2,420	11,010	9,280	8,110	6,860
Maize	-	-	810	720	810	720
Soybeans	-	-	405	360	405	360
Vegetables	-	-	2,700	2,700	2,700	2,700

From the above tables, the rice production will increase about 380 % in both the Kandal Stung and the Tonle Bati areas. In addition to rice, production of the upland crops grown in the dry season will also increase drastically. These crop production increases resulting from the plan implementation will upgrade rural living standards in the study area and also improve the nutrition condition in and around the Capital, Phnom Penh.

8.1.2 Increase in Livestock Production

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

The incremental production of livestock has been estimated on units of pig, summarized as follows :

Incremental Livestock Production

(unit : head)

Description	Incremental No. of pig		
	Kandal Stung	Tonle Bati	Total
Incremental Pig Livestock	1,440	1,280	2,720
Increment per Typical Family	0.7	1.1	0.8

8.1.3 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

8.2.1 Improvement of the 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.

8.2.2 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.