

No. 52

THE KINGDOM OF CAMBODIA
MINISTRY OF AGRICULTURE,
FORESTRY AND FISHERIES

JAPAN INTERNATIONAL
COOPERATION AGENCY
(JICA)

**MASTER PLAN STUDY ON
THE INTEGRATED AGRICULTURAL AND RURAL
DEVELOPMENT PROJECT
IN THE SUBURBS OF PHNOM PENH**

MAIN REPORT

VOLUME-I

MASTER PLAN STUDY

February, 1995

NIPPON KOEI CO., LTD.

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PREFACE

In response to a request from the Royal Government of the Kingdom of Cambodia, the Government of Japan decided to conduct a Master Plan Study on the Integrated Agricultural and Rural Development Project in the Suburbs of Phnom Penh and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to the Kingdom of Cambodia a study team headed by Mr. Shinichi Yano, Nippon Koei Co., Ltd., three times from October 1993 to December 1994.

The team held discussions with the officials concerned of the Royal Government of the Kingdom of Cambodia, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Royal Government of the Kingdom of Cambodia for their close cooperation extended to the team.

February, 1995

A handwritten signature in cursive script, reading "Kimio Fujita".

Kimio Fujita
President

Japan International Cooperation Agency

February, 1995

Mr. Kimio Fujita
President,
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

Dear Sir,

We have the pleasure of submitting the study report for the Master Plan Study on the Integrated Agricultural and Rural Development Project in the Suburbs of Phnom Penh, in accordance with the Scope of Work agreed upon between the Ministry of Agriculture and the Japan International Cooperation Agency (JICA).

The study was carried out for a total period of 17 months from October 1993 to February 1995. The master plan for the integrated agricultural and rural development was basically formulated with principal aim of increase of agricultural production and improvement of rural life conditions, paying attention to environment conservation in the study area which consists of Kandal Stung Area in Kandal Province and Tonle Bati Area in Takeo Province, totalled 16,000 ha.

The basic development plans of the project consist of six aspects ; (1) protection from flood damage, (2) irrigation and drainage improvement, (3) agricultural production promotion, (4) improvement of rural life condition, (5) agricultural and rural infrastructure development, and (6) strengthening of the agricultural support institute and service systems, and these aspects are interlinked each other to achieve the main targets of the plan. We would recommend that the project will be soon implemented in line with the conclusions presented in this report.

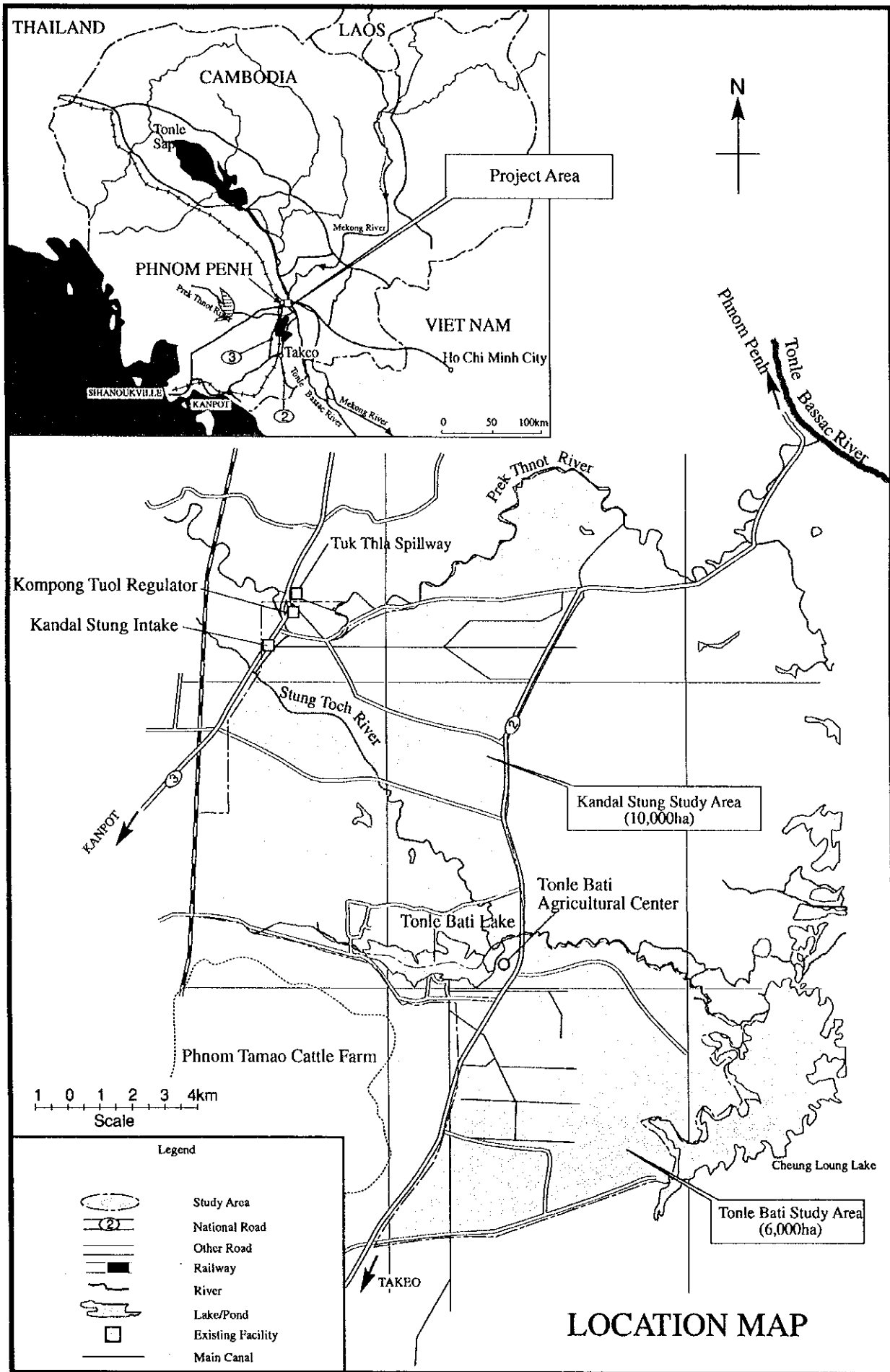
We wish to express our deep appreciation and gratitude to the personnel concerned of your and other Agencies, your Cambodia Office, the Embassy of Japan in the Kingdom of Cambodia, and the Authorities concerned of the Royal Government of the Kingdom of Cambodia as well as various NGOs for the courtesies and cooperation extended to us during our field surveys and studies.

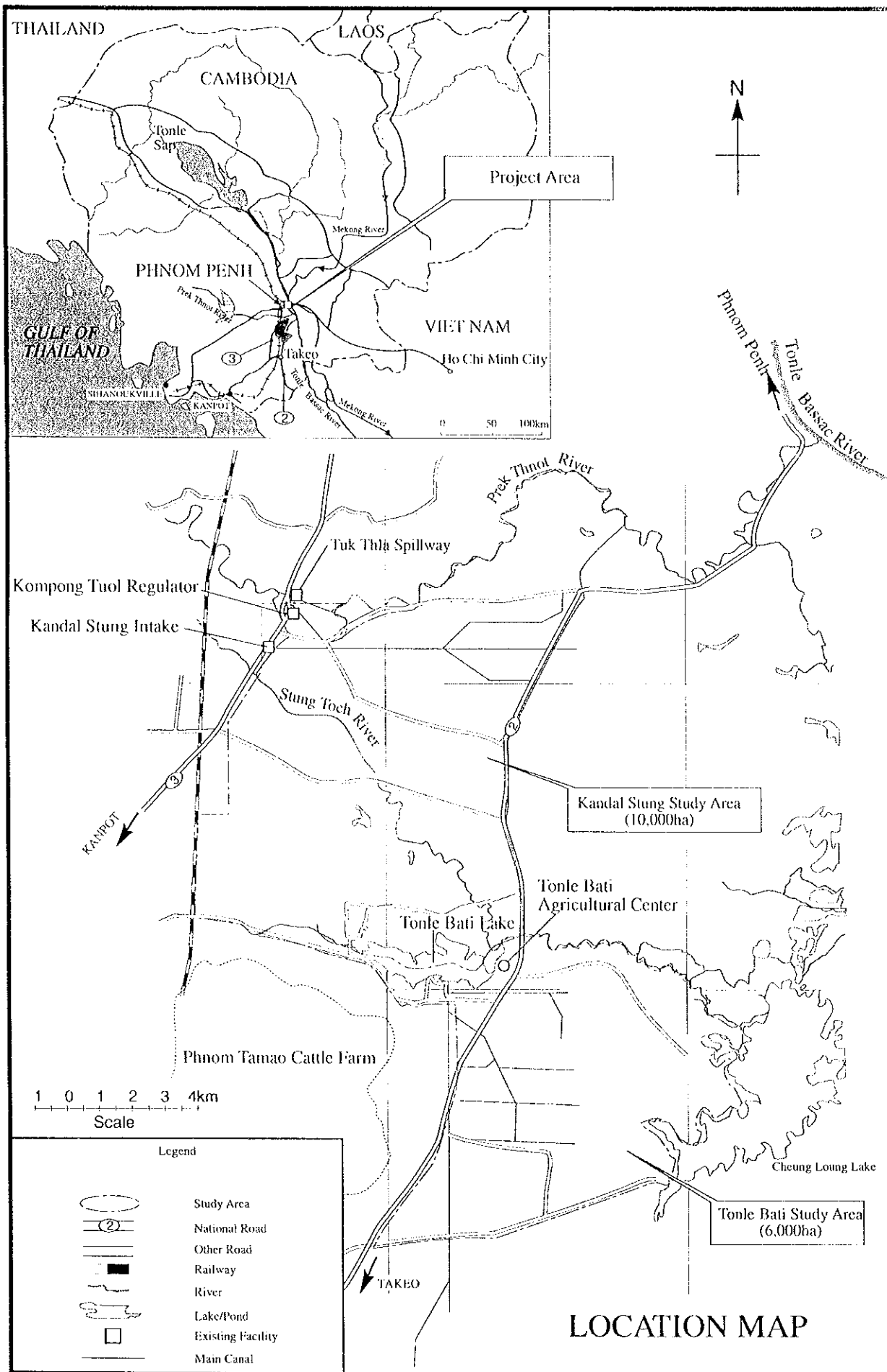
Very truly yours,



Shinichi YANO

Team leader of the Study Team for the Master Plan Study on
the Integrated Agricultural and Rural Development Project in
the Suburbs of Phnom Penh





SUMMARY

1. This report presents the results of the Master Plan Study which was carried out during the period from October 1993 through November 1994, describing the present conditions of the Study Area, the basic development concept, the general features of the priority development scheme and its development schedule.
2. Cambodia has an area of about 181,000 km². Forests cover about 12,300,000 ha or 68 % of the land and are located mainly in the northeastern part and between the Tonle Sap Lake and the Dongrek mountains in the north. Farmlands occupy about 3,800,000 ha or 21 %, comprising 2,700,000 ha of paddy fields, 1,000,000 ha of upland fields and 85,000 ha of rubber plantations. The cultivated areas are mainly concentrated in the lowland around the Tonle Sap Lake and on both sides of the Mekong River, in the south of the country.

The population in 1991 was about 8.8 million and the annual growth rate was 2.8 %. About 88 % of the population lived in rural areas, and the rate of females was about 54 %. The population density was 49 persons/km² in the whole country and 1,840 persons/km² in Phnom Penh. The total labour force was 3.7 million and adult literacy rate was about 30%.

3. Since the independence declaration in 1959, political instability caused by civil wars has retarded the social and economic development process, and continued to maintain a delicate political situation. At the 1991 Paris Conference of Cambodia, the Agreement on a Comprehensive Political Settlement of the Cambodia Conflict was signed. General elections were held from April to May 1993, and the new Royal Government was formulated in September 1993.

The Gross Domestic Product (GDP) of industry in 1991 was 280 billion Riels (US\$ 127 million), and the agriculture sector occupied 46.9 % of real GDP. Rice accounted for 17.6 %, other crops and rubber 11.7 %, livestock 11.2 %, fishing 4.8 %, and forestry 1.5 %. GDP per capita was US\$ 223 equivalent and its recent annual growth rate was 19 %. The export amount was US\$ 51.3 million in 1991 and the principal exports are timber, rubber, soybeans, maize and fish/fish products. The amount of import was US\$ 345.7 million in 1991 and the main imports are food, fuel, fertilizers, raw materials, equipment and consumer goods.

4. The agricultural sector is recognized as the top priority sector in the national reconstruction program. For the purpose of increasing agricultural productivity and thus improving living standards, the Government has been taking effective measures such as granting land ownership, introduction of a free market, and the decontrol of product prices in order to provide more incentives to producers. The supporting infrastructure such as irrigation and drainage facilities, and rural roads needs to be improved and expanded and the delivery of basic support services needs to be strengthened.
5. The Ministry of Agriculture, Forestry and Fisheries (MAFF) has overall responsibility for coordinating agricultural development activities. The most relevant departments in MAFF for agriculture and rural development are the Department of Agricultural Hydraulics and Hydro-meteorology (DOAHH), the Department of Agronomy (DOA), the Central Company of Agricultural Materials (CCAM) and the Land Titling Department (LTD). The Secretariat of Rural Development is responsible for the supervision and

management of rural development, having a target of achieving the same socio-economic level as that of other Southeast Asian countries by the year 2000.

6. Construction of the dam and power station under the Prek Thnot Multipurpose Project was started in 1969 and the works have been suspended due to past civil wars. A re-appraisal of the Project was carried out in 1991, and the irrigable area according to the appraisal result is 4,200 ha under the "without dam" conditions, 34,000 ha if irrigation is given priority, and 27,000 ha if hydropower generation is given priority.
7. The alternating monsoon system controls the climate in the Study Area. The wet season, the Southwest monsoon, is from May to November when about 90 % of total rainfall occurs. The remaining months, the Northeast monsoon, are hot, dry and less humid with a potential of particularly high transpiration demands in March and April. Annual mean rainfall is 1,365 mm and the monthly temperatures range from 21 °C to 35 °C.

Runoff from December to April forms a small part of the annual total. From May through the remaining months of the wet season, floods can occur at any time in response to intense rainfall, but the highest floods tend to occur towards the end of the wet season, usually in September or October. The hydrograph declines rapidly at the end of the wet season and this is similar for all years. The annual runoff of the Prek Thnot River is 1,130 - 1,620 MCM. Probable flooding at the Prek Thnot dam site is 1,900 m³/sec in a 100-year return period and 3,900 m³/sec in a 1000-year return period. The annual sediment transported at the dam site is estimated to be 0.37 to 0.31 million m³.

8. The two areas sandwiched between the Stung Toch and Prek Thnot rivers and extending immediately south of the Tonle Bati River consist of active alluvial flood plains with recent and silty soils. The lands extending south of the Stung Toch River and southwest of the Tonle Bati River are older terraces where natural flooding no longer occurs. The proposed new dike and existing Kompong Tuol regulator site is located on an underlain high permeable recent alluvium sand layer. These soils are loose and susceptible to piping. However, the less pervious layer having 3 to 5 m thickness extends between the recent alluvium sand and the old alluvium sand.
9. The main soils in the Study Area were classified into seven (7) soil units in accordance with the FAO system (FAO-UNESCO, 1974) and thirteen (13) land units were identified based on their formation on location, land form, soils, native vegetation and land use. Land suitability is assessed in terms of its ability to support three particular forms of land use - wet season lowland rice, dry season (irrigated) rice, and dry season (irrigated) upland crops, and classified into "Suitable: S1-S3", "Suitable with Conditions: N1" and "Non-suitable: N2" in accordance with the FAO system (1985). 80% of the total Study Area is suitable for wet season rice, 84% for dry season rice and dry season horticulture/upland crops.

Most of the farmland is devoted to the wet season rice cultivation: about 7,300 ha or 65 % of the gross Kandal Stung area and about 5,100 ha or 74 % of the Tonle Bati area. Out of 18,200 ha of the total Study area, 12,400 ha are used for rice fields.

10. The Master Plan Study Area is under the jurisdiction of Kandal Stung District of Kandal Province (the Kandal Stung area) and Tonle Bati District of Takeo Province (the Tonle Bati area). The Kandal Stung area includes 72 villages (Phum in Khmer) belonging to 13 of the 23 communes (Khum in Khmer, or sub-district) of the district, and the Tonle Bati area includes 34 villages belonging to 5 of the 11 communes of the district. The

Kandal Stung area covers about 11,300 ha and the Tonle Bati area about 6,900 ha in gross.

The population of the Study Area was estimated at about 26,100 (4.6 persons/family) for the Kandal Stung area and about 15,500 (4.9 persons/family) persons for the Tonle Bati area. The proportion of the female population is about 54 % in the Study Area. The Study Area seems to be relatively homogeneous in terms of the socio-economic position of the families and no great differences have been discovered, either in size of land holdings, assets, income, or type of house owned by the families. A quite vulnerable group in the area would be the Female Headed Households (FHHs) without adult male members, which account for about 20 % of families in the Study Area. The most problematic point of FHHs are the lack of manpower for ploughing fields and a shortage of funds. Another problem for FHHs is the lack of child care centres in the district.

Both districts in the Study Area have a similar curative public health services structure, headed by a district hospital of about 100 beds, and each village (khum) has an infirmary or khum clinic assisted by a khum Health Committee. Public health services in both districts are supported by foreign NGOs; 24 Hr TV supports the District Hospital while WVI has a Primary Health Care Program in the Kandal Stung district. In the Bati district JOCS provides support to the District Hospital and to Primary Health Care. However it can be concluded that the public health services in the Study Area, even with the assistance of NGOs, have got a long way to go in providing adequate services to the people, due to a shortage of staff such as nurses and midwives in a number of khum clinics. Some clinics have been damaged by war and are not functioning properly. There are several primary schools and some lower and higher secondary schools. The socio-economic survey results of the Study Area show that more than 90 % of children between 6-16 go to school. There does not seem to be a significant difference between girls and boys attending school. Classrooms are not sufficient to cope with the enrolled pupils.

Farming activities are either performed by males, females or both. Ploughing and threshing/pounding is traditionally done by men, and mostly in groups or with hired labour. Transplanting and harvesting are women's jobs. Manuring/fertilizing is mostly done by the female members of the family while seeding and weeding are activities performed by both male and female family members. Both districts are largely similar in relation to the traditionally female activities such as cooking, washing the dishes, cleaning the house and going to the market for shopping. But, while water carrying, firewood collection and caring for ill family members are very much shared activities in Kandal Stung District, the respondents in Bati District (95% of which are males) claim that the first two activities are predominantly done by males, and the third one is predominantly a female activity.

11. Private land ownership has been granted and the registration of land titles in the Study Area is being prepared by MAFF. The average land holding size by household is 1.2 ha for Kandal Stung and 1.3 ha for the Tonle Bati areas. The agriculture in the Study Area is dominated by rice cultivation and most of the farm land is rainfed lowland rice fields with a rather low average unit yield of about 1.2 - 1.5 ton/ha. A typical pattern is rain-fed single cropping in the wet season, however, annual double cropping using irrigation is done in a very limited area. The early rice, medium rice and late rice cultivated during the rainy season is 600 ha, 8,700 ha, and 3,700 ha in the Kandal Stung area, and 130 ha, 1,120 ha and 480 ha in the Tonle Bati area, respectively. In addition to rice cultivation, farmers grow other crops including vegetables, bananas, mangoes, and guava in limited areas in home gardens. Livestock raising is also very important in the Study Area. Most farmers keep pigs and poultry. Cattle is raised for ploughing and haulage.

Transplanting, using the wet nursery methods is a common practice for growing rice in the area. The farmers use farmyard manure as a basal dose and use chemical fertilizers

such as Urea, averaging 20 kg/ha, and Compound (16:20:0), averaging of 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. At half the number of villages, privately owned rice mills are providing services for the surrounding villages. At present, almost all the villagers use a rice mill for milling rice for their own consumption, instead of the pounding method. At present, the marketing of farm products in the area is under a free marketing system and no government control is observed, except for farm inputs supplied by the government (mainly fertilizers and chemicals). Usually farmers sell their products, especially paddy, pigs and poultry, whenever cash is required, to middlemen visiting each individual farmer. No organization has been established for the marketing of farm products, and the farmer has less power to negotiate with the middleman on the prices of their products.

12. The total production of rice, palm sugar and the number of livestock raised by the Study Area in 1993 are shown below:

Items	Kandal Stung Area	Tonle Bati area	Total
Paddy (ton)	9,120	6,570	15,690
Sugar (ton)	1,000	190	1,190
Cattle (head)	16,240	9,530	25,770
Pig (head)	7,320	4,130	11,450
Poultry (head)	64,000	27,500	91,500

The Study Area's main economy base is rice cultivation, but the production is not sufficiently high due mainly to an irrigation water deficit and a shortage of inputs and improved techniques. The farmers are at present earning income basically from rice cultivation, but the majority of farmers maintain their living supplemented by other incomes, livestock, sugar, wages, etc. The gross income of farm households in the Kandal Stung area is estimated at about 370 US\$ for farming and 160 US\$ for off-farm activities, totalling 530 US\$. Farm household income in the Tonle Bati area is estimated at about 570 US\$ for farming and 30 US\$ for off-farm activities. About 30 % of the gross income in the Kandal Stung area is derived from off-farm income, while more than 95 % of the gross farm income is derived from rice production in the Tonle Bati area. The average annual living expenditures in the Kandal Stung and the Tonle Bati areas is estimated at about 480 and 520 US\$, respectively. The study on farm budgets makes it clear that the farm economy for typical farmers in both Kandal Stung and Tonle Bati areas remains at a subsistence level.

13. Agricultural support services are offered by MAFF at the central level, the Provincial Agricultural Office at the provincial level, and the District Agricultural Office at the district level. DOA in MAFF is responsible for the formulation of an experimental plan at the national level and for the monitoring of food production in the country through provincial agricultural offices. There are seven (7) agricultural/rural development centres under DOA, and most of them are receiving support from NGOs. Each centre provides services for irrigation water management and farm input supplies for rice cultivation. However, most of the centres are forced to scale down their activities mainly due to shortages of manpower and budget. CCAM distributes agricultural inputs, mainly fertilizers, chemicals, and some agricultural tools such as sprayers through the agricultural development centres, and provincial and district offices at fixed Government prices. Timely distribution of the inputs is not always carried out mainly due to a shortage of manpower and facilities. A small amount of fertilizers is often sold through

private channels at rather high prices and some small farmers, especially the poorest, are unable to obtain the necessary inputs.

Agricultural extension work in the Study Area has been carried out under DOA, by the Tonle Bati Agricultural Development Centre (TBADC) in the Tonle Bati area and by the Kandal Stung Rural Development Centre (KSRDC) in the Kandal Stung area. The area covered for the agricultural extension by KSRDC is about 375 families in 12 villages belonging to 3 communes. Most of the activities concentrate on community development through small scale agricultural credit. But service is not provided for the priority development area in Kandal Stung. On the other hand, TBADC substantially provides agricultural support services in cooperation with the District Agricultural Office. These services include irrigation water supply, agro-input supply and extension works such as rural credit, operation of a demonstration plot to show farming techniques for fertilizer application and improved varieties, and community development such as repairing of rural roads, digging wells, and education of teachers for primary schools. The activities of the centres and agricultural offices are very limited due mainly to a lack of qualified manpower, budget and facilities.

The area and families covered by the small scale rural credit scheme are still very limited due mainly to a shortage of funds and qualified manpower. The items of activities covered by the credit are mostly vegetable gardens, pig raising, and the operation of small shops in the villages. There are no large differences between men and women's roles in the credit. The Family Food Programme (FFP), sponsored by UNICEF and implemented with the assistance of the World Food Programme (WFP) and the Khmer Women Association, specifically targets poor families with children under five, FHHs, widows, etc. At the more general level of the overall the health status of the population in the Study Area, it should be noted that, apart from government services provided through a district hospital and several khum health clinics, 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 vaccination.

14. During the Pol Pot regime 1975-79, an irrigation canal system was constructed in the Kandal Stung area. At first, the Prek Thnot By-pass Channel with the Tuk Thla Regulator was constructed at the National Road No. 3 crossing, together with a road dike, the Kompong Tuol Regulator, and a flood dike. Irrigation canals and their related structures were then constructed in the Kandal Stung area, following latitudinal and longitudinal grid lines, regardless of the topographic conditions.

The irrigation area envisaged in the Kandal Stung area is 3,100 ha, for which water is diverted from the left bank of the Prek Thnot River about 1 km south of the Kompong Tuol regulator. In 1987 to 1991, the rehabilitation of the irrigation facilities was executed by the Department of Hydrology and the joint effort of the Kandal Stung District and Kandal Province, under the assistance of MCC (Mennonite Central Committee). However the National Road No. 3 dike was washed out by the August 1991 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). But in October 1992, the road dike was washed out again by flood, and rehabilitated again in December 1993. However, the dike was destroyed again in August 1994 by flood. Therefore, the water supply to the Kandal Stung area has not been ensured since then.

15. During the period of 1975 - 1979, the canal system of the Tonle Bati Project, for the planned area of 6,000 ha was constructed, of which water was diverted from the Tonle Bati Lake. During 1987 - 1990, the irrigation system was rehabilitated by the Department of Hydrology with the assistance of WCC for an area of about 900 ha. However,

irrigation facilities are presently not functioning well due to insufficient rehabilitation, insufficient water level/storage of the Tonle Bati Lake, and the lack of an effective O&M system. At the head of the main canal, an intake and pumping station were installed. The pumping station is used for supplying water in the dry season. The operation and maintenance of the facilities is made by the Bati District office.

16. In the Study Area, there are about 14.3 km of national roads(NR No.2 and No. 3) and about 14.9 km of provincial road. The National Road is mostly paved with asphalt. The provincial road in the Kandal Stung area is asphalt-paved but is severely damaged, so that only four wheel driven car is passable in the rainy season. District roads remain unpaved and are affected more or less by erosion hazard. The district road of Kandal Stung is not passable due to breakage of bridge on irrigation canal. Farm road networks are insufficient for efficient transport of farm inputs and outputs. In the rainy season, those roads are hardly passable by car due to muddy or serious erosion.

Ground water is the main source for drinking and domestic purposes. At present, 161 dug wells and 90 tubewells are installed under the programs of UNICEF and two foreign NGOs in the Kandal Stung Study area and 17 dug wells and 32 tubewells have been installed in the Tonle Bati Study area. In most of these wells, water is drawn with a well bucket. Tubewells are equipped with manual operated pumps. River water or pond water is also used for domestic purposes. In the dry season many wells are dry forcing villagers to take water from other water sources such as lakes, canals or ponds. Generally they are faced with a severe shortage of domestic water.

The commune clinic is basically provided for each commune. The existing conditions of clinic buildings are : 4 under good condition, 4 fair and 3 marginal out of total 11 commune clinics. School facilities such as building, books and science equipment are inadequate. Some wooden buildings have been superannuated so that replacement with new building or additional building is indispensable for improvement of the quality of education. No community centre exists in both the Kandal Stung and the Tonle Bati areas.

Market Facilities in the Study Area are satisfactory, however, their facilities and access to the market areas need to be improved. Rice mill facilities at present, are mostly sufficient in quantity and quality.

17. The most striking feature in the Study Area is the absence of natural systems such as undisturbed forests or wetlands. Consequently, biological diversity is poor and larger animals are not evident. Water is plenty in the wet season but dries up in the dry season, resulting in severe shortages for domestic use. River and canal banks are eroding and riverine vegetation, which provides natural stability to river banks, has disappeared in many places. Although livestock are reared extensively, the integration of crops and livestock husbandry has not taken place with any seriousness. Often manure goes to waste. Pigs and poultry are free range, thereby making the excreta unavailable.

Firewood is in short supply throughout the Study Area. Part of the domestic needs are supplied by home gardens and from nearby wet lands. In the Tonle Bati district, part of the firewood demand is met by the Phnum Thamao forest reserve which is nearly denuded.

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

18. The major physical and socio-economic constraints in the Study Area are summarized below.

- | | |
|----------------------------------|---|
| (1) Soil Mechanical condition | - Embankment materials surrounding the proposed dike site are considered to be undesirable due to their dispersive property. |
| (2) Soils | - Soils in the older terrace geomorphic province, lying Southwest of the Study Area, have low fertility, requiring a large amount of farm inputs for effective production. |
| (3) Water Resources | - Inadequate timely water resources available in the dry season and through the early months of the wet season, and
- High potential for severe flooding both in terms of damage to irrigation facilities and by the inundation of cropped areas later in the wet season. |
| (4) Irrigation and Drainage | - Shortage of experienced engineers and technical staff in planning, design and implementation, and a lack of funds for rehabilitation / reconstruction and operation and maintenance
- Inadequate design and implementation due to a lack of design standards and construction specifications, and
- Lack of a systematic operation of the irrigation system including O&M organization. |
| (5) Rural Infrastructures | - Insufficient number of rural water supply facilities and the drying-up of water sources in the dry season,
- Muddy rural roads in the rainy season making it difficult to maintain daily transportation access, and
- Inadequate provision of facilities for community organization development, and health care services. |
| (6) Agriculture and agro-economy | - Insufficient supply of certified seeds, and agricultural inputs such as fertilizers and chemicals and
- Lack of supporting services and improved techniques. |
| (7) Socio-economic conditions | - No sufficient extension services to FHH families,
- Lack of sufficiently skilled Government staff, and
- Lack of credit opportunities at reasonable cost/interest rates. |
| (8) Environment | - River and canal bank erosion, and
- Shortage of firewood supply. |

The farmer's needs and expectation, for agricultural and rural development are summarized below :

Major expectations in the dry season

- 1) Supply of irrigation water
- 2) Supply of domestic water
- 3) Sufficient health services

Major expectations for production

- 1) Sufficient supply service of fertilizers and agro-chemicals
- 2) Need of drought animals
- 3) Supply of improved paddy seeds

Major expectations for living conditions

- 1) Increase of food for home consumption
- 2) Sufficient school facilities
- 3) Increase in living expenses
- 4) Convenience of medical services
- 5) Sufficient program for FHH

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

- (1) The objectives of the integrated rural development plan are to achieve substantial and sustainable improvement in the living conditions of the inhabitants of the Study Area.
- (2) To achieve the objectives of development, the strategy adopted is to increase farming output in the area through improvement and development of irrigation, drainage and rural infrastructure, together with suitable supporting services and schemes.

According to the development needs and the national development policy, the objectives for development of the whole area are described as follows :

- (1) To raise farmer's income level through the enhancement of agriculture, especially rice and livestock production, and by the effective utilization of land and water resources in the Study Area.
- (2) To contribute to regional and national needs to increase rice production with the aim of achieving self-sufficiency.
- (3) To raise the living standard and to improve rural people's life through increasing farm income and extending services.

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

- (i) **Production and self-sufficiency in rice**
To supply 310 kg of paddy for consumption per capita per year on the basis of a production target of 400 kg per capita.
- (ii) **Income generation**
To increase the present level of total annual farm household income of about 1.12 million Riels (US\$ 509) to more than 3.0 million (US\$ 1,364) or more than 2.5 times the present level, with an annual increase rate of 10%
- (iii) **Living cost and meal cost**
To reduce the ratio of the meal cost (Engel's coefficient) to less than 50% of the total living cost, and to reserve about 10% of annual income.

To achieve the objective mentioned above and solve the present problem, the following plan will be executed:

- (1) Irrigation and drainage facilities improvement,
- (2) Agricultural development,
- (3) Agricultural supporting services,
- (4) Farmers' organization development,
- (5) Rural infrastructure development,

- (6) Living standard improvement plan, and
- (7) Establishment of a model area.
- (8) Land scope improvement regarding environmental aspect.

20. The suitable land for wet season and dry season rice and upland crops in the existing agricultural land of the Study Area is assessed at about 12,000 ha (74 %), 12,600 ha (77 %) and 12,600 ha (77 %), respectively.

The available amount of water of the Prek Thnot River for irrigation development of the Study Area is as follows:

(1) Run-of-River Water

The flow available for the Study Area is estimated to be the residual flow after sharing the gross irrigation demands of the irrigation schemes located/envisaged upstream of the Tuk Thla and Kompong Tuol regulators. The average monthly flow derived from the 10-year series of residual flow at Tuk Thla is shown below:

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	1446

(2) With Prek Thnot Reservoir

The irrigation potential "with dam condition" is estimated at the range of 25,000 ha (maximum firm power) to 35,000 ha (irrigation priority) based on the double cropping plan.

21. The proposed cropping patterns are formulated for the "with and without Prek Thnot Reservoir conditions" as shown below, on the basis of the following basic principles:
- a. One crop of wet season rice and a portion of dry season rice as the main crop in the optimum planting time under irrigated conditions, harvesting for rice and secondary crops is to be avoided during the heavy rainy period of September and October. The rice varieties to be introduced are photo period insensitive monthly high-yielding varieties with an early to medium growth duration of about 120 to 150 days. However, local varieties will remain continuously at 20 %.
 - b. Some secondary crops such as vegetables, and also maize and soybeans are to be introduced for the dry season to diversify crops to increase household income by promoting livestock production.

Crops	With Prek Thnot Reservoir				Without Prek Thnot Reservoir			
	Wet season		Dry season		Wet season		Dry season	
	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)
Rice:	100	8,400	50	4,200	100	3,400	50	1,700
Early dry season rice			50	4,200			50	1,700
Early wet season rice	50	4,200			50	1,700		
Medium wet season rice	30	2,520			30	1,020		
Local varieties	20	1,680			20	680		
Maize & soybeans			38	3,192			15	510
Vegetables			12	1,008			15	510
Crop intensity/total area	100	8,400	100	8,400	100	3,400	80	2,720

22. It is necessary to introduce new high-yielding varieties or hybrid seeds with the appropriate use of fertilizers and agro-chemicals (minimum use and environmentally sound chemicals such as Fenitrothion, Buprofezin, Dithiocarbamate, Benomyl) along with the provision of irrigation facilities and institutional support services. The present farming practices prevailing in the project area are basically applied including animal

power for soil preparation and transportation, manual operation for transplanting and harvesting, wet nursery system, and ordinary transplanting method. Taking into consideration the present circumstances, rapid introduction of full mechanization is not practicable in the area, but some mechanization is necessary, especially for chemical application, threshing rice, and shelling maize and groundnut.

Regarding plant protection, farmers should choose the chemicals through consultation with the Agricultural Development Centres and their services and it is recommended to apply these under the guidance of the agricultural extension worker. It is recommended to organize an integrated pest management system for the protection the crops as well as the environmental conservation of the area. To promote livestock production, it is recommended to produce secondary crops for feed and to construct proper shelters to manage feeding effectively and for the better health condition of the animals. It is also essential to promote disease control by the extension of veterinary services such as vaccination and the breeding of healthy animals.

23. The target yield of crops at the full development stage is expected to be as follows :

crop	HYV rice	maize	soybeans	groundnuts	mungbeans	sesame.
yield	4.0	3.0	2.0	1.5	1.0	1.2

The anticipated annual rice production in the area at full target stage for the with Prek Thnot Reservoir condition is estimated at 59,240 tons, while that for without Prek Thnot Reservoir condition is estimated at 43,370 tons. The present rice production is estimated at about 15,600 tons, and the increment of rice production by the project is expected at about 43,600 and 27,800 tons for the with and without alternatives, respectively.

Under "with Prek Thnot Reservoir" conditions, the expected production of secondary crops is estimated at about 9,600 tons of maize, 4,800 tons of soybeans, and about 10,000 tons of vegetables. Under "without Prek Thnot Reservoir" conditions, the production is 1,500 tons of maize, 800 tons of soybeans, and 5,100 tons of vegetables. The anticipated annual production of livestock is estimated as the increased production of pigs which are very common in the Study Area. Under "with Prek Thnot Reservoir" conditions, the increased number of pigs is about 17,200 heads, while under "without Prek Thnot Reservoir" conditions, it is estimated at about 2,720 heads.

24. The area is located in the suburbs of Phnom Penh and is densely populated with a high increase rate. It is anticipated that rice demand will considerably increase under these circumstances, and livestock production will also increase, especially for the markets of Phnom Penh, due to a rise in consumption brought on by a change of diet for protein.

The expected agricultural benefit under "with Prek Thnot Reservoir conditions", the anticipated agricultural benefit is estimated at about US\$ 13.1 million, for the irrigation development area and US\$ 0.7 million for the non irrigation development area. Under "without Prek Thnot Reservoir" conditions, the anticipated agricultural benefit is estimated at about US\$ 4.1 million, for the irrigation development area and US\$ 1.7 million for the non irrigation development area, totalling 5.8 million US\$.

The economic agricultural benefit for the irrigation development area under "without Prek Thnot Reservoir" conditions, is estimated at US\$ 2.1 million and US\$ 1.8 million for the Kandal Stung and the Tonle Bati areas, respectively, totalling US\$ 3.9 million.

25. In the irrigation area under "with or without Prek Thnot Reservoir conditions", the net income of households is sufficient to cover more than 3 million Riel (US\$ 1,364) of annual living expenses, therefore having considerable capacity to pay. While in the non

irrigation area of Kandal Stung at present, household's farm income nearly equals the total income (farm income plus off-farm income). The households in the Tonle Bati non irrigation area will get about 2.5 times their present income. In the non irrigation areas, household may need to earn off-farm income to improve their lives.

The strengthening plan of the support services includes activation of the existing Agricultural Development Centre in the Tonle Bati area, and the Rural Development Centre in the Kandal Stung area. The Kandal Stung Centre covers about 11,300 ha, which is too large to effectively provide services, forcing the establishment of one more agricultural development centre. The operation plan of the centres is formulated taking into consideration the cooperation and coordination between each district office, the relevant research stations, development centres other project such as the IRRI-Cambodia Project, and also the various activities regarding life improvement in the project area. In this Master Plan, it is proposed that the agricultural supporting services at the initial stage in the project area will be carried out by the Agricultural Development Centres which will be operated directly under the management of the Department of Extension. And afterward, operation of the Agricultural Development Centres with sufficient qualified extension workers and facilities will be transferred to the management under each district office. The supporting services extended by the centres are as follows:

- Extension of agricultural techniques,
- Agricultural inputs and equipment supply, rural credit supply and agricultural insurance system,
- Assistance and guidance for operation and maintenance of irrigation and drainage, and provided rural infrastructures, and
- Life improvement extension services

The proposed agricultural extension services will be provided mainly for food (rice) and other secondary crops, and livestock raising, mainly pigs, poultry, and cattle for draft power, through the provision of trained extension personnel, vehicles and equipment, and office buildings to be constructed. The key points of emphasis in the agricultural extension are as follows:

- Introduction of improved varieties,
- Supply of planting materials,
- Demonstration and guidance of cultivation techniques,
- Extension of livestock production,
- Introduction of a vaccination service, and
- Monitoring and evaluation.

26. All of the proposed agricultural support services including extension of agricultural techniques, agricultural inputs and equipment supply, rural credit supply, assistance and guidance for the operation and maintenance of the irrigation and drainage system and rural infrastructures, and life improvement extension services will be extended through the established Agricultural Development Centre.
27. The area suitable for irrigation development in the Kandal Stung area is 4,200 ha. The irrigable areas are estimated on the water balance simulation shown below.
 - (i) Without Prek Thnot Reservoir Case
The Kandal Stung area will serve 1,950 ha from the Kompong Tuol regulator site with an irrigation dependable level of 4 out of 5 years. The year 1968 is the basic design year according to the simulation.

(ii) With Prek Thnot Reservoir Case

The run-of-river water of the Prek Thnot will ensure irrigation for 1,950 ha. The remaining area of 1,750 ha (4,200 ha less 1,950 ha and 500 ha of the Saba reservoir area) could be implemented only after the realization of the Prek Thnot reservoir as an extension area.

The Saba reservoir irrigation area of 500 ha lies between the Stung Toch River and the Tonle Bati Lake. The Saba Lake has no significant catchment area for water storage, requiring a supplemental water supply from the Prek Thnot River. The cost required for the irrigation and drainage system, mostly consisting of the construction of the Saba dam and a connection canal, is high compared with its service area. Because of its low economic efficiency, it will have a low development priority.

In the case that the irrigable area of 1,950 ha under the run-of-river water of the Prek Thnot is developed under the first phase and the remaining area is developed under the second phase, the general features of the proposed project works of the irrigation and drainage system are as follows:

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

28. The area suitable for irrigation development in the Tonle Bati area is 4,200 ha. The irrigable areas are estimated on the water balance simulation shown below.

(i) Without Prek Thnot Reservoir Case

- Without Kok Tel reservoir case

The water balance simulation of this case indicates that this plan could ensure irrigation to an area of 1,600 ha. Run-of-river water of the Prek Thnot, however, reduces sharply from December, reaching to a minimum in March. The supply from the Prek Thnot River via the connection canal could not be realized during the dry season of some years. In the later stage of the second cropping and the beginning of the first cropping, i.e. January through May, lake water levels reduce. This will necessitate pumping-up irrigation during the dry season.

- With Kok Tel reservoir case

On the other hand, in this case, gravity irrigation will be ensured throughout the year for an area of 1,600 ha

(ii) With Prek Thnot Reservoir Case

The Irrigation Plan of this case will ensure sufficient irrigation of the whole area of 4,200 ha without the Kok Tel reservoir.

In the case of "with Kok Tel reservoir" under Prek Thnot reservoir conditions, gravity irrigation can be ensured for an area of 1,600 ha, meaning the Kok Tel dam will contribute greatly to reducing the O&M works. However, in case the Prek Thnot dam is realized within a short time, the dam will not be economically justified. The implementation of the Kok Tel dam is largely dependent upon the construction time span of the Prek Thnot dam.

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

In the case that the irrigable area of 1,600 ha, using the supplementary water of the Prek Thnot river and without the Kok Tel reservoir, is developed as the first phase and the remaining area is developed as the second phase, the general features of the proposed project works of the irrigation and drainage system are as follows:

Description		First Stage Work	Second Stage Work
Main Canal			
- Improvement of main canal	(km)	8.3	-
- Construction of main canal	(km)	-	-
Lateral			
- Improvement of existing Lateral	(km)	6.9	-
- Construction of Lateral	(km)	3.1	6.3
Tertiary Canal			
- Improvement of existing tertiary canal	(km)	15.0	-
- Construction of tertiary canal	(km)	33.1	78.2
Quaternary canal system		(ha)	
		1,600	2,600
Improvement of Tonle Bati Lake Related Structures			
- Intake	(nos)	1	-
- Pumping Station	(nos)	1	-
- Spillway of Lake	(nos)	1	-
- Lake Dike	(km)	L.S.	-
Improvement of Connection Canal			
- Connection canal	(km)	4.6	-
- Stung Toch Regulator	(nos)	1	-
- Stung Toch Dike	(km)	1.0	-
- Kandal Stung Regulator	(nos)	1	-
Improvement of Drainage canals and structures			
- Main Drain	(km)	10.4	16.9
- Secondary Drain	(km)	13.7	22.3
- Tertiary	(km)	41.8	66.6

29. Improvement of the Tuk Thla and Kompong Tuol regulators are a prerequisite in the development of the Kandal Stung and Tonle Bati areas. The improvement plan is described below.

- a) Design flood without the dam : 1,900 m³/sec (100-year return period)
- b) Required intake water level : EL 11.50 m for water intake
- c) Allowable maximum flood water level : EL 13.00 m

The following five alternative cases are studied for the determination of the proposed plan:

- Case-1 Improvement of the Existing Regulators and Construction of an Additional Overflow Type Spillway.
- Case-2 Improvement of the Existing Tuk Thla Regulator and Construction of an Additional Overflow Type Spillway.
- Case-3 Improvement of the Existing Tuk Thla Regulator, Replacement of the Existing Kompong Tuol Regulator, and Construction of a New Overflow Type Spillway.
- Case-4 Improvement of the Existing Tuk Thla Regulator and Replacement of the Existing Kompong Tuol Regulator with a New Regulator consisting of a Rubber-made Dam and Bridge.
- Case-5 Construction of a new regulator at Kompong Tram which is located about 25 km upstream of the existing Kompong Tuol Irrigation Intake.

In Case-1 and Case-2, the proposed works require more than 650 m of over flow spillway along the National Road No. 3. It will be necessary to remove existing houses and a by-pass road. In regard to the rural people living around the site, these two cases will not be proposed.

According to a preliminary cost estimate for Case-3, Case-4 and Case-5, Case-4 is more costly than Case-3 due mainly to the high cost of bridges inherently required by rubber type weirs. Case-5 is also not economical due to the expensive cost for a division weir, bridge, and a headreach canal for about 25 km long to Kompong Tuol. Accordingly, it is proposed to adopt the improvement plan given in Case-3.

The proposed improvement works are summarized as follows :

- Tuk Thla Regulator: Replacement of gates, (6m x 3m x 5 sets)
- Kompong Tuol Regulator: Replacement of existing regulator,
(Gate: 6m x 8.0m x 5 sets, bridge: width = 15 m)
- Spillway: Overflow type, 400 m in length
- Route National No. 3: Total width 15 m, asphalt pavement and width 9 m
- Flood Dike on Upstream: Length about 5 km, top dike width 4 m
- Tele-communication system: Main, branch and two site stations

30. The overall water management of Prek Thnot river will be carried out by the Ministry of Agriculture and Forestry. The responsibility of operation and maintenance of the irrigation and drainage systems will be divided into two types of administrative bodies, i.e., a project operation body, responsible for the head regulator to the lateral systems, and water users group responsible for tertiary irrigation and the drainage system.

The Water Management Division in DOAHH will be responsible for the operation, maintenance, and management of the head regulators and localized reservoirs in order to ensure the equitable water management and safe operation of the large facilities. The local governments concerned will be responsible for the operation, maintenance and management of the main canal up to the lateral systems. To co-ordinate smooth operation and maintenance of the irrigation system and water management of the Project, the

provincial and district irrigation committees will be organized at provincial and district government levels. They are made up of representatives of the provincial or district government offices, including the agriculture office, the public works office, the rural development office, and the police/ military office.

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

31. The improvement of provincial, district and farm roads will be made using asphalt or gravel-metall. In order to stabilize the supply of domestic water, additional tubewells are proposed to be provided where existing wells are insufficient. Regarding health services facilities, it is proposed to improve the existing Khum clinics whose facilities have severely deteriorated and to construct new clinics in place of those destroyed during the Pol Pot regime. Since the present primary school facilities are very poor and substantially short of classrooms, 58 additional classrooms are proposed to be provided in the respective Khums, to be used as multi-purpose facilities for rural social structure improvement.

Facilities		Unit		
Road				
Trunk	Provincial	(km)	14.9	Asphalt pave.
	District	(km)	15.9	Gravel pave.
Farm or rural		(km)	97.6	Gravel pave.
Tubewell	Depth more than 50 m	(Nos)	67	
	Depth less than 50 m	(No.)	196	
Khum clinic	Kandal Stung	(No.)	4	384 m ²
	Tonle Bati	(No.)	4	384 m ²
School classroom		(No.)	58	
Community hall		(No.)	18	

32. The proposed measures to improve food and nutrition for the people are categorized into (i) attainment of food and balanced nutrition by intensification and increase of the staple food crop (rice), secondary crops, livestock raising and vegetables for home consumption and (ii) educational life improvement extension work including the improvement in knowledge of nutrition, hygiene and health management, the improvement of the effective cooking methods covering the modernization of cooking facilities and the saving of energy, the improvement in knowledge of safety and hygiene in food and domestic water, and improvement of the living environment, consisting of the construction of rural infrastructure wells for the domestic water supply, and the application of improved methods of livestock raising, especially relating to their living conditions.

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

To improve support services for life improvement is need to strengthen the support services by reactivating and improving the Agricultural Development Centres and to carry out most of the relevant services and programmes in cooperation with the agricultural support services. To improve household management is need to educate and also offer practical training on the importance of clothing for safety and health, and offer training on basic accounts and record keeping of income and expenses.

Community development is the most important for improving the conditions of the people in the area. The proposed measures for this development are the promotion of people's participation at the planning stage of programs, and organizing grass root communities including water users' associations, small farmers' credit groups, life improvement leading groups, and FHH /women's group.

33. Special consideration should be paid to health and sanitation among the environmental issues envisaged along with agricultural development in the Study Area. The rural people at present depend on fish and small aquatic animals in the rivers, canals and ponds for their protein supply. In order to minimize the adverse impacts to the environment and to enjoy sustainable improved agricultural production, special attention should be paid to chemical application for pest control, and environmental conservation pest control techniques such as an integrated pest management system should be established.
34. The project cost consists of construction cost, procurement of machinery, land acquisition cost, engineering and administration cost and contingency. The total cost is estimated to be US\$ 101.3 million. The cost required for the implementation of the first stage works will be about US\$ 67 million.
35. This integrated agricultural and rural development project includes various schemes for the development and consolidation of infrastructure as well as for the reinforcement and/or activation of supporting functions. In order to effectively implement the various components, and taking into account the technical and managerial capacity of the staff concerned, the implementation of the schemes should be made in well designed stages. It could be divided into the following two stages:

(1) Priority development

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

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

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

(2) Second Stage Development

The remaining area will be covered under the second stage development. On the basis of the accumulated results and the institutional set-up from the first stage development, the second stage could be successfully implemented. Commencement of the irrigation works will be subject to the schedule of the Prek Thnot multipurpose dam.

36. The implementation of the first stage will be concentrated in the Kandal Stung area of 1,950 ha and the Tonle Bati area of 1,600 ha. The implementation program will include the following:

- (1) Agricultural development
 - Improvement and strengthening of agricultural support services, and
 - Establishment of a Rural Development Centre, including a demonstration farm
 - (2) Development of irrigation and drainage development
 - Urgent work for the improvement of the Tuk Thla and Kompong Tuol regulators,
 - Improvement of irrigation and drainage facilities of the Kandal Stung Irrigation Project of 1,950 ha,
 - Improvement of irrigation and drainage facilities of the Tonle Bati Irrigation, Project of 1,600 ha
 - (3) Development of rural infrastructures
 - Improvement of rural road network,
 - Construction of rural water supply facilities,
 - Improvement of village clinics,
 - Improvement of school buildings, and
 - Construction of community halls
 - (4) Measures for rural life improvement
 - (5) Support services to Women's group
 - (6) Measures for environment problems
37. The main agricultural impact will be the increase in agricultural production through improved irrigation, inputs and extension services. These crop production increases will bring about not only the upgrading of rural living standards in the Study Area but also the improvement of nutrition in and around Phnom Penh. Incremental crop production is summarized below :

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

Remarks ; Dam means the planned Prek Thnot dam*

Livestock production will also increase after the proposed development. A certain portion of incremental coarse grains could be fed to livestock, which can be regarded as a form of value-added farm activities. The increased livestock production will contribute not only to the increase in farmers' cash income but also to the improvement of nutrition in and around the Project area. The incremental production of livestock is estimated on units of pigs:

Description	Without Dam*	With Dam*
Incremental Pig Livestock	2,720 heads	17,200 heads
Increment per Typical Family	0.8 "	2.6 "

Remarks ; Dam means the planned Prek Thnot dam*

Farmers in the Study Area as well as in other agricultural areas, especially in the suburbs of Phnom Penh, will become familiar with modern irrigation farming practices and value-added livestock raising. 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.

The improvement of the rural water supply, roads, community facilities, clinics, etc., will contribute to the development of the project area, and the living standard of the people will be greatly improved.

The increase of the net farm income will provide motives for improving the living standards of the farmers as well as the rural economic development. In addition, the farmers' increased purchasing power will activate the stagnated rural markets. Employment opportunities for unskilled laborers will be generated during the construction period. Employees will be able to gain more experience and skills in the various working fields. The accumulation of experience and skills will be very useful for the O&M work of the farmers.

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

A preliminary evaluation of the proposed agricultural development plan under "without-dam" conditions has been made in order to confirm the viability of the plans. The calculated EIRR is 12 %, proving that the proposed plan will be highly viable from an economic point of view.

38. It is concluded that the priority project is justified, because the project will significantly contribute to the economic development of the priority area as well as to rural life improvement, in addition to the numerous direct and indirect benefits already described. It is recommended that the feasibility study should be carried out in the priority areas as selected through the Master Plan.
39. The integrated rural development herein conceived includes various components ranging widely in both soft and hard-ware technologies. It is therefore suggested that the Government of Cambodia particularly MAFF shall organize the project implementing agency together with a coordinating system for its efficient implementation. In this context, it is proposed to establish a Project Steering Committee, a Project Development Office, etc. The operation and management of the Agricultural Development Centre are recommended to be carried out in close contact and cooperation with other Government organizations and NGOs.
40. Along with the development of the priority area, it is strongly proposed to carry out a feasibility study and the subsequent implementation of the remaining development area when the Prek Thnot Multipurpose Dam Development Project is sure to be implemented. In this context, the following points are particularly recommended to be taken into account for the smooth implementation of the project.
 - 1) The early improvement of the Kompong Toul and Tuk Thla regulators.
 - 2) Farmers' participation in the project, particularly strengthening the farmer's beneficiaries intention for agricultural development.
 - 3) The establishment of an irrigation association and sufficient technical guidance on irrigation water management and O&M by the Government organization in order to smoothly manage operation and maintenance of the existing irrigation facilities.
 - 4) The early establishment of a telecommunication system on river basin water management in order to minimize flood damage and for the effective irrigation water use of the Prek Thnot River.

- 5) The establishment of a demonstration farm which would exhibit modernized irrigation farming and demonstrate to the surrounding areas for extension.
- 6) Training of the Government staff related to the Project and the leading farmers on technical and management of improved farming in Cambodia and abroad.

1. The first step in the process of creating a new product is to identify a market need. This involves conducting market research to determine what consumers want and what problems they are trying to solve. Once a need is identified, the next step is to develop a concept for a product that addresses that need.

**MASTER PLAN STUDY
ON
THE INTEGRATED AGRICULTURAL AND RURAL DEVELOPMENT
PROJECT
IN THE SUBURBS OF PHNOM PENH**

MAIN REPORT

Contents

LOCATION MAP

SUMMARY

	<u>Page</u>
I. INTRODUCTION	1
1.1 Authority	1
1.2 Background of the Study.....	1
1.3 Scope of the Study	2
II. NATIONAL BACKGROUND	4
2.1 Land and Population	4
2.1.1 Land	4
2.1.2 Population	4
2.2 Current Situation of National Economy.....	5
2.2.1 Government Administration	5
2.2.2 National Economy.....	5
2.3 Agricultural and Rural Development Plan of the Government.....	6
2.3.1 Agriculture and Agricultural Economy.....	6
2.3.2 National Agricultural and Rural Development Policy and Plans	7
2.3.3 Agricultural Supporting System at National Level.....	8
2.3.4 Prek Thnot Multi-purpose Project.....	10
2.4 Socio-economy.....	11
2.5 Environmental Organisation and Policy	11
2.5.1 Institutional Organization	11
2.5.2 National Policy.....	13

III.	PRESSENT CONDITIONS OF THE STUDY AREA.....	14
3.1	Natural Conditions	14
3.1.1	Geomorphology and Geology	14
3.1.2	Meteorology	15
3.1.3	Hydrology	16
3.1.4	Soils and Land Suitability	18
3.1.5	Present Land Use	20
3.2	Socio Economic and Administrative Setting	21
3.2.1	Administrative Jurisdiction	21
3.2.2	Population	21
3.2.3	Socio-economic Conditions	22
3.3	Present Agricultural Setting	23
3.3.1	Present Land Tenure System and Land Holding Size.....	23
3.3.2	Crops and Farming Practice	23
3.3.3	Crop Yield and Production	24
3.3.4	Livestock and Fishery	25
3.3.5	Agro-processing	25
3.3.6	Marketing System	26
3.3.7	Agricultural Production Value	26
3.3.8	Farm Economy	26
3.4	Present Agricultural Support Services	28
3.4.1	Agricultural Support Institutions	28
3.4.2	Agricultural Extension and Input Supply.....	28
3.4.3	Agricultural Credit Services	28
3.4.4	Agricultural Support Activities by NGOs.....	28
3.5	Existing Irrigation and Drainage Conditions	29
3.5.1	General Description of the Study Area	29
3.5.2	Kompong Tuol Irrigation Intake	30
3.5.3	Kandal Stung Irrigation Project	32
3.5.4	Tonle Bati Irrigation Project	35
3.6	Existing Rural Infrastructures	38
3.6.1	Existing Road Networks	38
3.6.2	Domestic Water Supply	38
3.6.3	Social Infrastructures	39
3.7	Environment	40
3.7.1	Environmental Situation	40
3.7.2	Environmental Problems	42

IV.	DEVELOPMENT CONSTRAINTS AND NECESSITY	43
4.1	Development Constraints and Limitation	43
4.1.1	Physical Constraints	43
4.1.2	Agricultural and Socio-economic Constraints	44
4.2	Farmers' Intention to Development and Development Needs	44
V.	BASIC CONCEPT FOR INTEGRATED AGRICULTURAL AND RURAL DEVELOPMENT PLAN	46
5.1	Basic Development Concept	46
5.2	Development Target	46
5.3	Strategies of Integrated Agricultural and Rural Development.....	47
VI.	INTEGRATED AGRICULTURAL AND RURAL DEVELOPMENT PLAN.....	49
6.1	Land and Water Resources Development Potentials	49
6.1.1	Land Resources	49
6.1.2	Water Resources	49
6.2	Agricultural Development Plan	50
6.2.1	Proposed Agricultural Development.....	50
6.2.2	Marketing and Price Prospect	54
6.2.3	Anticipated Agricultural Benefit.....	55
6.2.4	Farm Household Economy.....	55
6.2.5	Agricultural Support Services Development Plan	56
6.3	Irrigation and Drainage Development Plan	59
6.3.1	General	59
6.3.2	Irrigation and Drainage Water Requirements	60
6.3.3	Improvement of Kompong Tuol Irrigation Intake	61
6.3.4	Irrigation and Drainage Plan of the Kandal Stung Area	64
6.3.5	Irrigation and Drainage Plan of the Tonle Bati Area	67
6.3.6	Operation and Maintenance	72
6.4	Rural Life Improvement Plan	73
6.5	Rural Infrastructure Improvement Plan	75
6.5.1	Rural Road Networks	75
6.5.2	Rural Water Supply	75
6.5.3	Social Infrastructures	76
6.6	Environmental Assessment	77
6.6.1	Environmental Assessment of Irrigation and Agricultural Development.....	77

6.6.2	Environmental Management	77
6.7	Cost Estimate	78
VII.	PROJECT IMPLEMENTATION AND SELECTION OF PRIORITY DEVELOPMENT AREAS	80
7.1	Basic Approach to Project Implementation	80
7.2	Priority Development Area	81
VIII.	PROJECT IMPACTS AND PRELIMINARY EVALUATION	82
8.1	Agricultural Impacts	82
8.2	Impacts on Improvement Rural Infrastructures	84
8.3	Socio-economic Impacts	84
8.4	Environmental Impacts	85
8.5	Preliminary Economic Evaluation	86
8.5.1	Evaluation of Economic Factors	86
8.5.2	Economic Cost	86
8.5.3	Economic Benefits	87
8.5.4	Economic Evaluation	87
8.6	Financial Analysis	87
8.6.1	Farm Budget Analysis	88
8.6.2	Capacity to Pay	88
8.7	Conclusion and Recommendation	88

List of Annex

Annex I	Hydrometeorology
Annex II	Soils and Land Use
Annex III	Geology and Embankment Materials
Annex IV	Agriculture and Agricultural Economy
Annex V	Irrigation and Drainage
Annex VI	Rural Infrastructure
Annex VII	Socio-economy and Life Improvement
Annex VIII	Environmental Aspects
Annex IX	Cost Estimate

List of Tables

		<u>Page</u>
Table 1	List of Existing Irrigation Canals of the Kandal Stung Irrigation Project Area	T-1
Table 2	Present Conditions of Canal Related Structures of the Kandal Stung Irrigation Area	T-2
Table 3	List of Existing Irrigation Canals of the Tonle Bati Irrigation Project Area	T-3
Table 4	Present Conditions of Canal Related Structures of the Tonle Bati Irrigation Project Area	T-4
Table 5	Proposed Farming Practices for Each Crop	T-5
Table 6	Proposed Staffing and Facilities of the Agricultural Development Centres	T-6
Table 7	Implementation of the Project Works	T-7
Table 8	Summary of Project Cost	T-8

List of Figures

	<u>Page</u>
Fig. 1(a) Land Unit Map of Kandal Stung Area	F-1
Fig. 1(b) Land Unit Map of Tonle Bati Area	F-2
Fig. 2(a) Land Use Map of Kandal Stung Area	F-3
Fig. 2(b) Land Use Map of Tonle Bati Area	F-4
Fig. 3 Administrative Jurisdiction of Kandal Stung Area	F-5
Fig. 4 Administrative Jurisdiction of Tonle Bati Area	F-6
Fig. 5 Present Cropping Pattern in the Study Areas	F-7
Fig. 6 Organizational Structure of Ministry of Agriculture, Forestry and Fisheries	F-8
Fig. 7 Existing Irrigation System of Kandal Stung Area	F-9
Fig. 8 Existing Irrigation System of Tonle Bati Area	F-10
Fig. 9 Existing Rural Road Network in Kandal Stung Study Area	F-11
Fig. 10 Existing Road Network in Tonle Bati Study Area	F-12
Fig. 11 Existing Irrigation Schemes in the Prek Thnot Multi-purpose Project Area	F-13
Fig. 12 Proposed Cropping Pattern in Irrigation Area with/without Reservoir Condition in the Study Area	F-14
Fig. 13 Proposed Organization of Agricultural Development Centre	F-15
Fig. 14 Overall Irrigation Development Plan	F-16
Fig. 15 Water Balance Simulation of Kandal Stung Irrigation Project	F-17
Fig. 16 Preliminary Irrigation Plan of Kandal Stung Area	F-18
Fig. 17 Water Balance of Tonle Bati Irrigation Project	F-19
Fig. 18 Preliminary Irrigation Plan of Tonle Bati Area	F-20
Fig. 19 Alternative Plans of Improvement of Kompong Tuol Irrigation Intake	F-21
Fig. 20 Conceptual Framework Project Components and Essential Elements of Life Improvement	F-22
Fig. 21 General Plan for Improvement of Rural Road Network	F-23
Fig. 22 General Plan for Improvement of Rural Water Supply Facility	F-24
Fig. 23 General Plan for Improvement of Other Rural Infrastructure Facilities	F-25
Fig. 24 Implementation Schedule of Integrated Rural Development Project	F-26

LIST OF ABBREVIATIONS

24HRTV	24 Hour Television
ACR	Australian Catholic Relief
ADB	Asian Development Bank
ADRA	Adventist Development and Relief Agency
AIDAB	Australian International Development Assistance Bureau
ANS	Action Nord Sud
ASEAN	Association of Southeast Asian Nations
BOD	Biological Oxygen Demand
IBRD	International Bank of Reconstruction and Development
CAA	Community Aid Abroad
CCAM	Central Company of Agricultural Materials
CCC	Cooperation Committee of Cambodia
CDAI	Chamcar Daugn Agricultural Material
CIDSE	Cooperation International Pour le Developement et la Solidarite
CIRP	Cambodia IRRI Rice Project
CMEA	Council for Mutual Economic Assistance
CNMC	Cambodia National Mekong Committee
CWS	Church World Service
DO	Dissolved Oxygen
DOA	Department of Agronomy
DOF	Department of Forestry
DOH	Department of Hydrology
DOL	Department of Livestock
EIA	Environmental Impact Assessment
IERR	Internal Economic Rate of Return
ESCAP	Economic and Social Commission for Asia and the Pacific
FAO	Food and Agricultural Organization of the United Nations
FD	Fisheries Department
FFP	Family Food Production Programme
FHH	Female Headed Household
FX	Foreign Exchange
GDP	Gross Domestic Product
GO	Government Organization
GPV	Gross Production Value
ha	Hectare
HEKS	Hilfswerk der Evangelischen Kirchen der Schweiz

	(Swiss Interchurch Aid)
HSP	Hydrology Support Programme
HYV	High Yielding Variety
ICO	Irrigation Community Organizer
ICORC	International Committee for the Reconstruction of Cambodia
ILO	International Labour Organization
IMF	International Monetary Fund
IPM	Integrated Pest Management
IRRI	International Rice Research Institute
ISF	Irrigation Service Fee
IUCN	International Union for Conservation of Nature and Natural Resources
JICA	Japan International Cooperation Agency
JOCS	Japan Overseas Christian Medical Cooperative Service
JSF	Japan Special Fund
km ²	square kilometre
KWA	Khmer Women Organization
LTD	Land Titling Department
LUMO	Land Use Mapping Office, MAFF
MAFF	Ministry of Agriculture, Forestry and Fisheries
MCC	Mennonite Central Committee
MCM	Million Cubic Meter
MOE	Ministry of Education
MOP	Ministry of Planning
MRD	Ministry of Rural Development
MTCP	Ministry of Transport, Communication and Posts
NGO	Non Governmental Organization
NPV	Net Production Value
O&M	Operation and Maintenance
ODA	Overseas Development Administration
OECD	Organization for Economic Cooperation and Development
PADEK	Partnership for Development in Kampuchea
PHC	Primary Health Care
PIU	Project Implementation Unit
PMCU	Project Monitoring and Coordination Unit
PSC	Project Steering Committee
PTMP	Prek Thnot Multipurpose Project
RBD	Roads and Bridges Department
RLR	Rainfed Lowland Rice
SIDA	Swedish International Development Agency

SNC	Supreme National Council of Cambodia
TAC	Technical Advisory Committee
TB	Tuberculosis
TBA	Traditional Birth Attendant
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNHCR	United Nations High Commission for Refugees
UNICEF	United Nations Children's Educational Fund
UNTAC	United Nations Transitional Authority in Cambodia
USAID	United States Agency for International Development
USBR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
VSO	Voluntary Service Overseas
WCC	World Council of Churches
WFP	World Food Programme
WHO	World Health Organization
WPO	Wildlife Protection
WUO	Water Users Organization
WVI	World Vision International

KHMER WORDS USED IN THE TEXT

Khet	Province
Srok	District
Khum	Sub-District or commune
Phum	Village
Krom	Sub-Village
Krom Samakki	Solidarity Group
Provasday	Mutual Help
Riel	Cambodian Currency

MEASUREMENT

Length

mm	millimeter
cm	centimeter
m	meter
km	kilometer

Area

m ²	square meter
km ²	square kilometer
ha	hectare

Weight

kg	kilogram
ton	ton (= 1,000 kg)

Volume

cc	milliliter
l, lit	litter
m ³	cubic meter

Time

s, sec	second
min.	minute
hr	hour

Temperature

°C	degree Celsius (centigrade)
----	-----------------------------

Currency

\$, US\$	United States Currency (Dollar)
¥	Japanese Currency (Yen)
Riel	Cambodian Currency

Others

HP	horsepower
W	watt
kW	kilowatt
MW	megawatt
kVA	kilo-volt-ampere
no(s).	numbers

I. INTRODUCTION

1.1 Authority

This Final Report on the Master Plan Study on the Integrated Agricultural and Rural Development Project in the Suburbs of Phnom Penh (the Study): was prepared in accordance with the Scope of Work agreed upon between the Ministry of Agriculture of the Kingdom of Cambodia and the Japan International Cooperation Agency (JICA) on January 26, 1993.

The Study was completed in two steps: Phase I and Phase II. During the Phase I Study from October 1993 to March 1994, the Master Plan Study on the whole Study Area was carried out and the Kandal Stung and Tonle Bati areas were selected as the priority development areas. During the Phase II Study from May 1994 to November 1994, the Feasibility Study was carried out for the selected priority development areas.

The Final Report consists of the Master Plan Report, Feasibility Report, Annexes, Drawings and Executive Summary. This Report on the Master Plan describes the overall development plan of the Study Area, and the selection of the priority development areas. The Feasibility Study Report, which is prepared in a separate volume briefly explains the integrated agricultural and rural development plan for the selected priority areas, as well as examines the technical, economic and financial viability of the project. The Annexes provide a detailed report on the Study, including an assessment of the present situation of the Study Area, all the development components with alternative case studies, etc. The Drawings constitute as one of the essential reference documents for the development plan.

1.2 Background of the Study

The agriculture sector has been recognized as the top priority sector in the national reconstruction program. The productivity of the sector, on which about 85% of the national population relies, is still low due to the lack of rural infrastructure and agricultural production technology. Agriculture in Cambodia is mostly dominated by rainfed paddy cultivation. Although irrigation development can greatly increase cropping intensity and agricultural production, a lack of capital accumulation has long limited the irrigated area. Since irrigation development requires a rather large investment and accrual of its benefit is often delayed, it would be more effective to begin with scale-wise development.

In order to formulate a basic approach to assistance to agricultural development in the Kingdom of Cambodia, the Government of Japan sent a mission for the Project Formation Study of the Agriculture Sector in March 1992. After the investigation on the sector, discussions with Government officials and identification of individual projects, the mission concluded that the highest priority should be given to an integrated rural development project which centers on irrigation improvement in the suburbs of Phnom Penh. Implementation of such a project near the capital would have high extension and dissemination effects. In September 1992, JICA dispatched a preparatory study mission to define the scope of the Study. The Government of the Kingdom of Cambodia requested the Government of Japan to extend technical assistance for master plan and feasibility studies on the project. In response to the request, JICA sent a preparatory study team again in January 1993 and agreed on the Scope of Work for the "Master Plan Study on the Integrated Agricultural and Rural Development Project in the Suburbs of Phnom Penh" according to which this Study was undertaken.

1.3 Scope of the Study

The Scope of Work for the Study is summarized as follows:

(1) Objectives of the Study

The objectives of the Study are :

- i) to prepare an overall Master Plan for the Study Area focusing on the water resources, agricultural resources, social and agricultural infrastructures, rural living improvement, etc.;
- ii) to conduct a Feasibility Study for the selected project area identified through the Master Plan in order to formulate an integrated agricultural and rural development plan;
- iii) to carry out technology transfer to the Cambodian counterpart personnel during the Study.

(2) Study Area

The Study Area consists of the Tongle Bati area (6,000 ha) and the Kandal Stung area (10,000 ha) which administratively belong to Takeo Province and Kandal Province, respectively. The areas lie about 30 km south of the capital city, Phnom Penh.

(3) Scope of the Study

The Study has been carried out in two phases in accordance with the Scope of Work. The Study period is 18 months from October 1993 to March 1995. The Scope of the Study is summarized below:

i) Phase-I Study

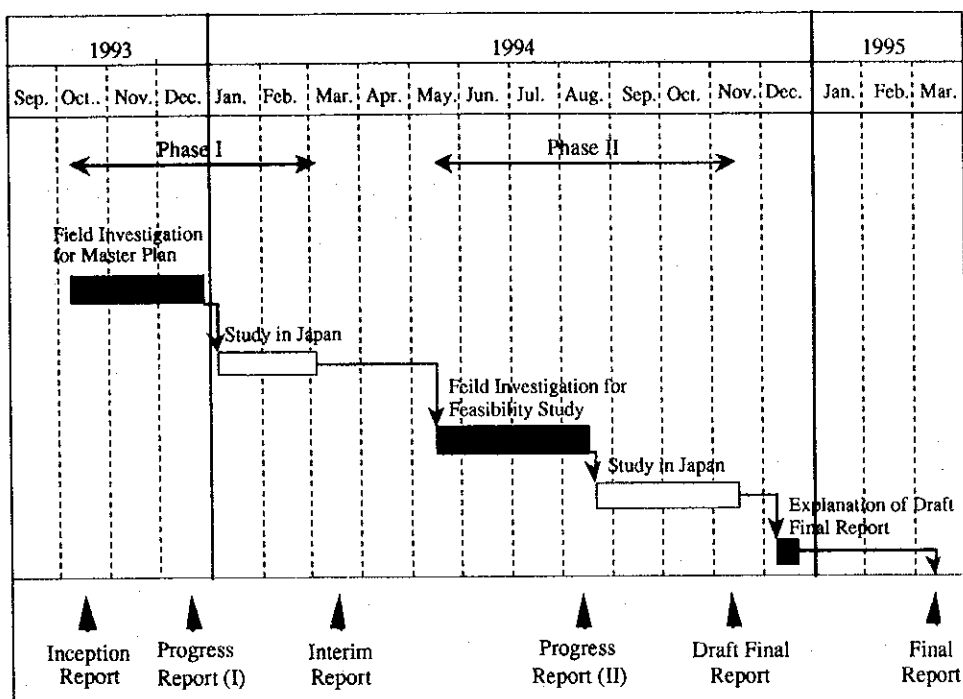
A Master Plan for integrated agricultural and rural development will be formulated for the Study Area in the Phase-I Study which will be composed of field works in Cambodia and home office works in Japan.

ii) Phase-II Study

The Phase-II Study will be composed of a Feasibility Study which will be carried out for the priority project selected in the Phase-I Study. The Study will also consist of field works in Cambodia and home office works in Japan.

The Study has been carried out in accordance with the following schedule:

Schedule of Study



II. NATIONAL BACKGROUND

2.1 Land and Population

2.1.1 Land

Cambodia covers about 181,000 km² of land and its use categories are summarized below:

Present Land Use of Cambodia			
		Area (1,000 km ²)	Share (%)
I	Natural Areas	138	76
	A. Forest	123	68
	a.Dense evergreen forest	63	35
	b.Deciduous forest	60	33
	B.Other Vegetation	15	8
II	Cultivated Areas	38	21
III	Other Land Usage	5	3
Total		181	100

The total forest area is about 12.3 million ha, or 68 % of the country, of which 6.3 million ha (51 %) are dense evergreen forest. The deciduous forest is mainly located in the north-eastern part between the Tonle Sap Lake and Dongrek mountains in the north. About 1.5 million ha (8 %) are covered with other vegetation, consisting of thickets, scrub, brushwood, grass savannah and grassland susceptible to flooding, and swampy vegetation is distributed all over the country. The cultivated area covers about 3.8 million ha or 21 % of the total area. This includes 2.7 million ha of paddy field, 1.0 million ha of upland crops, and 85 thousand ha of rubber plantations. This also includes settlement areas and other infrastructure. Other land use categories such as bare land, sandy banks, open water areas, and rivers account for about 0.5 million ha or 3 % of the total land of Cambodia.

The cultivated areas are mainly concentrated in the lowland around Tonle Sap Lake and on both sides of the Mekong River, in the south of the country. The upland crops are distributed all over the country, while the field crops and fruit gardens are mainly located along the banks of the main rivers.

2.1.2 Population

According to the Ministry of Planning Statistics Book (1980-1991), the population of Cambodia in 1991 was about 8.8 million and the annual growth rate was 2.8 %. About 88 % of the total population live in the rural areas. The population density is 49 persons/km² on the national average and 1,840 persons/km² in Phnom Penh. Females totalled about 54 % of the total population.

The labour force population (males from 16 to 60 years old and females from 16 to 55 years old) was 47.2% in 1980 and the demographic dependency ratio (non-labour force population to labour force population) was 1.11. The total labour force in the country was estimated at 3.7 million and the agricultural labour force was estimated at about 2.6 million or 70.4 % of the total population (Selected Indicators , 1991, FAO). The adult literacy rate is about 30 %.

2.2 Current Situation of National Economy

2.2.1 Government Administration

Since Cambodia declared its independence in November 1959, the country has consistently experienced political power upheavals due to numerous civil wars. The political instability caused by civil wars has retarded the social and economic development process, and maintained a delicate political situation. In 1991, at the final meeting of the Paris Conference of Cambodia, the Agreement on a Comprehensive Political Settlement of the Cambodia Conflict was signed by Cambodia and 18 other nations in the presence of the UN Secretary General. The general election was held from April to May 1993.

During 1980 to 1990, Cambodia was administrated by 14 Ministries, 23 governmental supervisory administrative offices, and about 49,000 state cadre personnel. However, reform of the administrative structure was made by the Royal Government of the newly formulated Kingdom of Cambodia in September, 1993. The newly formulated Royal Government of Cambodia comprises 19 Ministries and 4 Secretariats of state.

2.2.2 National Economy

(1) GDP

The industrial Gross Domestic Product (GDP) at constant prices (million of Riels) from 1987 to 1991, is summarized in the following table. GDP in terms of constant 1989 prices has experienced uneven growth in recent years, advancing by 16.2 % in 1988, 2.4 % in 1989, and 13.5 % in 1991, and falling by 0.1 % in 1990.

Item	1987	1988	1989	1990	1991
1. GDP (million of Riels in Constant 1989 Prices)	207,873	241,534	247,300	247,015	280,304
2. Real Growth Rates of GDP (%)	-	16.2	2.4	-0.1	13.5
3. Share of Real GDP (%)					
Agriculture	51.4	44.0	45.8	45.4	46.9
Industry	15.3	16.9	16.7	16.3	15.6
Services	33.3	39.1	37.5	38.3	37.5

Paddy accounts for 17.6 %, other crops and rubber 11.7 %, livestock 11.2 %, fishing 4.8 % and forestry 1.5 %. Per capita GDP from 1987 to 1991 was estimated at US\$ 127, 170, 153, 171 and 223, respectively. The average annual growth rate of per capita GDP was estimated at about 19 % for the period.

(2) Trade

Export amounted to US\$ 34.7 million in 1990, and US\$ 51.3 million in 1991. The principal exports were timber, rubber, soybeans, maize and fish products, while imports amounted to US\$ 115.3 million in 1990 and US\$ 345.7 million in 1991. The main imports were food, fuel, fertilizers, raw materials, equipment, and consumer goods. A huge influx of personal transport equipment and materials was observed in 1990 and 1991.

2.3 Agricultural and Rural Development Plan of the Government

2.3.1 Agriculture and Agricultural Economy

(1) General

In spite of the importance of agriculture in Cambodia at the end of the 1970s, Cambodia's agricultural sector was virtually devastated. Rice production was down to 0.5 million tons in 1979, compared with 3.2 million tons in 1968. Rubber production of about 53,000 tons in 1967 drastically declined to almost nil in 1979. The number of animals recorded in 1969 decreased to about one third in 1979. The fish catch fell to 20,000 tons in 1979 from the pre-war level of 100,000 to 125,000 tons.

Since 1980, activities in the agricultural sector have recovered steadily. The cultivated area and production of rice in 1991 were about 1.8 million ha and 2.5 million tons respectively. Fish production in 1991 increased six times from its 1980 level. Rubber production rose to about 30,000 tons in 1989 from practically zero in 1979. The number of cattle in 1991 recovered to the level at the end of the 1960s, 2.3 million heads, pigs increased to 1.6 million heads in 1991 from 50 thousand heads in 1979, and poultry increased to 8.4 million in 1991 from 870 thousand in 1979. Despite these increases, the agricultural economy in the country, still remains at a subsistence level.

(2) Rice Production

Rice is the most important crop in the country, accounting for about 23 % of agricultural production in terms of GDP in 1991. Some 85 % to 90 % of agricultural land is under rice cultivation. The rice production area is widely divided into four regions: (i) Plain region, (ii) Tonle Sap Lake region, (iii) Coastal region, and (iv) Plateau and mountain region. Among these regions, about 85 % of rice area is concentrated in the plains along the Mekong and Bassac rivers and in the Tonle Sap Lake region.

Rice ecosystems in Cambodia are broadly classified into four systems depending on the condition of water availability, rainfed upland, rainfed lowland, deepwater land and dry season irrigated crop. More than 90 % of rice cultivation is dependent on rain in the wet season while the irrigated dry season rice accounts for less than 10 % of the total cultivated area. In 1990, the average unit yield of rice was still stagnating at low levels of 1.5 tons/ha, mainly due to the dependancy of wet season rains and the cultivation of low quality of rice. In other words, there exists a great potential for increasing rice production by stabilizing the water supply and by applying improved varieties and farming practices.

(3) Other Crops

The other crops grown in the country include rubber, maize, mungbeans, soybean, sesame, tobacco, groundnuts, coconuts, sugar palm, vegetables, jute and sugar cane. The total planted area for these crops in 1967 was about 250 thousand ha, decreasing to 120 thousand ha in 1979, and recovering to 150 thousand ha in 1991. In recent years, soybean, mungbeans and maize (yellow) were exported, but in small quantities. The cultivated area of maize was about 120 thousand ha in 1967 and decreased to about 75 thousand ha in 1979, and 46 thousand ha in 1991. This was mainly due to reduced markets and storage problems. Vegetables grown mainly along the river banks, accounted for about 27,000 ha in 1991. Rubber is cultivated on plantation farms and is one of main agricultural exports. Exports reached 33 thousand tons in 1989.

(4) Livestock

Livestock husbandry is mainly characterized by small scale units, mostly occurring in small subsistence farms. Most farm families keep a few cows as draught animals, and pigs,

chickens and ducks mainly for cash income. The number of draught animals is still insufficient for crop cultivation, although substantial increases occurred after the liberalization of the economy in 1980. These livestock animals are frequently affected by diseases. Their efficiency could be greatly increased if their nutrition and health conditions are improved.

(5) Fisheries

Fisheries provide important protein for the people of Cambodia. The main fishery resources are inland fisheries at the Tonle Sap and the Mekong rivers, lakes and marshes alongside rivers, farm ponds and marine fisheries. The inland water bodies in Cambodia are useful fish resources. Fishery production has substantially recovered to about 117,000 tons in 1991 from 73,600 tons in 1986 (1.6 times). Out of 117,000 tons of product, 75,000 tons were from fresh water which increased from 64,200 tons in 1986 (1.2 times). 1991 per capita fish consumption in Cambodia was estimated at 13 kg/year.

(6) Forestry

Cambodia still has a substantial proportion of forest coverage totalling about 60 % in the late 1980s. There is rapid forest depletion, particularly in the Southeast, where population density and therefore increased timber and fuel wood consumption is higher. Commercial logging has officially been between 200,000 and 300,000 m³ per year over the past five years, while unofficial logging, which is not controlled by the present administration, is roughly estimated at two to three times that figure. Reforestation occurred in only 2,100 ha from 1986 to 1990 with 70 % of the seed surviving. The Forest Department's annual target for reforestation is 5,000 ha from 1991 to 1995, and 7,500 ha from 1996 to 2,000. Timber exports were about 18,000 m³ in 1980, and increased to about 260,000 to 300,000 m³ in 1991 and 1992. The new government intends to promote forest conservation in connection with environmental protection.

2.3.2 National Agricultural and Rural Development Policy and Plans

(1) Agricultural and Rural Development Policy

The agricultural sector is recognized as a top priority sector in the national reconstruction program. The productivity of the sector, which about 85 % (7.5 million) of the national population rely on, is still low, however, there is considerable potential to increase and diversify agricultural production. For the purpose of increasing productivity and thus improving living standards, the Government has taken effective measures including the granting of land ownership rights, the introduction of free markets, and deregulation of product prices in order to provide more incentives to producers.

In order to quickly realize the sector's potential, improvement is necessary in farmer's access to agricultural inputs, such as fertilizers, pesticides, seeds and agricultural credit. The sector should also be improved and expanded in the supporting infrastructures such as irrigation, flood control and drainage facilities, and rural roads, and to have the delivery of basic support services, such as research and extension services strengthened, to promote production and to improve rural living standards.

Agriculture in Cambodia is mostly dominated by rainfed rice cultivation. Although irrigation development can greatly increase the cropping intensity and agricultural production, a lack of capital has limited expansion of the irrigated area. Since irrigation development requires large investments and accrualment of its benefit is often delayed, the Government intends in the beginning to promote cost-effective and quick-responding small scale developments as model schemes in which sustainable and self-reliant agriculture can be achieved. The model schemes can work as show-cases to display the effects of agricultural and rural infrastructure development, strengthened agriculture support services, and rural life improvement and community development.

The Secretariat of Rural Development (SRD) recently published the 'Programme for Rural Development'. The SRD's target is to achieve by the year 2000, the same level of social and economic well-being in Cambodia's rural population as is prevalent in other South East Asian countries. To achieve this, a number of measures are envisaged, including the creation of pilot and model villages; the strengthening of rural credit institutions to assist the population in rural areas and to increase production capacity; the training of a rural development cadre, and assistance to promote small scale on and off-farm rural industries.

Rural development is to be formulated in line with the SRD's programme to ensure the development of rural communities in becoming self-sufficient, and to contribute to overcoming the rural-urban disparity currently existing in the country.

(2) Agricultural Development Plans

i) Five Year Plan

Cambodia First Five Year Plan (FFYP) was inaugurated in 1985 as an accomplishment for the nation's economic development covering the period of 1985 to 1990. The Second Five Year Plan (SFYP) covers 1991 to 1995, which is a milestone in the transition of Cambodia's economic development. The plan notes concern for the capacity of the state in guiding economic development, and identifies key sectors for emphasis as follows :

Sector	Total Investment (million Riels/1984 Price)	Distribution (%)
Agriculture	3,318.90	30
Communication	2,765.75	25
Industry	1,106.30	10
Electrical Energy	1,659.45	15
Tourism	553.15	5
Others	1,659.45	5
Total	11,063.00	100

The SFYP strives to move towards a market-oriented economy. In the plan, increase in food grain production is projected as per capita production and the total paddy food grain production for 1991 was 340 kg/year, and 3,030 thousand tons for maize.

ii) Five Year and Two Year Agricultural Development Plan

MAFF prepared the Five Year Agricultural Development Plan titled " Situation and Objectives of Agricultural Development Policies " to follow the SFYP (1991-1995), and under the new government MAFF drafted up the Two Year Agricultural Development Plan for 1994-1995. The objective of the Two Year Plan is to identify the urgent need of national economic strengthening included in the program of the SFYP. It is targeted in the Two Year Plan by strengthening the national economy based on the improvements of rural infrastructures. Funds will be mostly donated by the international communities to the economic development priorities. The development policies incorporated in the SFYP are followed basically in the development.

2.3.3 Agricultural Supporting System at National Level

(1) Ministry of Agriculture, Forestry and Fisheries (MAFF)

MAFF has the overall responsibility for coordinating the agricultural sector development activities at the central level. In addition, each province has a Provincial Agriculture Department which is responsible for coordinating agricultural activities at the provincial level through the Agricultural Office of each district. Although MAFF is the key

institution in the sector, there are a number of relevant authorities, in particular the Secretariats of State for Rural Development, the Environment, and Women's Affairs.

The government organization is still at a transitional stage, and at present the Government is improving the organization of the Ministry, as shown in Fig. 6.

(2) Technical Departments of MAFF

Among the 16 departments of the Ministry, the technical departments which are relevant for agriculture and rural development are, the Department of Agricultural Hydraulic and Hydro-Meteorology (ex-Department of Hydrology), the Agronomy Department, the Central Company of Agricultural Materials (ex-Department of Agricultural Materials), Department of Animal Production and Health, and the Department of Land Titles.

The Department of Agricultural Hydraulic and Hydro-Meteorology (DOH) is responsible for the planning, design, construction and maintenance of all water conservation, flood control, irrigation and drainage works, and is also responsible for water management. Technical aspects relating to large-scale (larger than 1,000 ha) and multipurpose projects are dealt centrally by the DOH, while small and medium scale projects are handled at the provincial level.

The implementation of the Government's policies and programmes for livestock production and health is the responsibility of the Department of Animal Production and Health (DAPH). The Department is currently divided into 5 sections, Animal Production, Animal Health, Finance, Planning and Administration. The Animal Health Section consists of the National Veterinary Diagnostic Laboratory, the Veterinary Vaccine Laboratory, the Veterinary Clinic, and the Vaccination Services. The Animal Production Section includes 3 breeding stations, the Phnom Tamao Cattle Breeding Station (Takeo Province), the Pig Breeding Station (KM 11), and the Poultry Breeding Station (Prek Samron).

The Department of Agronomy (DOA) is responsible for formulating experimental plans at the national level and, to monitor food production in the country through the provincial agricultural offices. The Department also manages a network of agricultural research stations and state farms, including three rice seed production farms, two rice experimental stations, a vegetable research station, a plant protection research station, two cotton farms, and a pepper farm. In addition to these 10 stations, MAFF has operated the International Rice Research Institute (IRRI) -Cambodia Project since 1989 in collaboration with the IRRI. The main activities are to carry out various studies and experiments on improving rice cultivation in Cambodia.

There are seven (7) agricultural/rural development centres operated under DOA. Each development centre has a target area to provide services for cultivation. The agricultural development centres were established under the control of the Department of Agronomy, with most receiving support from NGOs. The centres provide services for irrigation water and farm input supplies for rice cultivation. However, most of the activities have been scaled due to a shortage of manpower and budget.

(3) Agricultural Extension and Input Supply

i) Agricultural Extension

At the national level, the Department of Agronomy and the Department of Extensions under MAFF, provide agricultural extension services, which have limited impact at field level in small areas. Each department in MAFF has its own extension unit and executes extension works through the provincial and district agricultural offices. The Department of Extension, (consists of Offices of Technical Extension and Rural Credit), established under MAFF, is training the extension workers at the Prek Leap Agricultural College. It aims to dispatch Community Extension Workers at a commune

level to each province with the support from the District Extension Leaders. But the present extension work covers a very limited area mainly due to a shortage of qualified manpower and budget.

ii) Input Supply

There are two channels to supply inputs to the farmers, a Government operated Central Company of Agricultural Materials (formerly the Department of Agricultural Materials), and the private market. The Company under MAFF is responsible for the distribution of agricultural inputs, mainly fertilizers, chemicals, and some agricultural tools such as sprayers, through government channels. The Company distributes at fixed Government prices to the agricultural development centres, provincial and district offices upon request. The farmers can receive the fixed prices by paying in cash. A small amount of fertilizers are often sold through private channels at rather high prices, and the poorest are unable to obtain the necessary inputs. Timely distribution of the inputs is not always carried out, when the farmers need them for the cultivation of rice. Credit sales of fertilizers are not practised at present.

2.3.4 Prek Thnot Multi-purpose Project

The Prek Thnot river, a tributary of the Mekong river, had been studied and investigated by national and international agencies since the early 1960s. A feasibility study on the Prek Thnot Multipurpose Project was conducted in 1962. The project envisaged in the original plan consisted of the construction of a storage dam with a 18 MW hydropower station, construction of irrigation facilities, and provision of flood control facilities. The project was conceived to irrigate 70,000 ha of land at the full development on both banks of the Prek Thnot river.

The construction of the dam and power station started in 1969, but the works were sometimes interrupted due to hostilities and completely suspended in 1973. Till the Khmer Rouge takeover in 1975, some foundation works of the dam for power generation and a diversion weir for irrigation at Roleng Chrey had been completed. The construction of irrigation canals was continued by the Cambodian Government and the upstream part of the left bank canal with related structures was completed until the works were suspended completely due to the war activities.

In 1991, a re-appraisal of the Prek Thnot Multipurpose Project was carried out, taking the present conditions of agriculture and existing facilities into consideration. The study included improvement measures for the ongoing irrigation projects and examination of future irrigation development in the Prek Thnot area. The study was carried out in four packages: (i) power development, (ii) civil works and study coordination, (iii) power plant and equipment, and (iv) irrigation development.

The study examined possible irrigation areas under three alternative cases and determined as follows :

Irrigable Areas

Alternative Conditions	Irrigation Area
1) Run-of-river water without a storage dam:	4,200 ha
2) Regulated water with a storage dam and with priority on irrigation	34,000 ha
3) Regulated water with a storage dam and with priority on power generation	27,000 ha

2.4 Socio-economy

The overall socio-economic situation has changed dramatically during the last few years, particularly following the May 1993 elections which resulted in a democratic system of government. But despite these changes, Cambodia still has got a long to go before it recovers from decades of turmoil and human disaster. The prolonged war and unrest in the country during the seventies and eighties has caused considerable damage to the social and physical infrastructure. Today's per capita income is around US \$ 220 (amongst the lowest in the world) while life expectancy at birth is below 50 % and the literacy rate is less than 30 %. The current situation is further aggravated by continued unrest in parts of the country and the legacy of millions of uncleared mines rendering large parts of fertile agricultural land inaccessible for cultivation.

Apart from these physical constraints, human resources have also been depleted. Millions of lives were lost during the turmoil and large contingents of skilled people fled the country. About half the population is below 15 years of age and growing at 2.5-3 % annually. This, combined with inadequate health and education services, and continuing problems with law and order, makes it extremely difficult for the country to recover quickly.

At the micro level, and particularly in the rural areas, the lack of social and physical infrastructure has resulted in low production figures and poor household hygiene, causing a situation which, for most families, is difficult to endure. Agriculture, employing approximately 80 % of the 9 million population, lacks important support and extension services while education facilities are limited, inadequate and/or non-existent. Chronic malnutrition and preventable diseases are major concerns with less than 50 % of the population having access to (adequate) health services. Rehabilitation, reconstruction and (further) development of Cambodia therefore requires a comprehensive long term strategy, focusing on improving the physical and social infrastructure while stimulating and enabling the population to actively participate in this process leading to structural, sustainable and equitable progress.

2.5 Environmental Organization and Policy

2.5.1 Institutional Organization

Cambodia has an abundance of important natural resources, including land, forests, fishery and water. These can, if rationally harnessed, serve the needs of the current relatively small population and the future generations. In the past two decades, any pretensions to good management had to be put aside due to the unsettled conditions, when institutional capability, administrative ability, and jurisdiction of the central governments, were either seriously challenged or were subject to extraordinary political influence. This does not, however, mean that there was rampant over-exploitation of the country's resources. In fact, the opposite occurred, except in certain provinces where government control was totally absent.

The extensive bombing in the first half of the 1970s killed many people and caused the destruction of forests, and animal life. A bleaker period in history was during 1975-79, when all institutional capability broke down and thousands of people were murdered. Education was also affected forcing schools and the only university to close.

It was a case of starting from nothing when the government changed in 1979. More important than resource conservation, was the priority to get the administrative machinery in place. It was only after the Paris Peace Accord in 1991, and the nationwide election which followed in 1993, that the pieces began to fall into place. However, a long, difficult road lies ahead.

Having recognized the importance of the environment as a key factor in the economic development process, the present government created the Ministry of Environment in July 1993. In November 1993, the Ministry was transformed into the State Secretariat for the

Environment, with a clear mandate for formulating environmental policy, instituting environmental legislation and regulatory requirements, undertaking environmental planning, initiating environmental impact assessments, supervising environmental education, and taking responsibility for the overall coordination of environmental protection and management. Daunting tasks for a fledgling institution. However, the Secretariat has gathered a nucleus staff and has initially embarked on a programme of capability building, with the assistance of the donor community. Other programme components including the preparation of draft legislation for pesticide control and the preparation of environmental assessment procedures are being currently pursued. With the new political order, the government believes that greater investment opportunities will be available in the field of natural resources and that these resources, if managed wisely, can benefit the current rehabilitation effort. However, this requires a strong executing and guiding capability within the confines of the State Secretariat for the Environment, and this is yet to be developed.

The Secretariat is headed by a Secretary of State, and an Under-Secretary and three Directors make up the senior executive staff. The following five main technical departments are under a single Director, while a second Director is responsible for administration. The current cadre position is shown in the organogram in figure 1, annex-VIII. The technical departments are:

- a. Environmental Planning, Water Management and Land Use,
- b. Nature Conservation and Protection,
- c. Pollution Control, Reduction and Prevention,
- d. Legal Affairs, and,
- e. Education and Communications.

The Secretary of State for the Environment is an *ex. officio* member of the following national committees:

- a. Land Use and Urbanization for Phnom Penh and the Provinces;
- b. Investment;
- c. Rehabilitation and Development; and,
- d. the National Mekong Committee.

Participation at these committees at such a senior level provides opportunities for the submission and safeguarding of environmental concerns by consultation, compromise and consensus, whenever development objectives cut across narrow sectoral and departmental boundaries, as they often do. This also will hopefully ensure that parochial sectoral interests are not pursued at the expense of long-term sustainability of the resource base.

Another useful step has been the creation of the Environmental Assessment Commission, comprising senior officials representing the following ministries:

- a. Agriculture, Forestry and Fisheries;
- b. Industries, Mines and Energy;
- c. Public Works and Transport;
- d. Culture and Fine Arts;
- e. Education;
- f. Health;
- g. Tourism; and,

h. Secretariat of Rural Development.

The Commission is chaired by the Prime Minister and the vice-chairman is the State Secretary for the Environment. It is expected to pave the way for inter-ministerial co-ordination.

2.5.2 National Policy

At present, the country lacks an environmental policy. It also has not defined sectoral policies for the major natural resource fields. The damage and inaction of the past two decades demands a concerted rehabilitation effort with priority in setting up an institutional framework encompassing provincial and sectoral matters. One of the key policy goals of the government is to integrate a policy for environmental protection and management. In the present context, preparation of such a policy is not easy. However, the beginnings have been made, shortcomings recognised, and efforts are underway to face new challenges. Policies, legislation, education, guidelines and controls are all part of a package of initiatives currently being worked upon.

In the current efforts in formulating an integrated environmental policy, emphasis is being placed on four areas, considered to be of importance in the current development climate. These include:

i) Environmental Legislation:

There are no laws, regulations or standards to manage either the environment or the exploitation of natural resources;

ii) Environmental Impact Assessment:

With a likelihood of rapid investment in the near future, the Government finds itself lacking the capability to screen proposals for their environmental stability, and impact assessment is seen as one of the tools available to ensure balanced development;

iii) Environmental Education:

The Government acknowledges the importance of education to achieve desired goals, particularly as there is little appreciation of the need to use resources rationally; and,

iv) Inter-Agency Coordinating Mechanisms:

To avoid conflict among users of resources and to ensure that ecological principles are honoured by those competing for scarce resources, the Government sees the urgent need for consultation, compromise and consensus.

III. PRESENT CONDITIONS OF THE STUDY AREA

3.1 Natural Conditions

3.1.1 Geomorphology and Geology

(1) Geomorphology

The Study Area consists almost entirely of alluvium of various ages. A very small area of siliceous rock related to the upland hills exists in the southwest of the Tonle Bati area. Three distinct geomorphic provinces are identified based on the age and state of activity of the landscape: the younger floodplains geomorphic province, younger terrace geomorphic province, and older terrace geomorphic province.

There is evidence that at various times the Stung Toch river and the two smaller streams to its north were all either former channels of a northward-migrating Prek Thnot River, or are parts of a current Prek Thnot distributary system. It is probable that the Stung Toch is the oldest of these streams and that originally it was a section of the Tonle Bati river.

The land located between the Stung Toch and Prek Thnot rivers, and immediately south of the Tonle Bati river consists of active alluvial floodplains with recent silty soils, and these belong to the younger floodplains geomorphic province.

A similarly young but now no longer active area exists in the central part of the Tonle Bati area. This is thought to have recently been a levee and floodplain of a former Tonle Bati river, which at that time flowed in a southerly direction. This area is no longer subject to flooding, and is termed the younger terrace geomorphic province.

The landscape and soils in the south of the Stung Toch river in the Kandal Stung area and in the remainder of the Tonle Bati area are older. These areas were no longer subject to natural flooding, but some floods occur now due to the alteration of natural drainage patterns by the construction of canals, etc. These areas belong to the older terrace geomorphic province.

(2) Geology

The proposed dike and the existing Kompong Tuol Regulator site are underlain by a high permeable recent alluvium sand layer. This layer is loose and susceptible to piping. Hence it is considered that failures occurred in the past partially because the hydraulic gradient and the velocity of seepage in this area might have been greater than the critical level. However at the proposed dike site, the less pervious layer – the old alluvium fine grained soil, 3 to 5 m thick is located between the recent and old alluvium sand strata. On the other hand, at the proposed Kompong Tuol Regulator site, the less pervious old alluvium fine grained soil is not thick enough (2 m approximately). Taking into account the above geological condition, cut-off works such as one or two rows of sheet piles will be needed in the recent alluvium sand to the old alluvium fine-grained soil areas located between the existing Kompong Tuol regulator site and the proposed Kompong Tuol regulator site. At the proposed Kompong Tuol regulator site and Tuk Thla Regulator site, the similar type of cut-off works will be carried out to the required depths, which will be determined according to the empirical theory of creep ratio.

For the dike embankment materials, borrow sites were selected based on the results of geological surface survey and test pitting followed by laboratory test. Due to its physical and mechanical properties, the fine-grained soil near the new dike site is not suitable as embankment material but a mixture of fine-grained soil and either laterite or gravel is

considered desirable. On the other hand, the in-situ fine-grained soil itself and the mixture are not suitable according to the dispersion test by a double hydrometer. Therefore neither the in-situ fine-grained material alone nor the mixture with laterite or gravel can be used as embankment materials.

To cope with problems of embankment materials, the following two alternatives are recommended: (1) dispersion may be decreased by adding hydrate lime, alum or gypsum to the dispersive fine-grained soil near the proposed dike site; (2) a large quantity of laterite is available around Ph. Prinh and Ph. Con Don Pha Cum, about 28 km to 30 km along the road from Ph Kompong Tuol. The thickness of the laterite ranges from 70 cm to 110 cm, and a fine-grained soil layer underlies the laterite. According to the observation of this fine-grained soil soaked with distilled water, the fine-grained soil is considered non dispersive. Therefore mixed materials of fine-grained soil and laterite with a mix-proportion of 3:7 (fines: laterite) may be desirable in view of their mechanical property, resistance against leakage and dispersion.

3.1.2 Meteorology

The alternating monsoon system controls the climate in Cambodia. The wet season, the southwest monsoon, is from May to November when about 90% of total rainfall occurs. The remaining months, the northeast monsoon, are hot, dry and less humid with a potential of particularly high transpiration demands in March and April. The table below summarises the main features of the climate using data from Phnom Penh. This record is typical of the lowland region and represents the Project area. The potential transpiration figures are derived by the Penman equation from the meteorological information.

Average meteorological data for Phnom Penh

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall	mm	6	9	28	71	139	143	150	160	236	256	130	37	1,365
Minimum rainfall	mm	0	0	0	0	25	27	37	44	93	63	2	0	935
Maximum rainfall	mm	57	127	193	359	395	393	359	380	474	650	324	186	2,310
Number of raindays		2	1	1	4	14	18	17	18	20	21	10	4	129
Maximum temperature	deg C	30.7	32.6	34.5	35.2	34.1	33.2	32.6	32.1	31.7	30.6	30.1	30.2	
Minimum temperature	deg C	21.2	22.7	24.2	25.4	25.3	25.0	24.7	24.7	24.4	24.2	23.6	21.7	
Sunshine	hours	8.6	9.0	9.0	8.0	7.3	6.3	6.3	5.6	5.8	6.8	7.6	8.5	
Humidity	%	67.4	65.3	62.5	67.0	75.4	77.0	78.7	79.3	82.4	81.9	76.6	71.2	
Wind speed	m/s	2.4	2.2	2.7	2.2	2.1	2.4	2.7	2.6	2.1	1.8	2.3	2.4	
Potential transpiration	mm	145	161	206	188	165	149	150	147	132	136	135	142	1,857

The Chaine de l'Elephant mountains to the west of the project area causes rain shadow over the lowland area to the east. Annual rainfall of 3,000 to 5,000 mm is recorded to the west of the watershed, whereas 1,300 mm is more typical in the lowlands. All the upper basin of Prek Thnot lies on the eastern facing slopes. Average runoff from the upper basin is just over 300 mm. With actual transpiration losses about 1,200 to 1,500 mm per year, the average rainfall on the upper basin must be in the range 1,500 to 1,800 mm. The annual rainfall is similar to the lowland average of about 1,300 mm on most of the lower tributaries and on the smaller rivers, including the Stung Toch and the Tonle Bati rivers.

The average seasonal distribution of rainfall and the number of raindays does not vary significantly across the lowland area. Also, the average rainfall per rainday is roughly constant between months and between stations. In other words some months are wetter than others only because it rains more often not because it rains more intensely. The exceedance probability of daily rainfall on raindays is found to be the same across the lowland region. Thus for drainage design, the past records for Phnom Penh are used to describe the statistics of short-term rainfall in the Project area.

Estimated Maximum Short Period Rainfall at Phnom Penh

	(mm)				
	1 day	2 day	3 day	4 day	5 day
Mean annual maxima	80	103	120	137	151
10-year return period maxima	100	142	169	196	212
20-year return period maxima	118	165	184	220	236

Rainfall is poorly correlated between the stations, even over an annual time scale. Over shorter time scales the correlation is insignificant. This means that rain storms are highly localized and that average rainfall over a river basin or even a large irrigation area is less variable than the records from an individual station would suggest. This is important in the assessment of water resources available to the Project area and to irrigation design.

The time series of annual and wet season rainfalls in Phnom Penh and Kompong Speu show few unusual features. The two years 1916 and 1917 had unusually high rainfall in July to November. Rainfall in March 1922 was unusually high in some stations and caused the highest flood in this century. The potential evapotranspiration estimates, based on 20-year meteorological data, show very little variations from year to year.

3.1.3 Hydrology

(1) Water resources

The only runoff records for the region comprise of about ten years of measurements at the Prek Thnot river from two stations between Kompong Speu and the proposed dam site, and some older records from a third station in Kompong Speu. These records represent runoff from the upper mountainous basin of Prek Thnot. No records exist for the lowland tributaries or the smaller rivers. The records are reviewed as to their rating curves and general consistency, and may be regarded as fairly good. They suggest an average runoff of about 335 mm from a basin area of about 3650km².

The runoff from December to April forms a small part of the annual total. From May through to the remaining months of the wet season, floods can occur at any time in response to intense rainfall, but the highest floods tend to occur towards the end of the wet season, usually in September or October. Rarely, high floods have occurred unseasonably. The hydrograph declines rapidly at the end of the wet season and this recession is similar for all years.

In the Prek Thnot River, the excess flow for 80 % of the time is a little more than 1 m³/s. But, the Roleng Chrey regulator and associated canal offtakes have the capacity to withdraw up to 50 m³/s from the river. Thus, the low-flow regime in the lower river is now controlled by the irrigation operations upstream.

Specific runoff from the lower tributaries of Prek Thnot, and the smaller rivers, should be less than from the headwater basin. Rainfall is lower, losses are higher, and there is greater potential for retaining water in the bunded fields and other natural storage areas. Runoff is not perennial. Flow ceases soon after the end of the wet season and after the river valleys are cultivated.

Runoff from these smaller rivers is estimated using a monthly rainfall-runoff model calibrated on the headwaters basin above Anlong Touk. As rainfall intensities in the upper basin and in the lower areas are similar, the model can be used to provide estimates of runoff in the lowlands. The model is modified to allow for the increased storage potential of paddy fields and natural depressions.

The table below summarizes the estimates of runoff from the tributaries and the smaller rivers, which are described in detail in Annex I.

Average River Flows for the 10-year Design Period (mcm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Dam site	9.3	5.2	4.5	9.5	38.0	78.9	130.0	187.2	292.2	383.2	131.3	64.0	1334.0
Tributaries	0.9	0.1	0.0	0.0	0.0	2.7	13.5	15.3	31.0	52.5	19.6	9.6	145.2
Stung Toch	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.8	7.0	2.5	1.2	14.6
Stung Tonle Bati	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.4	3.9	9.6	3.5	1.6	20.1

Runoff from all but the upper basin is severely curtailed in the dry season, the majority concentrated in the months of September and October. The rapid decline of flow during December and January accords with field observations that flow ceases during the dry season in all the rivers except Prek Thnot.

(2) Flood Discharges

Estimates of flood discharge are required for the rehabilitation of the Tuk Thla and Kompong Tuol regulators and embankments that enable the diversion of water to Kandal Stung and Tonle Bati. The embankment south of Tuk Thla was breached by the flood of August 1991, the first time in the 14 years after its construction.

Flood estimation is extremely difficult due to the poor records. There were no severe floods during the periods when flows in the Prek Thnot were recorded, primarily in the 1960's, and there is no systematic surveying of flood levels or general flow conditions. Most information refers to the upper river between the proposed dam site and Kompong Speu. There are no data for the lower part of the river.

Each succeeding flood analysis appears to increase the estimate of the floods that can be expected. In 1965 SMHEA estimated the 100-year flood peak at the dam site at 1000 m³/s. In 1992 SMEC increased this estimate to 1800 m³/s. More recently SMEC have suggested a 100-year flood of 8000 m³/s, based largely on a review of the August 1991 flood. This wide range of estimates is a measure of the uncertainty in predicting rare and intermediate floods, and not the result of more significant flood data.

A regional flood frequency analysis is used to estimate flood discharges, based on published regional curves for Thailand and Malaysia. In this method only the shape of the frequency curve is transferred. The curve is scaled by an estimate of the mean annual flood derived from data at Prek Thnot.

The 100-year flood is estimated to be 1900 m³/s, and the 1000-year flood 3900m³/s. These figures compare well with those presented by SMEC in 1992 and the shape of the frequency curve is similar. They bear no comparison to the more recent and much higher estimates which cannot be supported. The higher estimates imply a mean annual flood of about 2000m³/s which would result in out-of-river floods in most years, and are difficult to reconcile with the history of the Kompong Tuol embankment. The necessary simplifications made in the SMEC (1993) analyses could well result in exaggerated estimates of peak flows and the data are insufficient to support stronger analytical techniques.

The tributary floods were estimated in the Reappraisal Report, using empirical equations derived from flood data from eastern Thailand. These equations are accepted as reasonable as they imply growth factors for different return periods that are consistent with the regional flood frequency curve discussed above.

The balance between flood attenuation and the additional flood flows from the tributaries downstream of the dam site cannot be defined accurately. However, the assumption that floods at Tuk Thla will not exceed flood flows at the dam site, as proposed in the Reappraisal Report, is accepted as conservative.

The recommended design floods for Tuk Thla are summarized in the following table:

	Estimates of Flood Discharge						
	(m ³ /s)						
	Return Period (years)						
	10	20	25	50	100	500	1000
Prek Thnot at Tuk Thla	860	1,100		1,500	1,900	3,200	3,900
Stung Toch			54		121		
Stung Tonle Bati			103		231		

Estimates for Stung Toch and Stung Tonle Bati are derived by Euroconsult (1992)
 Estimates for Stung Toch refer only to floods from its own basin area

(3) Sediment Load

In the lower Prek Thnot, downstream of Kompong Speu, the river channel meanders across the flood plain, with the low flow channel located within the wide sand bed of the river. Typically, the river section is 80-100 m wide and the bank-full depth is about 8 m. The river channel incises into the flood plain and the banks are near vertical cliffs of 2-4 m high. There are shallow levees on both sides of the river.

The main channel bed is predominantly coarse sand, which is exploited for construction work, primarily in the river reaches from Kompong Tram down to Kompong Tuol. The banks are comprised of unstable and friable materials with a wide distribution of grain size. Floods deposit layers of a much finer silt on the lower parts of the banks and on the shoals in the river bed.

Sediment samples were analysed to provide particle size distribution for samples typical of the coarse sand that forms the river bed in the lower reaches of the river, below Kompong Speu, and the finer material that is deposited on the banks. It is reasonable to assume that the former is carried as bed load during periods of flood discharge and the latter is carried in suspension over a wider range of discharge.

In the absence of any direct measurements of sediment load, it is necessary to estimate the sediment rating curves by empirical methods using a range of widely used equations. The ranges can be integrated with the flow duration curve to provide estimates of the total sediment transport. The Shields and Einstein-Brown bed load equations give estimates of average annual sediment load of 0.37 and 0.31 mcm/year respectively for a typical median grain size of 1.4 mm.

3.1.4 Soils and Land Suitability

Soil classification has been made in accordance with the FAO system (FAO-UNESCO, 1974). Generally, the soils of the two younger geomorphic provinces are good agricultural soils and occupy about 9,800 ha (54 %) of the Study Area. Meanwhile the soils of the older terrace geomorphic province, 8,400 ha (46 %), are very poor for agriculture. The soils in the Study Area are mainly classified into seven (7) soil units. The soil classification is summarized below and detailed descriptions are given in Annex II and detailed soil profile descriptions are given in Appendix II-1.

Soil Units in the Study Area

Soil Unit (FAO)		Area (ha)	%
Acrisols	Gleyic Acrisol	5,385	29.6
Arenosols	Albic/Luvic Arenosol	604	3.3
Cambisols	Dystric/Ferralic Cambisol	1,071	5.9
	Eutric Cambisol	162	0.9
	Vertic Cambisol	6,093	33.5
Fluvisols	Eutric Fluvisol	453	2.5
Luvisols	Orthic/Albic Luvisol	783	4.3
Other soils	Gleysols	1,624	8.9
	Regosols	162	0.9
	(Eroded/Truncated Soils)	1,428	7.8
	(Lakes)	435	2.4
Total Area		18,200	100.0

13 (thirteen) land units have been identified in the Study Area. A land unit is defined as an area of land having a relatively uniform assemblage of information on location, landform, soils, native vegetation and land use. They are also described in detail in Annex II. It is important to note that the mapped land units are not individual soils and some variation in soils occurs within them. This is especially so for the land units identified as having internal complexity. Land units in the Study Area and the soil units they occur in are shown as follows:

Land Unit in the Study Area

Geomorphic provinces	Land Unit	Soil units	Area (ha)	%
River Levees with Positive Relief				
Younger levees, mainly active (clayey)	Hy	E.Fluvisol	167	0.9
Older, relict levees (sandy)	Hs	A/L Arenosol, O/A Luvisol	755	4.2
	Ht	O/A Luvisol	330	1.8
Low levee remnants (clayey)	Hc	D/F Cambisol	735	4.0
Active Floodplains and Levees	Al	E Cambisol, V Cambisol	1,430	7.9
		E.Fluvisol, Gleysols		
Almost Level Plains				
Younger floodplains	Y1	V Cambisol	1,435	7.9
	Y2	V Cambisol, E Cambisol	3,243	17.8
		D/F Cambisol, Regosols		
Older plains	O1	Gleyic Acrisol	3,655	20.1
	O2	Gleyic Acrisol, O/A Luvisol	1,511	8.3
	O3	Gleyic Acrisol, D/F Cambisol	1,738	9.5
		V Cambisol		
Low Lying Land				
Poorly drained areas	Lw	Gleysols	613	3.4
	Ls	Gleysols	725	4.0
River banks and lake margins	Le	(eroded/truncated soils)	1,428	7.8
Water bodies	La	(lakes)	435	2.4
Total Area			18,200	100.0

Land unit maps are shown in Figure 1.

In this report the land is assessed in terms of its ability to support three particular forms of land use - wet season lowland rice, dry season (irrigated) lowland rice, and dry season (irrigated) upland crops, so the term suitability is appropriate. Soil suitability data for lowland rice and horticultural crops are classified into "Suitable: S1-S3", "Suitable with Conditions:

N1" and "Non-suitable: N2" in accordance with a recognized and widely used system; the FAO (1985) system for the evaluation of land for irrigated agriculture.

Land suitability assessments are based on two main lines of evidence. Firstly, the environmental factors likely to limit each form of land use can be enumerated, and assessed against soil profile descriptions, soil analysis results, geomorphological lines of evidence, and other base data. Secondly, using the results of field trials, and the observations of the performance of plants in the field. Other things were also considered, including factors such as the potential for soil erosion that may be hazardous to the land itself rather than to the crop. The important environmental factors for crop production are adequate water supply, suitable soil conditions, minimum landscape complexity, no serious flooding, and commandability. The land suitability for the three crop are rated in the following table.

Land Suitability for Land Unit

Land Unit	A1	Hc	Hs	Ht	Hy	Le	Ls	Lw	O1	O2	O3	Y1	Y2
Wet Season Rice	S2	S2	N1	N1	S1	N1	N1	S2	S3	S3	S2	S1	S1
Dry Season Rice	S1	S3	N2	N1	S1	N2	S3	S2	S3	S3	S2	S1	S2
Horticulture/Field Crops	S2	S2	S3	N1	S1	N1	N2	S2	S3-N1	S3-N1	S2	S1	S2

In the Study Area, 80 % of the total area is suitable for wet season rice, and 84 % for dry season rice, and for dry season horticulture/field crops. Land suitabilities in the Study Area are summarized in the following table.

Land Suitability for Rice and Horticultural/Field Crops

Suitability Class	Wet Season Rice		Dry Season Rice		Horticulture & Field Crops	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
Study Area	18,200		18,200		18,200	
<u>Suitable</u>	<u>14,527</u>	<u>79.8</u>	<u>15,252</u>	<u>83.8</u>	<u>15,282</u>	<u>83.9</u>
S1	4,845	26.6	1,602	8.8	1,602	8.8
S2	4,516	24.8	7,024	38.6	7,759	42.6
S3	5,166	28.4	6,626	36.4	5,921	32.5
<u>Un-Suitable</u>	<u>3,238</u>	<u>17.8</u>	<u>2,513</u>	<u>13.8</u>	<u>2,483</u>	<u>13.7</u>
N1	3,238	17.8	330	1.8	1,757	9.7
N2	0	0	2,183	12.0	726	4.0
Lakes	435	2.4	435	2.4	435	2.4

3.1.5 Present Land Use

According to the present land use survey, the present land use in the Study Area was classified as summarized in the following table. The present land use maps for the Kandal Stung and the Tonle Bati areas are shown in Figure 2.

Present Land Use

(Unit : ha)

Land use categories	Kandal Stung	%	Tonle Bati	%	Total	%
Villages,roads,etc	1,500	13.2	400	5.8	1,900	10.4
Rainfed wet season rice	7,300	64.6	5,100	73.9	12,400	68.1
Wet season upland crops	300	2.7	50	0.7	350	1.9
Cattle grazing,unused	2,200	19.5	1,350	19.6	3,550	19.5
Gross area	11,300	100.0	6,900	100.0	18,200	100.0

Most of the farm land is devoted to wet season rice cultivation, about 7,300 ha or 65 % of gross land in the Kandal Stung area, and about 5,100 ha or 74 % in the Tonle Bati area. Out of the 18,200 ha of the total Study Area, 12,400 ha are used for rice fields.

3.2 Socio Economic and Administrative Setting

3.2.1 Administrative Jurisdiction

Cambodia is widely divided into four regions, namely, Plain region, Tonle Sap Lake region, Coastal region, and Plateau and Mountain region. The Plain region covers only 14 % of the total area but 54 % of the total population, resulting in the highest population density of 190 persons/km² in the country.

Kandal and Takeo Provinces are located in the Plain region and the population density is 248 persons/km² in Kandal Province and 196 persons/km² in Takeo Province. The population density in the two provinces are the second highest following that in Phnom Penh City of 1,840 persons/km². The Plain region produces about a half the rice production in the country followed by 33 % in the Tonle Sap Lake region.

The Master Plan Study Area (the Study Area) is under the jurisdiction of the Kandal Stung District of Kandal Province (Kandal Stung Study Area) and the Tonle Bati District of Takeo Province (Tonle Bati Study Area), shown in the Location Map. The Kandal Stung Study Area includes 72 villages (Phum in Khmer) belonging to 13 (Khum in Khmer, or sub-district) of the 23 communes in the district, and the Tonle Bati Area includes 25 villages belonging to 5 of the 11 communes in the district. The Kandal Stung Study Area covers about 11,300 ha and the Tonle Bati Area covers about 6,900 ha in gross. The administrative boundary is shown in Figure 3 and Figure 4.

3.2.2 Population

The population of the Study Area is estimated at about 26,100 and 15,500 for the Kandal Stung and Tonle Bati Study areas, respectively, so that the density of the both areas is estimated at 231 person/km² for the Kandal Stung Study Area, 225 person/km² for the Tonle Bati Study Area, and the most highly populated areas in the country. The details of the name of commune, and the number of families and population by commune, are presented in the following table:

Commune	No. of villages	No. of families	Total population	Average family size
Kandal Stung Area				
Anlong Romeath	6	451	2,152	4.8
Trapeang Veng	4	354	1,895	5.4
Tbeng	2	135	717	5.3
Thuney	5	259	1,221	4.7
Trea	9	738	3,812	5.2
Prek Roka	4	645	3,069	4.8
Spean Thmar	8	512	1,875	3.7
Rolous	3	353	1,386	3.9
Preas Puth	5	356	1,604	4.5
Kong Nory	4	222	1,003	4.5
Tean	6	345	1,400	4.1
Bakou	7	612	3,040	5.0
Kok Trop	9	716	2,949	4.1
Tonle Bati Area				
Cham Pey	7	797	4,249	5.3
Puth Sar	11	1,350	7,583	5.6
Kraing Thnang	3	356	2,067	5.8
Kandoeung	3	228	1,140	5.0
Trapeang Sap	1	97	464	4.8
Study Area total (18 communes)	97	8,526	41,626	4.9

Details in ANNEX VII

3.2.3 Socio-economic Conditions

The Study Area seems to be relatively homogeneous in terms of the socio-economic position of the families. Great differences have not been discovered, either in the size of the landholdings, assets, income, or type of house owned by each family.

According to most informants, a quite vulnerable group in the area would be the Female Headed Households (FHHs) without adult male members. In particular it would be necessary to establish sufficient supporting programs for FHHs if land is sold by this group, since FHHs would have to become tenants, sharecroppers or agricultural laborers, contributing to a further decline in their already weak socio-economic position.

Both districts in the Study Area have a similar curative public health services structure headed by a district hospital with around 100 beds. The District Health Officer is in charge of the hospital and the health services delivery system in the district. At the next level down, each village (khum) has an infirmary or khum clinic assisted by a khum Health Committee. About 50 % of the rural population, however, receive treatment at home, mostly through self-medication. The number of nurses and midwives is insufficient for the khum clinics, and some clinics are damaged and are not functioning properly.

There are several primary schools and some lower and higher secondary schools. The socio-economic survey results of the Study Area show that, more than 90 % of children between 6-16 go to school. A high proportion of children of school going age actually go to school. The percentage of girls attending schools decreases in the higher secondary schools or above. Classrooms are insufficient for the number of enrolled pupils.

The most time spent on work by members of the households is on the production of rice. Farming activities are either performed by males, females or both. Ploughing and threshing/pounding is traditionally done by men, and mostly in groups or with hired labour. Transplanting and harvesting are women's jobs, frequently in large groups and/or with hired (female) laborers. Manuring/fertilizer is mostly done by the female members of the family while seeding and weeding are activities performed by both male and female family members.

Both districts are largely similar in relation to the traditionally female activities such as cooking, washing the dishes, cleaning the house and going to the market for shopping. But, while water carrying, firewood collection and caring for ill family members are very much shared activities in Kandal Stung District, the respondents in Bati District (95 % of which is male) claim that the first two activities are predominantly done by males, and the third is predominantly a female activity.

The 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 agricultural knowledge than currently the case and, simultaneously, requires a change in attitude/behavior of the farmer who is now very much preoccupied with trying to grow more rice. This obsession will need to be satisfied before any other intervention such as crop diversification can be introduced.

3.3 Present Agricultural Setting

3.3.1 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 Study Area is also being under taken. The average land holding size by household is 1.2 ha and 1.3 ha for the Kandal Stung and the Tonle Bati Study Area, respectively and the average family size in the Kandal Stung and Tonle Bati areas is 6.0 person/family, out of which about 2.5 persons are adults.

3.3.2 Crops and Farming Practice

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.

(1) Rice

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 highly relate to the seasons. The main types of rice in the area are early, medium and late. The present cropping patterns including the cropping season and the type of rice planted by area are summarized as follows and illustrated in Figure 5.

Planted Area & Cropping Intensity

			(Unit : ha)
Season	Kandal Stung	Tonle Bati	Total
Early	300	300	600
Medium	4,600	4,100	8,700
Late	2,700	1,000	3,700
Dry season	0*	30	30
Total planted area	7,600	5,430	13,030
Total field area	7,300	5,100	12,400
Cropping intensity (%)	104	106	105

* The data not available.

(2) Farming Practices

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) Other Crops

Other crops grown in the Study Area are sugar palm, maize, cassava, sweet potato, vegetables. Farmers have home gardens and grow bananas, mangoes, guavas, and cocos. The area planted with these crops is less than 2 % of the total cultivated area. In several communes, sugar palm trees play an important role in farm income during the dry season, especially in the Kandal Stung Study Area. Vegetable production has not been popular in the Study Area, however, recently some farmers have started to grow vegetables and mushrooms for marketing. Other crops are mostly consumed domestically.

3.3.3 Crop Yield and Production**(1) Rice**

The yield of rice is still very low, about 1.2 to 1.5 ton/ha on an average. The yield varies depending on the varieties, application rate of fertilizers, planting seasons, and condition of irrigation and soils. Among these factors, it is said that irrigation water shortage and the availability of fertilizers are said to be the most influential factors for the 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 Study Area is roughly estimated, based on the data on cultivated area and the average unit yield of 1.2 ton/ha for rainfed lowland rice, and 3.0 ton/ha for dry season rice. The total production of rice in the Study Area was estimated at about 15,690 tons in 1993 and the breakdown is given below :

Rice Production

Season	Kandal Stung Area		Tonle Bati Area		Total	
	Area (ha)	Production (ton)	Area (ha)	Production (ton)	Area (ha)	Production (ton)
Early	300	360	300	360	600	720
Medium	4,600	5,520	4,100	4,920	8,700	10,440
Late	2,700	3,240	1,000	1,200	3,700	4,440
Dry Season	0*	0	30	90	30	90
Total	7,600	9,120	5,430	6,570	13,030	15,690

* The data not available.

(2) Other Crops

The area for crop cultivation except sugar palm trees, is quite small compared two the area for rice, about 300 ha in the Kandal Stung and 50 ha in the Tonle Bati Study Area, respectively.

An important crop other than rice, in the Study Area, is sugar palm tree. The number of trees is estimated at about 40,000 and 7,600 in the Kandal Stung and the Tonle Bati Study Areas, respectively. The estimated potential of sugar production is about 1,190 tons/year. Sugar production is recognized as one of the important economic elements of the Study Area. According to the socio-economic survey in the Study Area, about 47 % of farm families cultivate sugar palm trees in the Kandal Stung study Area.

3.3.4 Livestock and Fishery

Livestock raising is an important activity for farmers in the Study Area. Most farmers keep cattle, pig, and poultry. Cattle is raised for draught power for field preparation and cart transportation, and for manure. Pig and poultry are not for domestic consumption, except for special occasions, and are mostly sold to markets. There is out 16,000 head of cattle in the Kandal Stung Study Area and 9,500 head in the Tonle Bati Study Area.

The number of cattle for preparation of rice field in the Study Area is still inadequate in more than half the number of communes at present, but in few years after when the cattle under three years old at present will become old enough to supply power and the draught power in the area will be sufficient for farm operation. 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 popular source for domestic consumption in the Study 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 Study Area.

3.3.5 Agro-processing

The most important agro-processing activity in the Study Area is rice milling. About a half number of villages have privately owned rice mills in their villages. Most rice mills were installed in the last 2 to 3 years, due to the free rice market system introduced recently. At present almost all villagers use rice mill for milling rice for their own consumption, instead of pounding method. The milling charge is about 45 US\$/ton (paddy).

Two types of rice mills with milling capacity of 400 kg/hr and 150 kg/hr are popular in the Study 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. The recovery rate of the milling is about 60 to 62 % for both types according to the millers. Some milling machines are manufactured in Phnom Penh, and spare parts are available locally.

3.3.6 Marketing System

At present, the marketing of farm products in the area is under a free marketing system, without controls except for farm inputs supplied by the government (mainly fertilizers and chemicals). Usually farmers sell their products, especially paddy, pigs and poultry, whenever cash is required, to middlemen who visit individual farmers. No organization has been established for the marketing of farm products, reducing farmer's power to negotiate with the middleman on prices.

3.3.7 Agricultural Production Value

Total production of rice, and palm sugar and the number of livestock equal the gross production value in the Study Area. 1993's gross production value is shown below:

Gross Production Value

Items	Kandal Stung	Tonle Bati	Total	Price/kg		Value		%
				Riel	(\$)	million Riel	(1,000\$)	
Paddy (ton)	9,120	6,570	15,690	400	(0.18)	6,276	(2,853)	62
Sugar (ton)	1,000	190	1,190	800	(0.36)	952	(433)	10
Cattle (head)	2,400	1,430	3,830	260	(0.1)	996	(453)	10
Pig (head)	11,000	6,200	17,200	80	(0.04)	1,376	(625)	14
Poultry (head)	96,000	41,250	137,250	3	(-)	412	(187)	4
Total						10,012	(4,551)	100

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

As seen in the above table, about 62 % of annual farm production value is dependent on rice cultivation, while livestock contributes to about 28 % of the major agricultural production.

3.3.8 Farm Economy

In order to grasp the agricultural economic condition of the farm family in the project area, a sample survey was carried out. The surveyed number of houses in the Kandal Stung area is 76 and 41 in the Tonle Bati area.

The average farm size per family is about 1.2 ha in the Kandal Stung Study Area and 1.3 ha in the Tonle Bati Study Area. The family size is 6 persons per family in both areas, out of which about 2.5 persons are able to work.

(1) Food Balance of Farm Household

A rough analysis on food balance for the average family in the Study Area was made based on the results of the sample survey. The requirement of rice consumption is calculated at 310 kg/capita/year, while the production in 1993 was 1,440 kg of paddy per capita, resulting in a certain shortage of rice as shown below :

Area cultivated	1.2	ha
Average unit yield	1.2	ton/ha
Production	1,440	kg (paddy)
Consumption	1,860	kg/family (310 kg x 6 person/family)
Balance	- 420	kg

(2) Income Base

The main economy base in the Study Area is rice cultivation, but the production is not sufficiently high mainly due to an irrigation water deficit and a shortage of inputs and improved techniques. The farmers are at present earning income basically from rice cultivation, but the majority of farmers maintain their living supplemented by livestock, sugar, and wages. The following table shows the major types of income sources of farm families:

Farmer's Income Distribution

Income source category	Kandal Stung Study Area		Tone Bati Study Area	
	(No.)	(%)	(No.)	(%)
1. Rice cultivation	5	7	1	2
2. Rice and livestock	6	8	27	66
3. Rice, livestock, and other crops	10	13	0	0
4. Rice, livestock, and other off-farm income	44	58	7	17
5. Rice and other off-farm income	11	14	6	15
Total	76	100	41	100

As shown above, livestock raising contributes fairly to farm incomes, 28 % of farmers in the Kandal Stung Study Area and 68 % in the Tonle Bati Study Area being fully dependent upon agriculture.

(3) Income and Expenditures

The gross income of farm households in the Kandal Stung Study Area is estimated at about US\$ 380 and US\$ 220 for farming and off farm activities. The farm household income in the Tonle Bati area is estimated at about US\$ 300 only from farming activities. About one-third of the gross income in the Kandal Stung Study Area is derived from off-farm income consisting of salaries, wages earned by labour work, and remittance from family members working in Phnom Penh. More than 80 % of the gross farm income is derived from rice production in the Tonle Bati area.

The average expenditure, including production costs, in the Kandal Stung and the Tonle Bati Study Areas is estimated at about US\$ 600 and US\$ 300, respectively. The average total annual living expenses of farm households in the Kandal Stung and the Tonle Bati Study Areas are estimated at about US\$ 510 and US\$ 200 per household, respectively. The study on farm budgets makes it clear that farm economy for the typical farmers in both Kandal Stung and Tonle Bati Study Areas remains on a subsistence level.

3.4 Present Agricultural Support Services

3.4.1 Agricultural Support Institutions

The Government institutions directly concerned with the Kandal Stung Study Area are the agricultural office of the Kandal Stung District of Kandal Province and Kandal Stung Rural Development Centre (KSRDC), while the Tonle Bati Study Area receives support from the agricultural office of the Bati District of Takeo Province, and the Tonle Bati Agricultural Development Centre (TBADC). There are no engineers and an insufficient number of staff to effectively execute agricultural extension work in both offices.

3.4.2 Agricultural Extension and Input Supply

Agricultural extension work in the Kandal Stung Study Area started in 1991 by KSRDC under DOA. The area covered by KSRDC is about 375 families in 12 villages belonging to 3 communes. Most of the activities are concentrated with community development through small scale agricultural credits. TBADC was established in 1986 in collaboration with DOA and WCC. WCC transferred the supporting activity to HEKS in December 1993. The main objectives of TBADC is to distribute irrigation water to an area of about 6,000 ha and distribute farm inputs. The extension work was started in 1992 including such activities as rural credit, operation of demonstration plots to show farming techniques for fertilizer application and improved varieties, as well as community development.

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

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 middlemen who visit individual farmers. No organization has been established to trade farm products, reducing the farmer's power to negotiate with the middleman on prices.

3.4.3 Agricultural Credit Services

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

3.4.4 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.

3.5 Existing Irrigation and Drainage Conditions

3.5.1 General Description of the Study Area

(1) Irrigation and Drainage Conditions of the Kandal Stung Study Area

The Kandal Stung Study area is located in Kandal Stung District of Kandal Province, covering a gross area of 11,300 ha. The area is bounded by the Prek Thnot River on the north, the National Road No. 3 and National railway on the west, the National Road No. 2 on the east, and the Tonle Bati River and Lake on the south. Topography of the area in general, slopes to the east, facing the Cheung Loung Lake with an average of 1:1,500 to 2,000, except the northern and southern edges which are drained directly to the Prek Thnot and Tonle Bati rivers. Geomorphic land units are broadly classified into younger flood plains and older plains; the former mostly extends in the north of the Stung Toch and the latter lies in the south of the Stung Toch. The older plains are slightly elevated with a ground elevation higher than 12.0 m.

In the Pol Pot regime 1975 to 1976, the Tuk Thla Regulator and Kompong Tuol Regulator were constructed at the crossing point of the Prek Thnot River with the National Road No.3 to supply irrigation water to the Kandal Stung and the Tonle Bati area. An irrigation canal system was also constructed in the Kandal Stung area. Pol Pot canal systems were also provided in the north of the Stung Toch River in the younger flood plains. The slightly elevated area, a south-western part of the Study Area, is not provided with an irrigation system.

The rehabilitation/construction of the Pol Pot canal system in the Kandal Stung area was executed from 1987 to 1991 by the Department of Hydrology with the assistance of MCC (Mennonite Central Committee), covering about 2,000 ha of agricultural land. The National Road No. 3 dike between the Kompong Tuol and Tuk Thla regulators was washed out several times, resulting in repeated rehabilitation of the road dike. In August 1994, the road dike was further breached by flood. Therefore, the irrigation system for the Kandal Stung area has not been functioning for a long time. Under those situations, farmers have had to use different kinds of lifting irrigation, such as indigenous tools or small private capacity engine-driven pumps to a limited extent.

Irrigation water sources for the Kandal Stung area are the Prek Thnot and Stung Toch rivers. The annual river flow of the Prek Thnot is estimated to be 1,334 MCM, equivalent to 42 m³/sec. The Stung Toch is a seasonal river, and is not reliable for irrigation. The Prek Thnot River flows in the dry season, especially from January to April, decreases drastically to about 2 to 4 m³/sec. The existing irrigation intake in upstream diverts most of the dry season river flows at present. The only irrigation system in the Kandal Stung Study area is the Kandal Stung Irrigation Project which has been rehabilitated, but is still not functioning well at present.

Most of the Kandal Stung Study area is drained to the Cheung Loung Lake through the Pol Pot canals, the northern part is however directly drained to the Prek Thnot River also through Pol Pot canals. Drainage water in the south west discharges to the Tonle Bati River and Tonle Bati Lake.