CHAPTER 3 MASTER PLAN FOR AGRICULTURAL DEVELOPMENT IN THE MEKONG FLOODED AREA

3.1 Agricultural and Rural Development Policies in Cambodia

3.1.1 National Program to Rehabilitate and Develop Cambodia

In February 1994, the National Program to Rehabilitate and Develop Cambodia (NPRD) was started with the following objectives:

- reform the State, its institutions, and its public service;
- rely on private entrepreneurship and market as engines of growth;
- double the present level of GDP by 2004 in real terms, and place heightened emphasis on harnessing Cambodia's agricultural, industrial and tourism potentials;
- extend health, educational and social services to the entire population so as to ensure, within the decade, a substantial improvement in the standard of living;
- improve rural living by promoting rural development;
- ensure the pattern of sustainable development socially, politically, environmentally and fiscally; and
- strengthen domestic self-reliance and reduce external financial and technical assistance.

For the above objectives, the reinforcing strategies are; 1) to reform the administrative and judicial institutions of the State, 2) to promote economic stabilization and growth, 3) to ensure structural adjustment and sectional reform, 4) to provide direct support for sustained development and 5) to optimize the sustainable utilization of the natural resource base:

The agriculture sector, therefore, receives a high priority, as it is a key to bolster rural economy. In the First Socio-economic Development Plan (1996 - 2000) prepared by the Ministry of Planning in February 1996, the basic goals of agricultural sector are to;

- ensure food security through expansion of rice production, or its market availability, and of secondary food crops;
- contribute to economic growth and to foreign earnings through exports; and
- improve income opportunities for farm households by diversifying crop production.

3.1.2 Strategy for Agricultural and Rural Development

The Royal Government regards agricultural and rural development as being central to rehabilitation and development plan. The Government is pinning considerable hope on the initiatives of increasingly dynamic private sector and the flowering of such initiatives would be supported through;

- improving infrastructure and rural access to markets and to Sihanoukville port,
- privatizing the rubber estates,
- maintaining liberal trade, distribution and exchange rate systems,

- ensuring an adequate supply of credit at realistic but commercial rates of interest,
- assisting the rural population take advantage of the growing commercial opportunities by continuing to assist their integration into an emerging market economy,
- addressing land tenure, land mines and internal security.

(1) Agriculture

The Government's agricultural development plans rest on the efficient exploitation of the country's considerable resource potential, including;

- soil and topographic diversity, and the potential for growing a wide range of crops and livestock;
- forest resources, both in terms of their biodiversity and their productive potential;
- fisheries resources, notably in the Mekong, Tonle Sap, coastal mangroves and Gulf of Thailand;
- rural labor force with the intention of prospering through farming and commercial activities;
- large group of motivated local and foreign NGOs;

The Government requests contributing countries and agencies to focus their supports on the followings:

- Achieving rice self-sufficiency as an immediate goal with limited capital-intensive investment
- Rehabilitating selected irrigation/drainage systems and physical infrastructural facilities including the following:
  - promoting greater fertilizer use through the market mechanism,
  - fostering an expansion in rural credit facilities,
  - accelerating the removal land mines to encourage the cultivation of abandoned land.
- Promoting a growing market orientation in order to foster the following:
  - agricultural diversification into farming activities offering higher returns to crops other than rice,
  - growth of agro-processing/agro-industries,
  - exports of raw and processed agricultural products,
  - search for "niche" products,
  - addressing land tenure and accelerating the process of providing land titles,
  - ensuring more rational and sustainable exploitation of the forest resources.

(2) Rural Development

There are some priority areas such as providing training centers, water supply, primary health care and rural roads, as being critical to rural development. The Government pursues two parallel strategies; 1) to improve the management of rural development programs, by supporting greater consultation and better coordination among the development partners, 2) to improve and to increase the linkages between the design and implementation of development programs, by promoting participatory methodologies and an integrated approach to rural development.

To pursue the above strategies, the key policies are; 1) to invite all national and international organizations and agencies involved in rural development, and 2) to ensure a shift towards an integrated and more people-orientated approach to rural development, in order to reinforce sustainability through people participation and gender sensitivity.

3.2 Basic Approach to Agricultural Development

3.2.1 Significance of the Master Plan Study and Objectives of the Plan

(1) Significance of the Master Plan Study

Cambodia is now executing the First Socio-economic Development Plan, up to the year 2000. In the plan, the Government regards agricultural and rural development as being basic requirement to rehabilitate and develop Cambodia. It is considered that agricultural development is the key to the short-term needs to satisfy immediate nation's expectations. The Study Area is recognized as the most important area for agricultural development. It has high agricultural and rural development potentiality. Promotion of the development will contribute to attain the nation's reconstruction target.

Under such circumstances, the Master Plan Study was conducted by considering the importance of the Study Area and development strategy for nation's goals.

(2) Objectives of the Plan

The Study Area is characterized by the most important agricultural region for Cambodia's social and economic reconstruction. Agricultural production is still low and at subsistence level. In due consideration of the Government policy for agricultural and rural development, the development objectives are defined as follows.

- To contribute to regional and national agricultural economic growth in increasing rice production and in promoting crop diversification with assurance of rice self-sufficiency, and
- To stabilize rural life through the enhancement of agriculture by providing agricultural and rural infrastructures, and
- To harmonize the fishing and farming activities through the conservation of natural fishery resources.

(3) Development Target Years and Production Targets

To attain the above mentioned agricultural development objectives, development plan should be formulated under the nation's development policy and strategy considering the importance and urgency of agricultural and rural development in the flooded area. Under such considerations, the concept of development target year is introduced in the study. The target year is set taking account of the time span of nation's development plan, as follows.

Short term target year	;	2000
Medium term target year	;	2005
Long term target year	;	2010

The role of the five (5) provinces in the Study Area is very important because of its contribution of about 40% of the paddy production of Cambodia. In order to forecast an agricultural outlook of the Study Area, study on demand for paddy on the basis of the projected population, rice consumption and required seed, are made for the target years. As the result, it is estimated that about 3.1% of annual growth in paddy production would be required to meet the demand in the Study Area.

	Required Production (ton)	Annual Growth (%)
1995	1,008,190	-
2000	1,171,520	3.05
2005	1,362,780	3.07
2010	1,586,800	3.09

The First Socio-economic Development Plan (1996 - 2000) sets up the target of 5.2% as the average annual growth rate of agricultural sector, 6% for paddy production and 4.5% for other crops. Assuming that 6% for paddy production is applied to the Study Area, the following production would be required:

	Required Production (ton)	Annual Growth (%)
1995	1,008,190	-
2000	1,349,180	6.0
2005	1,805,500	6.0
2010	2,416,160	6.0

3.2.2 Basic Concepts for Agricultural Development in the Mekong Flooded Area

To achieve the above-mentioned development objectives, the Government's policy focuses on the following points:

- Expansion of productive agricultural lands for increase in crop production.
- Provision of agricultural infrastructural facilities for productive farming.
- Provision of rural infrastructures for stable rural life.
- Conservation of fisheries resources for sustainable fisheries production.
- Expansion of agricultural supporting services for accelerating crop production
- Fostering farmers' organization for improvement of agricultural activities and rural life.

The development plan is formulated considering agricultural characteristics of the flooded area.

Agriculture in the flooded area is linked with annual cycle of Mekong river flooding. Frequent heavy flood imposes many constraints on agricultural development for wet season though annual flooding brings many benefits into farming, fishing and various ecosystem. Flooded water stored in the flood plain is used for fisheries development and dry season agriculture, and flows

back into the Mekong river. Flood plain serves as the flood control reservoir for down stream areas, especially in Viet Nam delta.

The mechanism of inundation and recession is inherent in the flooded area. Present traditional and common farming system developed under such seasonal flooding is considered to be essentially a sustainable and rather advantage agriculture harmonized with water regime of Mekong river.

Construction of large scale facilities to control water flow of the Mekong river will cause changes of water regime, though it will bring a stable and productive agriculture through introduction of advanced farm production technology. But, if it is developed without proper studies, it may affect present sensitive fish ecosystem, and rapid improvement and construction works in some areas may cause detrimental effects to the other down stream areas. Such development plans should be proceeded by considering change of comprehensive hydrological regime and environmental interests in related basins and areas. There is no prospect of running any such large scale development projects at present, which will face with many financial and technical difficulties and will require long development term to realize the projects.

Taking account of the above situations, development objectives should be attained by improving the present traditional agricultural system. Master plan is formulated taking the advantage of traditional farming practice with annual hydrological and ecological cycle into consideration.

3.2.3 Framework of Agricultural Development Plan

Present agricultural pattern in the Study Area is characterized as follows;

Colmatage farming : Colmatage farming is practiced by bringing silt-bearing water into farmland and backswamp behind the natural levees. The agricultural land is extended in and around the colmatage canals.

Lowland irrigation farming : Lowland irrigation agriculture is practiced around swamps and lakes by using impounded flooding water. Fishing activity is also practiced together with lowland farming.

Rainfed agriculture : Agricultural land without any irrigation facilities is dependent on annual rainfall distribution and inundated water.

To attain the development target of the Study Area, the above agriculture patterns should be developed based on the water and land resources potentials. By taking account of the development concept and the agricultural patterns, the following three development plans are proposed (see Figure 3.1).

(1) Colmatage Farming Improvement Plan

This plan is developed for the agricultural area around the colmatage canals along with the Mekong, Bassac, and Tonle Sap rivers in order to promote crop diversification and increase crop production. The area is located around the 386 colmatage canals. Covered area is estimated

at 25,500 ha and 52,900 ha in wet and dry season, respectively. The severity level of inundation is less than the other areas.

(2) Agriculture Development Plan Harmonized with Fisheries

This plan is developed for the lowland agricultural and fisheries areas around swamps, lakes and canals including the present lowland irrigation area in order to increase crop production maintaining fishing ground and resources. The area involves in the 292 areas with lowland irrigation system. Covered area is situated 33,700 ha and 75,800 ha in wet and dry season, respectively. Inundation damage is more severe.

(3) Rainfed Agriculture Development Plan of the Inundated Area

This plan is developed for the flooded rainfed areas around lowland and colmatage farming land in order to increase wet and dry season crop production. The degree of inundation is relatively not severe. Covered area is estimated at 491,200 ha.

The above three development plans are developed in close combination with each others, based on the regional agricultural characteristics and development potentials (see Figure 3.2). The following development component should be incorporated in all three plans.

- Improvement of farm production system

Two approaches are required to increase agricultural production, namely, boosting crop yields and expanding cultivable and irrigable area. Increasing crop yield would be attained through improvement of farming practices. Cultivable land would be expanded by improvement of agricultural infrastructures. Improvement of farming technology to enhance cropping system should be pursued in combination with agricultural supporting service development plan.

- Provision of agricultural infrastructures

Provision of agricultural infrastructures is the basic physical requirement for increasing crop production. The infrastructures including the present facilities have to be rehabilitated or constructed based on the development concept of three agricultural patterns. In parallel with improvement of physical conditions, institutional capability of GDIMH has to be strengthened to operate and manage the infrastructure facilities in an effective manner.

- Promotion of agricultural supporting service

Agricultural supporting service activities is also the key for the improvement of farming practice. It includes research for crop diversification and paddy production, extension for improvement of farm technology, and development of agro-processing, marketing and agricultural credit system.

- Provision of rural infrastructures

Provision of rural and farm road network and drinking water supply system are the basic needs for stable rural life and agriculture activities.

- Establishment of farmers' organization and promotion of rural development

While improving farming practice and providing infrastructures, farmers themselves have to manage and operate the agricultural facilities to secure their agricultural benefits. Farmers' participation is prerequisite for sustainable agricultural development in the flooded area. Organizing plan would be proceeded in close cooperation with NGOs concerned with rural development.

- Fisheries development in harmony with agriculture

The root cause of conflicts in fishing ground is due to existence of allocated fishing lot area and overfishing. To avoid the conflicts, development concept harmonizing the agriculture and fisheries developments has to be introduced into the fishing and farming area.

3.3 Colmatage Farming Improvement Plan

3.3.1 Agricultural Land Use

(1) Basic Concept

At present, colmatage farming is one of the most productive farming systems not only in the Study Area, but also in the whole of Cambodia. It is also adapted for the natural conditions and utilizes them for agricultural production.

Upland and recession rice fields, characterized by colmatage farming, are usually located along each colmatage canal and fertilized every year with nutritional sediments of annual flood. Basically, upland field is composed of fertile soil such as brown alluvial or alluvial soil. The expansion rate of upland field depends on the conditions of each colmatage canal, flood extent, the contents of flood water and so forth, so it is difficult to estimate or forecast its average. The farming itself has continued since the end of the last century because of its sustainability and environmental adaptability.

In consideration of those characteristics, it is the basic concept not to change the present system and land use pattern but to maintain the present colmatage farming system and promote the development of the system under proper management.

(2) Agricultural Land Use

Upland field developed along the colmatage canal is classified into two types, namely the non-flooded upland field and the flooded upland field. The non-flooded upland field is usually distributed along the river banks and the canals. Anytime in wet season, farmers can practice farming with rainfall on the field. During dry season, farming is impossible without irrigation. Some farmers recently practice dry farming utilizing water remaining in colmatage canals and they sometimes use small mobile pumps for irrigation (see Figure 3.3).

Next to the non-flooded upland field, lie the upland field, receiving periodic flood through colmatage canal. Generally, this upland field is cultivated before/after flooding so cropping season depends on the flood water level and is not uniform every year. In the very long term,

this upland field will be gradually built up and change to non-flooded upland field by sedimentation of annual flood.

The rehabilitation of colmatage system makes it possible to keep flood water in colmatage canals for dry season irrigation by operating water control facilities such as gate to practice dry season farming. Consequently, it is the target for the colmatage farming areas to make the possible cropping season longer by utilizing water stored in the colmatage canal and expand agricultural production through cropping intensity increase without any changes in land use.

3.3.2 Farming Practice

(1) General

Basically, colmatage farming is defined as farming on the upland fields extended along the canals and rivers. It includes only small area of dry/wet paddy farming practiced around back swamp areas at the end of colmatage canal.

Colmatage farming system is one of the most diversified agriculture in Cambodia so it is well adapted to a national agricultural policy; crop diversification. It is also market-oriented agriculture, especially in the three districts in Kandal, Saang, Kean Svay and Muk Kampoul located around the capital, Phnom Penh.

On the non-flooded upland fields, farmers plant a wide range of crops such as maize, sesame, sugarcane, mungbean, vegetables, etc. On the river banks, where they have the least possibility to receive flood and are residential areas, the mixed cultivation of home consuming crops and fruit trees such as banana, mango, longan and so forth is usually practiced.

On the upland fields where it receive annual flood, short duration crops such as maize, mungbean, sesame, are commonly cultivated before flood from May to August. After the flood water start to recede, the crops which can survive with less water from residual soil moisture like some vegetables, peanut, tobacco, are cultivated in addition to those above mentioned crops.

(2) Farming Plan

Since the colmatage farming is highly diversified and considered as one of the most productive farming in Cambodia, basic farming system will not be changed. The agricultural production increase in the areas will be achieved through the increase in cropping intensity during both dry and wet season.

As mentioned above, the colmatage farming of the three capital suburban districts functions as vegetables supplying areas and this farming is the prototype of typical agriculture of suburbs observed in other countries. For these areas, the target of development is to expand the present farming and make it more intensive through market incentives. In particular, leafy vegetables, easy to get damage in handling and transport, are important for those suburban areas.

For other colmatage farming areas, remote from the capital/populated areas, the large-scale vegetable production is not practical because of some problems such as marketing and transport. For those remote areas, the stable production of cereal and legume crops is recommendable as a

first target under the poor infrastructure conditions. Those two crops can be stored for a longer duration after drying and are possible to export in the future. Moreover, legume crops can contribute to maintain soil fertility through the action of rhizobium in the soil.

Leuk Dek in Kandal with 51 colmatage canals along the Mekong could be one of the models for these remote areas because its colmatage farming is highly concentrated on maize production during early wet season before flooding. Koh Thom in Kandal could be another model which is characterized by dry season chili cropping. Dried chili is presently exported to Thailand.

The annual flood water also brings the seeds of the nuisance thorny plant, *Mimosa pigra*, and therefore constant manual land clearing is necessary to be able to use the land which receives flood for either short or long period.

3.3.3 Colmatage Canal Rehabilitation

(1) Function of Colmatage Canals

Figures 3.4 and 3.5 show the typical use of colmatage canals based on the mosaic photos along the Bassac river. The former shows that the land elevation in between the canals is high, not inundated and has already been developed for uplands crops and recession cropping is practiced in the back swamp area. The latter shows that the land around the canal, looking like a tree, is used to cultivate the upland crops. The land in between the canals has good potential to be reclaimed.

After harvesting of wet season crops in the middle of August, gates are opened or earth dikes are demolished at the entrance of canals to introduce flood water to back swamp areas for recession cropping in the beginning of dry season. During this process, the functions of the colmatage system are categorized into two types. Figures 3.6 and 3.7 show the typical section and the function of colmatage system. In the Figure 3.7, as for type II, it is very interesting to note that farmer makes a small ditch perpendicular to the colmatage canal and along the boundary of his land in order to introduce silty flood water to expand agricultural land and area for recession cropping.

Colmatage canals have generally many functions such as supply of silt-bearing water, conservation of backswamp's ecosystem and route of fish migration. It also serves as the impounded water for dry season cropping. However, most of the canals have deteriorated. They have to be rehabilitated urgently to recover their functions.

(2) Types of Colmatage Canal

Based on the colmatage canals inventory, for construction/rehabilitation, colmatage canals are divided into 5 types as below. Rehabilitation plan is drawn up for each canal type in accordance with the present canal dimension and type (details of the inventory are shown in Appendix D.1).

Type of Colmatage Canal

Type	Bottom Width of Canal (m)	Number	Water Control Facility
A	6.0 <	200	Culvert
B	6.0 to 10.0	77	2 series gate
C	10.0 to 15.0	30	3 series gate
D	15.0 to 20.0	41	5 series gate
E	> 20.0	38	7 series gate

(3) Rehabilitation Components

(a) Gate

The function of gates is to protect wet season harvesting crops from flooding water and to keep water in canal and backswamp area for irrigation and drinking water. About 10% of the canals are equipped with steel type slide gates. Almost all of them have deteriorated and are not in operation. At present, the number of canals with gate is about 40, and the number of canals blocked by dikes built by farmers to control flood water intrusion is also about 40. Total of 80 canals should be provided with control facility to protect wet season crops. The necessity of gate in the other canals should be examined by each canal, taking account of negative effects on the downstream area brought by installation of gates, farmers' capability of operation and maintenance of gate and importance of fish migration route.

Gate facility should be light weight and be easy to operate for water control. Bank protection around the intake is necessary. About 40 existing canals equipped with gates are not operational. Installation plan of gate is ; 1) about 40 existing gates should be reconstructed first. 2) the remaining 40 canals blocked by dike should be provided with gates.

(b) Bridge

There are three types of bridges, concrete, steel iron and wooden bridge. According to the inventory survey, almost all of the wooden bridges have deteriorated and are unsafe to use. They should be replaced by the concrete type as soon as possible.

(c) Canal

As a general observation, depth of canals is shallow, slope is eroded by flood water and maintenance work to repair the canals is limited. To protect the slopes in the canal, the velocity of flow should be more than 0.6 m/sec but less than 1.5 m/sec and a side slope of 1: 1.5 is required. If lowland area is to be developed for upland crops, secondary canal which are perpendicular to the colmatage canal should be dredged by farmers. Since most of the colmatage canals are classified as small scale system, it is the responsibility of farmers to dredge and repair the canals as well as to manage proper water use. In order to develop colmatage farming system, not only rehabilitation of water control facilities but also strengthening of farmers' organization in water control and allocation is necessary.

(d) Maintenance road

The improvement of maintenance road of the canal consists of gravel pavement, banking and construction of related structures. According to the land holding system, the area from the crest of canal front slope to the toe of the dike belongs to the governmental property but the boundary between the private and public lands at site is often not clear. At the implementation stage of rehabilitation/construction of the maintenance road, GDIMH has the responsibility to acquire the land for maintenance road.

To promote rehabilitation plan of canals, present whole canals are grouped together at administrative levels of provinces and districts. Rehabilitation priority is given into the groups based on ranking factors such as intensity of agricultural activity, development potentiality, possibility of organization of water users' association and deterioration of canals and intake gates. In the rehabilitation plan, small scale works of canal excavation might be conducted by beneficiaries themselves under supervision of GDIMH.

(4) Potential of Water Resource and Agricultural Land

There are about 386 colmatage canals and total length of the canal is about 840 km. According to the estimation of storage capacity of canals, more than 22 MCM of water can be stored in the canal at the end of wet season if gates are installed and the canals are re-excavated for 1.5 m in depth. Taking into account of evaporation and percolation in the canal, about 11 MCM, 50% of the stored water can be utilized for upland crops in the dry season. In this case, 4,500 ha of upland crops can be cultivated, which is 25% of total (18,279 ha) in the area. To develop maximum cropping, proper water management is required.

3.3.4 Operation and Maintenance of Canal Facilities

Irrigation systems in Cambodia are generally to be constructed, operated, and maintained by hydrological offices at each administrative level and the beneficiaries according to the guideline on scales of the systems as described below. Most of the colmatage canals classify into the small scale and should be maintained by beneficiaries. The management and maintenance include dredging of canal, gate operation and maintenance, rehabilitation of canal and maintenance of roads, etc.

(1) Small Scale (service area less than 200 ha)

- The system is managed by District Office of Irrigation, Meteorology and Hydrology (DOIMH).
- Where the system is located at interdistrict, it is managed by Provincial Bureau of Irrigation Meteorology and Hydrology (PBIMH) or Municipal Bureau of Irrigation, Meteorology and Hydrology (MBIMH).
- The system is operated and maintained by the beneficiaries, supervised technically by PBIMH/MBIMH.

(2) Medium Scale (200 - 5,000 ha)

- The system is managed by PBIMH/MBIMH.

- Where the system is located at interprovince, it is managed by GDIMH.
- The system is maintained by PBIMH/MBIMH in cooperation with the beneficiaries.
- The system is repaired by GDIMH under the finance of government.

(3) Large Scale (more than 5,000 ha)

- The system is managed by GDIMH.
- The system is repaired by MAFF in consultation with the concerned ministries.

Most of the colmatage canals are poorly maintained at present because the organizations for maintenance do not function as they should do, though some of them in the areas between the Mekong and the Bassac rivers have been dredged by the beneficiaries under a guidance of DOIMH and commune chief.

Water users' association established by each canal shall maintain rehabilitated colmatage canal. Where colmatage is rehabilitated, the beneficiaries ought to be organized into a water users' association by the guidance of DOIMH under the supervision of PBIMH. The water users' association is likely to be easily organized because there exist canals and the beneficiaries recognize the importance of canals.

The established association shall define the duties on maintenance clearly. The O&M shall be transferred from PBIMH to the association after the rehabilitation is completed. The spare parts of the facilities shall be purchased and construction and maintenance machines shall be used to repair canals in the future. Subsequently, the association shall consider to collect necessary operating fees from the association's members for regular maintenance.

The gate is normally opened about the middle of August when wet season crops are harvested and closed at the beginning of dry season to keep water for irrigation and other water uses. The timing of opening and closing gate shall be decided by the association in consultation with DOIMH.

Dredging of canal and rehabilitation of side slope and maintenance road basically shall be done during April and May under the guidance of PBIMH. Such works shall be conducted by beneficiaries themselves.

3.3.5 Strengthening Program of Farmers' Organization

A spontaneous action for organizing farmers' group by farmers themselves is hardly expected at present. There is a need of an organizer to establish farmers' organization.

PBIMH and DOIMH have a role to organize and supervise the water users' association to manage and operate canal system. However, necessary action for organizing farmers' group and strengthening the group should be done by extension workers of provincial agricultural department and NGOs who have good experience in the field. It is required to have meetings more often to discuss the necessity of organization. It is also expected for them to hold workshops and training courses on farmers' organization until farmers understand importance

and necessity of organization. On the other hand, GDIMH plays an important role to fill the task for organizing farmers and operating the colmatage canal system.

The following points are required in farmers' organization.

1) The committee members of an organization should be elected by the members through a democratic procedure.
2) Chairperson should be the person trusted personally and especially on money by the members.
3) The organization should create rules and regulations of its own, such as water laws.
4) The organization should collect the necessary expenditures of its own at reasonable amount to cover operation, maintenance, and other necessities.
5) The organization should have a hall to meet, and rooms for clerk work, shortage of spare parts. The hall may be used also as a community hall.
6) Committee members should be paid with reasonable amount.
7) Special considerations should be taken to female headed households.

It will be difficult to organize water users' association in all of the colmatage canals at the same time due to different social background of the canals. It is therefore practical to begin with a model organization in a district in order to demonstrate the importance of organization to farmers not yet organized. This will be disseminated gradually to other colmatage systems. In case that it is difficult to organize the beneficiaries into water users' association, VDC may be one of the substitutive organization for a while. It could reflect voices of villagers directly to the colmatage farming system.

Canal rehabilitation will enable farmers to improve water management, but farming needs other technical improvements of farming practice. Agricultural supporting services such as extension, credit, etc. can be provided through the activities of water users' association. It is more practical to start with a single-purpose organization and to extend its activities for establishing an integrated organization like agricultural cooperative.

Women play important roles in farming. But they are put at disadvantage in many aspects of rural community. When an organization is established, equal positions with male headed households should be given on female headed families. More favorable consideration such as more chance for participation with farmers' organization and deduction of labor contribution to canal maintenance works, might be given into female headed families.

3.3.6 Agricultural Supporting Services Development

(1) Agricultural Research and Extension Service

Colmatage farming is characterized by upland crops and recession farming. Practiced crops are many; vegetables, cereals, legumes, industrial crops, fruit trees, etc. Still there is only one research institute in Kean Svay, Kandal, which sets vegetables as main objective crop in Cambodia. It provides three services, (1) selection and multiplication of vegetable seeds, (2) research activity of vegetables, (3) training for both governmental workers and farmers, but their

activities are limited due to lack of technical staff and budget. In spite of its limited human resources, there are only eleven staffs in the vegetables research center, it provided two-week farmer training course at 14 times in 1995, 25 to 30 farmers a course. Training course was financially supported by NGOs.

To increase agricultural production of upland crops in colmatage farming areas, it is indispensable to strengthen the research activities for all kinds of upland crops. In consideration of the present budgetary and staff constraints, some of the concrete targets should be set as high priority. The following are possible objectives; (1) selection of variety of several major upland crops which are highly suitable for colmatage farming, (2) seed multiplication of the selected variety, (3) establishment of seed distribution system. Moreover, the development of upland crops specialist is also important. In addition to the continuous domestic training in a long term, the invitation of some qualified researchers is recommendable because it brings the immediate effect.

Present extension services are officially managed by DTEE, although now practiced by two departments; DOA and DTEE. The number of extension workers of concerned provincial agricultural offices is very few for technology extension. Since Australian official assistance for DTEE has just started this year and will complete and achieve its objectives in 2000, practical results can not be observed at present. Close exchange of technical information between research and extension departments is vital to effective extension.

In the colmatage farming areas, application of agricultural chemicals, in particular, insecticide for vegetables, is more common and frequent than in other areas. If application method/dosage is not proper, not only the harvest will decrease but also some health/environmental damage will occur. Application standard for agricultural chemicals should be made immediately and extended to the farmers through extension service.

Technological improvements for farming vegetables, no matters how slight, are very useful. (Ex. 1: Corn and some leafy vegetables deteriorate earlier when they are kept horizontally than vertically. 2: By preparing separate nursery bed for upland crops made from local materials such as banana peel, it is possible to make short the growing duration on the main field and consequently increase cropping intensity.). Such low cost and instant technologies also should be extended to the farmers.

(2) Agro-Processing and Marketing

The areas irrigated by colmatage canals will practice crop diversification planting with maize, mungbeans, chili and other upland crops. In particular, Kandal province, can be characterized as upland crop producing areas in the future because of water availability and good accessibility to Phnom Penh. Phnom Penh is the biggest market in Cambodia, in which about 7% of the entire population live. Therefore, it could be said that potentiality for agro-processing and marketing is the highest in the Study Area. In considering production of diversified crops and paddy, the following agro-processing could be planned. However, small scale industry should be introduced if the present condition of this sector is taken into consideration.

Rice bran ---------- extraction of oil

Maize ---------- animal feed

Mungbean ····· noodles

Sesame····· extraction of oil

Cucumber ····· pickles

Vegetables····· pickles, dried vegetables (onion, garlic etc.)

(3) Agricultural Credit

As mentioned above, the potential for intensive agriculture in the colmatage farming area is high because of availability of irrigation by colmatage canals. However, annual farm household incomes in this area do not meet poverty line of about 2.23 million Riels per family yet. As farmers' capability for diversified farming and demand for agricultural credit in the colmatage farming area are considered higher than those in the other areas, institutional credit available for individual farmers and farmers' organization should strongly be implemented to expand and promote intensive agriculture and agro-processing.

3.3.7 Rural Infrastructure Improvement

(1) Rural Road Networks

Judging from comparatively easy access from colmatage farming area to national and provincial roads and larger number of villages therein, rehabilitation and new construction of rural roads would contribute much to the agricultural development. The rural road networks in this area is characterized as follows.

- This area is relatively located at high elevation such that major national and provincial roads run in the area.
- Rural roads run along villages being branched from or parallel with the national and provincial roads.
- The road density is relatively high being near to the national and provincial roads.

The rural roads are mostly unpaved and become muddy and not passable in wet season. Considering the above, improvement of rural road networks in the colmatage farming area is planned as follows.

- In the first step, the existing rural roads in the area, connecting from the national/provincial roads to the base villages for economic and farming activities, should be rehabilitated. The rehabilitation involves placing gravel pavement together with improvement of irrigation and drainage facilities. In addition, the roads along colmatage canals should also be improved in order to maintain the canals as being a part of major irrigation system. In the course of the implementation, the O&M system for smooth maintenance of rehabilitated roads shall be reinforced.
- In the second step, the rural roads between villages are to be rehabilitated and widened. After the improvement of rural roads, improvement of farm roads between villages and farmlands is followed.

(2) Rural Water Supply

According to the results of Rural Socio-economic Survey, people in the colmatage farming area has the largest ratio of using river water for drinking water, compared with drinking water source of the areas. This may be due to near location from the Mekong and Bassac rivers. The region, major national and provincial roads run and many villages are in, is active in agricultural production. Supply of hygienic drinking water is indispensable not only for rural population but also for development of rural economy. The improvement in this area can give much influences to the other areas.

In the improvement plan, deep wells are planned as follows.

- Deep wells are to be installed to achieve the following targets as programmed by the Department of Rural Water Supply (DRWS), MRD.
    - User per well : 200 persons/ well
    - Distance from residence to well : 300 m or less
- The installation work should be done with rural people participation. Through the installation work, know-hows for maintenance are transferred to rural people so that they can manage the operation and maintenance (O&M) independently.
- Cooperatives of well water-users are to be organized in each village. The cooperative will provide sanitary education and holds some stock of spare parts so that the constructed well may not be abandoned just because of minor troubles.
- A public organizational system to provide advises and guidance to the cooperatives shall be improved.

3.3.8 Environmental Impact

The Mekong river performs pronounced annual variation in flow. Instead of overflowing banks or levees, water flows into flood plains through tributaries and colmatage canals distributed along the Mekong and the Bassac rivers. Colmatage canals play an important role for agricultural land and fishing grounds with carrying fertile sediment and water during annual flood season.

The colmatage farming improvement plan aims to recover the deteriorated function of colmatage canals and to improve farming system. The canals will be expected to carry more stable water flow and more carrying fertile sediment on the farmland, after the improvement of canals.

In the area, traditional farming is practiced, in which agricultural inputs are minimized since silt bearing water serves as natural fertilizers and soil fertility is maintained naturally. After improvement of canals, farming input will be kept to the minimum level as long as silt bearing water will be supplied as in the present.

However, adverse impact on the ecosystem of swamp areas may be felt, when an intensive agriculture system with higher inputs of agrochemicals and fertilizers would be introduced into the natural levees and polluted water flows into backswamp areas. To prevent the occurrence

of negative impacts on the backswamp ecosystem, it is required to educate and train farmers on proper use agrochemicals and fertilizers with an extension service program.

The establishment of water users' association is required as essential in guaranteeing the operation of efficient use of water and the maintenance of the canals. Accumulation of sediments on canal bottoms year after year, should be removed by dredging.

In the future, land reclamation through sediment on the low elevation area will be extended toward backswamp areas, then the land might be changed into farmlands. In that situation, optimum land use concept including agriculture, fishery, natural ecosystem has to be defined, in which zoning for environmental conservation should be delineated politically, socio-economically and technically.

3.3.9 Anticipated Development Effects

Agriculture in the natural levee and its backswamp areas is practiced through introduction of periodic flood from colmatage canals. With the implementation of the plan, therefore, the following development effects are expected.

- The development plan will bring more intensive and commercial agriculture in the area. Farm production activity will become more active.

- The main agricultural impact is the increase in crop production of upland crops and vegetables by stable supply of silt bearing water in and around colmatage canals. Total irrigable area is expected at 52,000 ha in dry season and 26,000 ha in wet season.

- New farmland would be created by the rehabilitation of colmatage canals. The canals function more effectively for spreading silted water. Periodic siltation on the agricultural land will help to create new fertile land around the colmatage canals. Creation of new farmland will bring increase in crop production with stable farm income for rural people.

- Rehabilitation of colmatage canals would contribute to conservation of fishing grounds and resources in the backswamps and lakes, since the canal functions as fish migration channel and maintains fish habitat in the inundated bush through stable supply of flooding water.

3.4 Agricultural Development Plan Harmonized with Fisheries

3.4.1 Land Use

(1) Present Conditions

In the area, not only agricultural land but also several other land use categories are included. For example, inundated bush is not used for agriculture but it has some important functions for fishes to provide hatchery and habitat. Standing water; lake and reservoir, is utilized for both agriculture as irrigation water resource and fishery as fishing ground and fish habitat. Moreover, many fishing lots are set without any consideration of the relation between agriculture and fishery. The boundaries of fishing lots may clear on the maps, but not clear on the field.

Present land use situation in the area is not uniform. It changes in accordance with the seasonal shift of water level. In dry season, water level goes down and some upland crops and two kinds of paddy which includes flood recession paddy and dry season paddy with irrigation are practiced around reservoirs/lakes, where is inundated in wet season. Other land use categories, such as inundated bush, waste land and swamp, are not used except for pasture land during dry season.

In early wet season, some legume crops and vegetables are partly cultivated before flooding. The cropping areas decrease and commercial/family fishing become active with the rise of flood water. Although the planted area of deep-water paddy is decreasing in recent years, it is still cultivated in small areas.

(2) Land Use Plan

Freshwater fish is one of the important protein sources for rural people which is a land locked country, but its overall fish production is stagnated in recent years due to the reckless fishing and so forth. Accordingly, in the fishing lots, the agricultural land expansion to non-agricultural land such as inundated bush/forest, grassland, waste land, swamp, is not recommendable because it is feared that the decrease of fish habitat induce the further deterioration of freshwater fish capture. Out of the fishing lots, the agricultural land expansion to non-agricultural land is planned just in case that reclamation has no effect on fish resources.

As for fishing lots, the boundaries are not clear, that may induce confusion of land use on the field. It is important to set the boundaries clearly and notify to the concerned people for the coexistence of agriculture and fishery in the future. In that case, setting boundaries should be made not only by the authorities concerned but also by the residents. If the residents are not included, some problems may occur.

Because of annual flood from the Mekong and the Bassac, land use situation will not significantly change in the future. In the relatively high fields which receive late flood, cultivating some upland crops till flooding should be recommended and the expansion of agricultural production will be attained through the increase of cropping intensity. In dry season, the present land use situation will be almost same but some land reclamation to non-agricultural land will be done to expand production (see Figure 3.8).

3.4.2 Farming Harmonized with Fisheries

(1) General

Cropping patterns in the areas are limited because agricultural activity can be practiced only during non-flooded period. At present, two dry season paddy cropping patterns including flood recession paddy and dry season paddy with irrigation, are main activities and some upland crops are cultivated in early wet season before flooding. (Flood recession paddy is transplanted as the flood water recedes and then irrigated supplementary using impounded water in reservoirs built by low dikes and in canals.) Deep-water paddy is also planted in small areas. But its planted areas decreases gradually and convert to dry season paddy cropping because it is necessary to adapt a wide range of environmental change like flood duration and flood water depth varying

every year and the unit yield is low and unstable. Waste land and grassland are used for pasture land during dry season.

Though there is no statistical data which describe planted areas/production for this area, the two types of dry season paddy have generally higher yield and more productive than the wet season paddy.

(2) Farming Plan

For the areas where irrigation water is secured in dry season due to the provision of water control facilities, it is possible to expand dry season paddy and upland crops farming after receding flood water till the commencement of rain in wet season. Receding time is influenced by elevation, geography, flood extent, and it is variable every year.

Dry season paddy with irrigation needs irrigation water throughout the growth period. So its large-scale introduction is not practical because large scale water control facilities are also necessary to secure enough water. Flood recession paddy, utilizing flood water for the early stage of growth, needs less water than dry season paddy with irrigation so it could be cultivated on larger areas in comparison with dry season paddy with irrigation, using the same volume of water resource. If the projected facilities are not enough for the water requirement of flood recession paddy or the expansion of upland crops farming has higher priority than flood recession cropping, the expansion of agricultural production will be attained through the introduction of upland crops. The main objective of the plan is the expansion of flood recession paddy and upland crops farming by the proposed water control facilities.

As for flood recession paddy, the yield is generally higher than that of wet season paddy, which represents 80-90% of both planted area and production in Cambodia. Moreover, there is the possibility of buying fertilizers at cheaper prices (because of lower demand) and of selling rice at higher prices than during wet season. On the other hand, the supplemental irrigation is necessary during growth period. If gravity irrigation is impossible in the areas, pumping irrigation is required. Based on the Rural Socio-economic Survey, there are only four (4) % of paddy practicing farmers who have mobile pumps for irrigation. (36/855-out of the 36 farmers, 35 farmers are dry season paddy practicing farmers.) The majority of farmers, who have no pumps, sometimes have to rent pumps. Accordingly, the expansion of flood recession paddy needs the extension of mobile pumps. It is one possible option to establish public bank of mobile pumps or cooperative ownership of one mobile pump by several farmers.

3.4.3 Irrigation and Drainage

(1) Requirement of Rehabilitation and Extension of the Existing Irrigation System

Rehabilitation of the lowland irrigation facilities is required for recovery of irrigation area. The rehabilitation plan aims to boost production of dry season paddy. In the plan formulation, the capacity of facilities should be expanded as much as possible to increase irrigable area, considering agricultural characteristics and environmental aspects in and around area.

There are 292 irrigation systems in the area. They can be categorized into 151 small scale, 137 medium scale and 4 large scale system. Water source is divided into reservoirs, lakes and

rivers. Among them, reservoirs are accounted for 238 or 82% in total. As to the irrigation method, gravity by canal is 69, use of the canal and mobile pump or traditional lifting is 105 and pumping station is 25. Prey Veng province has the largest or 95, follows by Kandal 64 and Kratie 52. The smallest is 35 in Takeo (see Table 3.1 and Figure 3.9). Systems requiring rehabilitation in each province are summarized as below.

Number of Irrigation System to be Rehabilitated

Provincial Name	Number of System			
	Small Scale	Medium Scale	Large Scale	Total
Kratie	52	0	0	52
Kampong Cham	22	23	1	46
Kandal	25	39	0	64
Prey Veng	47	46	2	95
Takeo	5	29	1	35
Total	151	137	4	292

With the implementation of rehabilitation, irrigable area is expected to extend as follows.

	Present (ha)	Plan (ha)	Increment (ha)
Wet season	33,650	56,362	22,712
Dry Season	75,789	123,336	47,547
Total	109,439	179,698	70,259

Irrigation facilities to be rehabilitated are consisted of the followings (see Figure 3.10).

- Polder dike

To prevent flood water intrusion that is the biggest constraint for lowland agricultural development, construction of polder dike is a most effective way. The function of polder dike is not only to protect wet season cropping from flood water but also to contribute to transportation in the rural area. For rehabilitation, enlargement of dike crest, repair of embankment, slope reshaping, rehabilitation of intake gate and ancillary facilities are necessary. At present, almost all of dikes, have heights from 4 to 5 m. Dike crest is required to have more than 2 m width. Slope is planned at 1 : 2. As for new polder dike, concept of demarcation between agriculture and fishery should be taken into account.

- Water source facility

The function of reservoir is to store water at the end of wet season for dry season irrigation and recession cropping and also for conservation of fishing resources. For rehabilitation and expansion of reservoir, enlargement or construction of dike as polder dike, re-shaping slope of embankment, reconstruction/repair of spillway, installation of outlet gate and ancillary facilities are required. In plan formulation for rehabilitation of swamps and lakes as reservoir, demarcation and harmony of water use between agriculture and fishery should be considered.

- Canal

Section of all canals is in poor condition due to slope sliding and erosion. To prevent collapse of slopes and to minimize O&M cost, slope should be enhanced by sodding. Most of canals are severely eroded and sediments are silted-up in the canal. Canal re-shaping by earthfill and removal of sediment will be necessary. Laterite pavement for maintenance road is necessary after re-shaping.

- Pumping facilities

Taking into consideration of the capability of operation and maintenance of facility by GDIMH and villagers, development plan of large scale pumping station is not recommendable at present. However, small mobile pumps or traditional lifting means are strongly recommendable as a practical use. Small pump should be basically purchased and maintained by farmers themselves. Water users' association may manage the pumps as a common use facility if possible.

Water requirement without rehabilitation and incremental water requirement with rehabilitation are estimated at 1,120 MCM and 709 MCM respectively. Total water requirement with rehabilitation comes to 1,829 MCM. According to the LANDSAT images in December 1994, storage water (more than 0.3 m in depth) at the end of wet season is estimated at 12,100 MCM. Taking into account of evaporation, percolation, fisheries and domestic water use, about 25% (3,025 MCM) is assumed to be used for irrigation.

The balance of available water and water requirement with rehabilitation shows that surplus is 1,196 MCM. This surplus amount can be used theoretically to irrigate additionally about 90,000 ha in the dry season paddy.

Water Requirement for Existing Irrigation System

Rice	Irrigation Area	Water Requirement
Wet season	33,650 ha	135 MCM
Dry season	75,789 ha	985 MCM
Sub Total	109,439 ha	1,120 MCM

Incremental Water Requirement with Rehabilitation

Rice	Increment of Irrigable Area	Water Requirement
Wet season	22,712 ha	91 MCM
Dry season	47,547 ha	618 MCM
Sub Total	70,259 ha	709 MCM

Water resource potential is enough to cover the rehabilitation of irrigation systems. But the area inundated more than 3 m in depth is concentrated in the area along the Mekong and Bassac rivers, so the potential in other areas is limited. It is therefore necessary to construct new reservoirs to store flood water for the less potential areas.

Effects of rehabilitation will appear rapidly. Rehabilitation cost and construction period are cheaper and shorter than those of new construction of irrigation facilities.

(2) Institutional Capability Strengthening of GDIMH

Construction office in GDIMH and Provincial GDIMH (PBIMH) has the responsibility to rehabilitate/extend and maintain medium and large scale irrigation systems. For promoting rehabilitation of irrigation facilities, staff are needed to have knowledge not only in hardware but also in software aspects. As for the hardware aspect, machinery for O&M should be fully provided at construction office in GDIMH and PBIMH. Staff at each administrative level are responsible to inspect and to repair the facilities periodically. As for the software aspect, it is necessary to plan and execute proper water management and to promote organization of water users' association, etc.

In order to deal with these subjects, strengthening the capability of GDIMH is required. The staff should participate in water users' association meeting, periodical maintenance works of rehabilitated facilities to build up a closer tie with the farmers. Considering the present staff constraints and financial limitation of GDIMH, technical assistance is required to enhance it's organization and to conduct rehabilitation and extension of irrigation facilities. Required components for technical assistance are consisted of the various fields, such as providing O&M machinery including machine operator training, preparing guidelines of water control and allocation method of irrigation water, organizing water users' association, harmonizing water use between irrigation and fishery, and preparing maintenance guidance for the irrigation facilities of inundated area, etc.

3.4.4 Fisheries Development

The rationale for fishery resource management is to maintain a sustainable yield while utilization rate reach its maximum level. Habitat enhancement and stocking together with promotion of aquaculture are one of the best alternatives in compliance with this purpose. Harvesting alone as practiced in the past will inevitably lead to exhaustion of fish production regardless how effective the control is.

Proposed development plan comprises two parts, institutional approach and physical measures. Both will work together in a concerted effort in order to sustain or increase fish production.

From various constrains, general development strategy is proposed in a package as follows:

- habitat enhancement - swamp fishery management,
- protection of inundated forest,
- aquaculture development,
- strengthening the DOFi,
- amendment of fisheries law,
- improving of RUA and CA,
- making credit availability,

- establishing a self-sustained fishermen association or cooperative,
- demarcation of the preserved vegetation area in a fishing lot.

(1) Institutional Approach

Institutional approach in fishery management is composed of strengthening DOFi, amendment of fishery law, improving of RUA and CA, making credit availability, and establishing a self-sustained fishermen association or cooperative.

a) DOFi

DOFi's internal organization should be regrouped and expanded in order to meet the future development tasks, harvesting control together with other management. New organization chart is proposed as shown on Figure 3.11.

Under the new proposal the DOFi' Director will be supported by two organizations, Secretariat and Fishery Economic & Planning which are very important for administration and strategic planning. Furthermore he will be able to implement his policy through three Vice-Directors, for technical, supervision and operation. Vice-Director for technical's task is to look after creating bodies of knowledge in every field of fisheries, while Vice-Director for supervision's task is to supervise all the harvesting and control. The Vice-Director for operation will take care all the trading and all the processing development.

For the qualification of the Vice-Director for technical he/she should possesses a Ph.D. or M.Sc. with thorough experiences in research supervision and/or project management.

b) Amendment of fishery law

The existing law is lacking of consideration on socioeconomic implication. This in turn leads to unfair distribution of resources and social conflicts which may in the future causes social instability. Amendment of this law at least to enable a family fishing for subsistence with limited types and number of fishing gears to operate in a fishing lot during opened season is strongly recommended. Otherwise the gap between the rich and the poor will be wider and broader which may turn back to social instability.

c) Improvement of RUA and RCA

As human resource production is a key factor for future development in fishery field, not just only to the government but also to the private sector, improving these two institutes is very vital.

The area for improvement is to upgrade their faculty member and to provide the facilities for teaching research and learning so that they can produce the graduate of international standard. At least the faculty comprising of 3 Ph.D., 9 M.Sc. and 6 B.Sc. should be considered as minimum for the Faculty Science in RUA and 1 Ph.D., 3 M.Sc. and 9 B.Sc. for RCA.

The facilities that should be provided are laboratories with sufficient equipment, small hatcheries, scientific text book and journals. Levels of those facilities may be designed differently, for teaching and research in RUA and for technicians in RCA.

d) Rural banking

Rural bank providing credit through soft loans not only for fisheries but also for sectors of agriculture should be established because it is very crucial in the development of the private sector. If credit is available it will generate fishery development, particularly aquaculture, substantially.

e) Fishermen association

In the future development of swamp fisheries and aquaculture, participation of fishermen in every level is extremely important to achieve the objective goal of fish production at sustainability and/or increment level. Forming group of fishermen and to educate them in resource management as well as aquaculture is recommended to start at the beginning of development plan implementation.

The institutional approach in harmony with agricultural development is to set up a Swamp Fisheries Unit (SFU) of which its terms of reference can be assigned as follows:

- to regulate fishing in a swamp area at sustainable development,
- to create bodies of knowledge in swamp fish ecology,
- to conduct stock assessment in terms of species diversity and biomass,
- to regulate frequency, quantity and species composition for stocking,
- to promote aquaculture in swamp's adjacent areas inclusive of rice cum fish culture.

With the terms of reference, the facilities for the planned SFU shall compose of Fish Seed Production Center as a prototype (detail is shown on Figure F 3.1.1 in Appendix F). The planned SFU's staff should comprise of 1 Ph.D., 3 M.Sc. holders (one for fish breeding, one for fish production ecology, and one for aquaculture development), whom shall be supported by a number of B.Sc. and Diploma holders.

(2) Physical Measures

Most of the physical measures required for fishery development in specific case are elaborated (details are shown in Appendix F). Under this context emphasis will be on the structure that can be harmonized with agriculture development. To prevent the flood during the rainy season and to secure the water during the dry season in the flooded area, creation of water body such as swamp seems to be inevitable.

However, to create such a water body, it must be based on the four criteria; first the measures must be technically possible, second, must be economically feasible, third, must be socially acceptable and last, but not least, must be environmentally sound.

In general, there are many advantages in the swamp rehabilitation. Apart from agricultural benefit, sustainable fish yield of not less than 125 kg/ha/year can be obtained without difficulty

and it also act as a preserved pool for many kinds of fishes to complete their life cycle. Furthermore an aquaculture development in downstream can be generated.

Macrophytes that grow in a swamp can be harvested for animal feed or organic fertilizer production. Some can be used as human food such as lotus seed and root, water crest, water chestnut, and etc.

In integrated water resource development, criteria for enhancing fish production is that in some area of a swamp of about 20%, a depth must be more than 3 meters which will become a fish pool during the dry season.

From fishery point of views, three sites are selected for development plan formulation. They are, but not limited to, (1)the swamp in the Srok Ponhea Leu and (2)Srok Lvea Em in Kandal Province, (3)Srok Koh Sotin and Srok Srey Santhel in Kampong Cham Province. (Locations and supposed configurations of them are shown on the Figures F 3.2.1, 3.2.2 and 3.2.3 in the Appendix F.)

The swamp in the Srok Ponhea Leu (south of fishing lot no. 14) seems to be very good alternative since it is totally in a public fishing area. The conflict of resource exploitation can be avoided from the beginning. The modifications of this swamp can be done by embankment of the west side in parallel and same elevation with the road no. 5 in a distance of 3 - 5 km, depending upon the extent of the flood. Together with some other minor modifications such as water control gate at the colmatage canal, flooding over the hinterland can be protected and water and fish availability during the dry season can be secured. This will enable agriculture and fishing to be operated all year round. Since aquaculture in this area has already developed to some certain extent, 70 ponds is under operation with current production of 178.7 MT, the planned swamp can therefore enhance aquaculture expansion in the area as well.

For geographical and environmental considerations, *the swamp in the Srok Lvea Em* is also suitable for swamp fisheries development and may be considered as second alternative. It can be rehabilitated by embankment with water control gate at the Srok Kampong Leav together with some other modifications. After completion it will be a huge standing water bodies covering an area of about 455 km^2. However the area of about 250 km^2 or 55% still remained as fishing lots no. 17 & 18 of Kandal Province and part of lots no. 2 & 3 of Prey Veng Province, allowing only 161 km^2, (35%) for public fishing and 44 km^2, (10%) for fish sanctuary. From the development of this swamp annual fish yield of 5,700 MT can be obtained, or even more provided it is properly managed. Furthermore during the dry season substantial amount of water can be drawn for irrigation both dry and recession farming on a drawndown zone.

For the third alternative *the swamp at the Srok Koh Sotin and Srok Srey Santhel* in Kampong Cham Province can be also rehabilitated for the same purpose. But, the area is occupied by fishing lots no. 1, 7 and 9 covering the area about 60% of the planned swamp.

The selection is justified from fishery point of view, but not limited to that. If any other swamps are suitable by agricultural development justification and meet the fishery criteria that it should possesses about 20% of its area deeper than 3 meters for fish pool during the dry season, swamp fisheries and aquaculture can be harmonized with agricultural development.

(3) Aquaculture

Aquaculture proposed to be developed in harmony with agriculture is in three models, (1)pond culture, (2)rice cum fish culture and (3)rice-chicken cum fish culture. Integrated farming system which is very important in sustainable agricultural development is not recommended at the early step of development because the farmers must be familiarized with animal husbandry and many cash crop production except some innovative ones is lacking among the paddy practicing farmers.

Pond culture recommended is quite a simple method but site selection must be very careful with the drainage system. In the higher elevation area where the farmers have to build a pond for storing water for dry season crop production and, with proper design, the pond can be also used for fish culture. Multi-species culture of hardy fishes is recommended. Low input feeds can be derived from agricultural by-products such as rice bran, broken rice, waste part of vegetable, or some available water plants such as duck weed, water crest, and etc.

Rice cum fish culture is practiced by stocking fish in a paddy field. But modification is required by digging ditch around the field. Spoiled soil can be used for embankment. Fish can be stocked in the ditch from the time of early cropping. After transplanting water level is raised to inundate the paddy. Fishes can use that space to grow and at the same time they help to eradicate many pests of paddy. No artificial feeding is involved. Production of 20 - 30 kg per ha can be obtained by this method.

Rice-chicken cum fish culture can be done with the same method. If the farmers' residents is located next to the field, the chicken house can be built over the ditch. Chicken drop can be directly fish feed and can nourish the paddy. Production of 30 - 40 kg per ha may be obtained.

Average farm size for subsistence level in the Study Area is 1.2 ha per family size of 5.4 persons. Therefore rice cum fish culture will provide about 24 - 36 kg/farm or add up to per capita consumption of fish 4.5 to 6.6 kg, even more when chicken husbandry is incorporated (typical structure of paddy field for rice cum fish culture is shown on the Figure F 3.3.1 in Appendix F).

By this kind of coordination of fishery development in harmony with agriculture, it is expected to bring about maximum benefit. In the later stage when farmers/fishermen have been innovated by integrate farming system, comprising growing of fruit trees, cash crop, paddy and animal husbandry can be introduced.

3.4.5 Agricultural Supporting Services Development

(1) Agricultural Research and Extension Service

In Cambodia, there are presently 18 agricultural institutes, such as research station, agricultural development center, rural development center and state farm, under the management of DOA. Paddy is set as the main objective crop for research activity of 12 institutes. Among them, there are six institutes in Kandal and one institute in Takeo.

For the agricultural development plan harmonized with fisheries, it is one of the main targets to expand dry season paddy cropping. Based on the Rural Socio-economic Survey, 77% of dry

season paddy practicing farmer (480/623) adopt three of IR varieties, IR66, IR36, IR42, and 83% of them (517/623) adopt the improved IR varieties if other IR varieties are included. In general, the average yield of IR varieties is higher than that of the native varieties but IR varieties need more careful management such as fertilizer application and water control. It is consequently necessary to make the proper cropping standard for dry season paddy and to extend it to farmers.

The Rural Socio-economic Survey shows that 94% of paddy practicing farmer (784/835) habitually use self-keeping rice seed and 89% of the dry season paddy practicing farmers (286/320) who adopt even IR varieties use self-keeping rice seed. These facts may induce the production decrease due to the variety deterioration. Variety deterioration in the tropics usually progresses faster than in the temperate regions so it is recommendable to renew rice seed every several years. But the present rice seed multiplication and distribution system is not enough to satisfy domestic demand and the strengthening of the system will be needed.

For seed multiplication, more state farms should be established to strengthen the present weak system. In a long term, it is ideal to set one seed multiplication farm in each province because every province has its local varieties adapted to its local environment. The seed multiplication works presently conducted by several research institutes should be transferred to state farm entirely. This transference enables to clarify the functional difference between state farm and research institute.

If the increased earnings derived from the use of certified seed is more than the purchase cost, the use of certified seed is profitable and will be extended. It is recommendable to set model farms to compare the differences of both seeds and inform them to farmers.

Cambodia-IRRI-Australia Project (CIAP) has continued paddy research activity including field test and training/seminar with DOA since 1987 and has accumulated a lot of useful results and knowledge. Based on those activities, technology recommendations are suggested every year. Since the Australian government also gives official assistance to strengthen agricultural extension system with DTEE (Cambodia Australia Agricultural Extension Project, CAAEP), close cooperative activities of CIAP and CAAEP, paddy cropping support system in combination of research and extension, will bring more fruitful results.

(2) Agro-Processing and Marketing

This area is mainly located along Mekong and Bassac rivers covering Kampong Cham, Kandal, Prey Veng and Takeo provinces. Fishing lots are allocated along the rivers particularly in the downstream of the Mekong and Bassac rivers. Agricultural potential aiming at intensive farming could be considered as the same as the colmatage areas. However, potentiality for fishery processing should be considered in addition to agriculture.

Fish ----------dried fish, smoked fish, fish meal, fish sauce
Rice bran ----------oil extraction
Maize ----------animal feed
Mungbean ----------noodles
Vegetables ---------pickles, dried vegetables

Farm income of a farm household is depending on their paddy production. When paddy production and its marketing will be increased in the near future, post harvest facilities such as rice mill and warehouse, drying yard of paddy, will be required to improve and to increase their number and capacity to retain quality of products and a yield rate.

In Cambodia, fish is an important animal protein source taking about 15 kg per capita per year. This implies higher demand for processed fishes in the future too. Taking into account increasing demand for fishes, fish processing would be recommendable and can be realized easier than agro-processing, as small-scale fish processing, since some parts of this have been already practiced in the area. Agricultural processing mentioned above could also be planned in small-scale size aiming at consumption in and around Phnom Penh.

(3) Agricultural Credit

As commercial fishing is active in this area, demand for credit for fishing and fish processing might be higher than agricultural sector, and the potential for fish processing is considered high as mentioned above. However, rural credit services in Cambodia is going on only under the cooperation with foreign NGOs due to lack of domestic institutional agricultural credits. The institutional credit for agriculture and fishery sectors should be implemented and applied at low rate for both farmers and fishermen to encourage these sectors.

3.4.6 Strengthening of Farmers' Organization

Farmers' organization is basically strengthened in the same manner as described in 3.3.5. There are some farmers' organizations found in the area. They are groups with a single objective, such as water users' association, rice bank, credit, cow bank, etc. An integrated organization as an agricultural cooperatives does not exist in the Study Area. All of the organizations mentioned above were organized under the guidance of governmental offices or aid agencies. The VDCs have also been organized by related rural development offices or aid agencies.

At the beginning stage, it is more realistic to organize farmers into single purpose group such as water users' association under the leadership of relevant government offices in cooperation with aid agencies as NGOs. The rehabilitated facilities should be operated and maintained by the water users' association organized under the guidance of PBIMH and DOIMH.

To direct farmers' attention to organizing some groups, some organizers are required. At the first step, it is urgently needed to train the organizers. After training, qualified organizer should educate and train farmers for establishment of organization. Through such activity, farmers will understand the importance and necessity of organization. Then, the farmers will select the chairperson of the organization through a democratic procedure. The chairperson should manage the organization under the guidance of PBIMH and DOIMH and advice from extension workers and NGOs.

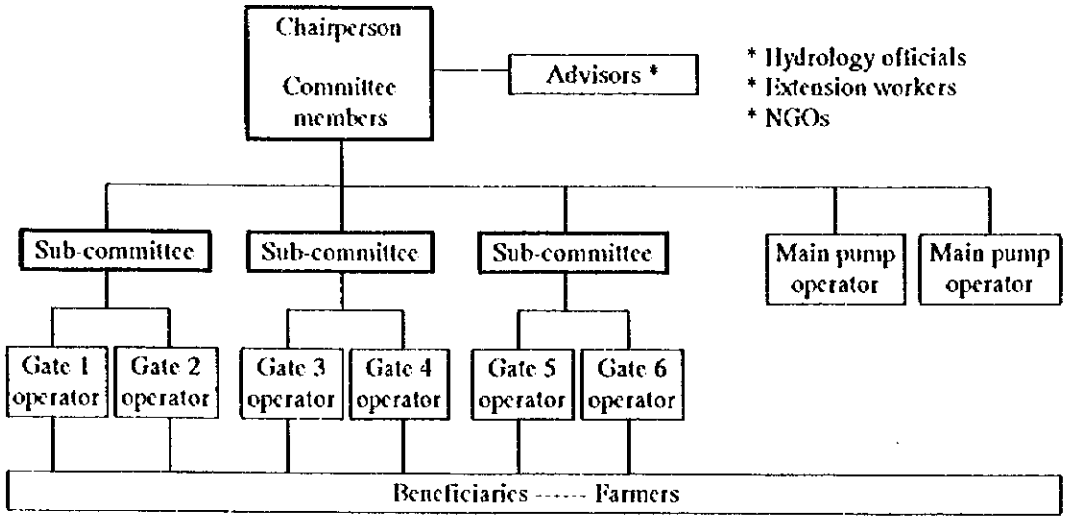
For operation and maintenance of rehabilitated irrigation facilities, water users' association shall be established under the chairperson. The association members shall be selected by each irrigation facility. They shall be responsible for operation and maintenance of the facility. Both of agriculture and fishery will be harmonized in various aspects through the activities of

water users' association. A regulation of the association should be made by members themselves.

Common use facilities such as hall may be necessary to discuss on activities of irrigation, organization, and other related matters. Such facilities may be also used for training and as a community hall of the village.

NGOs play a very important role in organizing farmers. It is an effective approach for the organizers to cooperate with NGOs in organizing farmers. Farmers should be trained and educated until they fully understand the objectives and the advantages of organization. Special considerations should be taken for women participation in the organization.

A model of organization chart for water users' association is planned as follows. The size may differ upon the scale of rehabilitation of the system. Sub-committees may be organized when the system covers many villages.



A Model Organization Chart of Water Users' Association

3.4.7 Rural Infrastructure Improvement

(1) Rural Road Networks

The agricultural areas in and around swamps are of low road density due to the low elevation and water logging during wet season. Many of the roads are on the natural banks of swamp and dikes of reservoirs, and they are being destroyed by flood flows and rainwater. The roads in this area, as being located between the colmatage farming area and the rainfed farming area, play the roles to connect the two areas and the road improvement is therefore important for comprehensive development of agriculture in the Study Area.

Taking the above into account, improvement of rural road networks in this area is planned as follows.

- In the first step, rehabilitation of the present roads is given priority. Since many of them are on the natural banks and reservoir dikes, they are to be rehabilitated as one of key components for comprehensive agricultural development. In addition, since this area suffers from floods every year, reinforcement of the system and organization for road maintenance and repair is so important that priority is also given to it.
- In the second step, new road construction in the area of low road density is programmed so as to improve the density level that are in the Study Area. Upon construction of new roads, priority is given to the roads that are multi-purpose and feasible ones as they are one of key components in the other development plans for flood control dike and reservoir dike.

(2) Rural Water Supply

Major sources of domestic water in this area are dug-well in dry season and rainwater in wet season. Supply of safe and hygienic water is important. The plan is mentioned in "3.3.7" as programmed.

- Target level of well installation is as follows. The location shall not be submergence during the wet season.
  - User per well : 200 persons/well
  - Distance from residence to well : 300 m or less
- The installation of wells is with participation of the residents so that the organization of the water users can independently manage the O&M.

3.4.8 Environmental Impact

The Mekong river basin is rich in wetland environment. Wetlands comprising of flood plains and flooded forests serve a wide variety of ecological functions which support important economic activities in agriculture, fisheries, tourism, energy and industry.

In the area, flooded forests are scarcely found particularly in Prey Veng, Takeo and Kandal, while shrubs are found widely in and around swampy area. The main threat is from firewood gathering and agricultural pressures.

Agricultural activities require a sufficient supply of water, especially rice production with significant role in economic activities. By the improvement program of irrigation systems, rainfall and annual flooding water are effectively reserved for use in the dry season and drought spell of the wet season. It lead to encourage farmers to apply more profitable and steady cropping system without extending their fields into flooded forests.

Moreover, water bodies rehabilitated will provide grounds for fisheries. Sustainable fish harvesting allows fish to reproduce at a level that maintains a stable population. Stocks should be protected from over fishing pressure during the breeding season for conservation of fishing grounds.

In addition to the rehabilitation program, educational campaigns and works about sustainable fishing should be vigorously conducted for parties concerned in fisheries to avoid conflict between farmers and fishermen in some areas.

The goal of the rehabilitation will be the restoration, security or increase in storage capacity of the reservoirs not only for irrigation during dry season and extension of cropping duration in wet season but also for fishing ground conservation. Efficient and equitable use of water in an environmentally responsible manner will require effective cooperation of all farmers and fishermen.

3.4.9 Anticipated Development Effects

Agriculture around backswamps and lakes is practiced in close linkage with fisheries. With implementation of agricultural development in harmony with fisheries, the following development effects are expected.

- The plan will bring about definite agricultural production benefits. The main impact is the increase in crop production. The major increase will be expected in dry season rice through the improved or expanded irrigation system and strengthening extension service of farming technology. Irrigable area will finally reach about 123,300 ha in dry season and 56,400 ha in wet season.

- The rehabilitation of swamp will bring about conservation of fishing ground and fish habitat enhancement, which can contribute to secure freshwater fish production in and around fishing lot area. Demarcation of fishing lot areas, public fishing areas, sanctuaries and vegetation areas will also bring stable and sustainable fishing for commercial and family fisheries. Consequently, the conflicts in the fishing areas will decrease.

- In addition, creation of new productive farmland will be also expected by provision of irrigation facilities in lowlands around swamps and lakes. It will bring landless farmers and refugee agricultural land and upgrading of rural life through secure of agricultural production activities.

3.5 Rainfed Agricultural Development Plan

3.5.1 Basic Concept of Water Resources Development

Rainfed agricultural development is scattered in the Study Area with relatively less inundation depth. The larger areas are concentrated in the catchment of tributaries such as the Prek Thnot, Tonle Toch, Prek Trabek and Tonle Prasat. Rainfed area is estimated at about 500,000 ha or 74% of the total cultivable area of 690,000 ha. The largest area is in Prey Veng province, about 240,000 ha, and the second is in Kampong Cham province, about 110,000 ha.

Annual average rainfall is about 1,000 mm in the south and 1,600 mm in the north. The range of annual rainfall fluctuation is wide, 700 mm in the north, 1,000 mm in the south and 400 mm in Phnom Penh. Due to anticyclonic circulation in June or July, short period of consecutive dry days which damages the growing of wet season rice or causes delay of timing of transplanting paddy, may occur. This shows that rainfall is not a safe and stable water source for wet season

crops, quantitatively and timely. On the other hand, according to the inventory of the rural water supply, the average yield of the tube well in the area is estimated at about 2.5 cu.m / hr. This means that the potentiality of groundwater for irrigation is little and cannot be counted on. Based on the above considerations, irrigation water for rainfed area is dependent on storage of rain water and use of river water.

For development purpose, rainfed agricultural development area is categorized into lowland small scale agricultural development area and tributaries agricultural development area. Use of Pol Pot irrigation facilities and making small ponds to store water is recommendable as water resources (see Figure 3.10).

Water resources for latter may come from rainfall and runoff of tributaries. The characteristics of the main tributaries in the Study Area is described as follows.

Characteristics of the Tributaries in the Study Area

Tributary name	Catchment (km^2)	Length (km)	Annul Runoff (MCM)	Dry Season Runoff (MCM)	Remarks
Tonle Toch	3,063	115	1,865	140	
Tonle Prasat	764	61	465	35	Tributary of the Tonle Toch
Prek Trabek	768	45	467	35	Tributary of the Tonle Toch
Prek Chhlong	5,689	190	4,938	543	
Stung Prek Thnot	5,166	142	3,585	118	F/S was completed
Stung Takeo	3,270	104	985	74	
Total			12,305	945 (7.6%)	

In the above table, data of Prek Thnot was adopted from the report "Irrigation Rehabilitation Study in Cambodia". Due to absence of observation records, water resources potential in the other tributaries are very difficult to estimate at present. Accordingly, based on the specific discharge of Prek Thnot, runoff of the other tributaries are estimated. According to this, total dry season runoff during December to May is estimated at 945 MCM. Taking into account the evaporation, infiltration, etc., 470 MCM or 50% of the total runoff can be utilized for dry season irrigation. Irrigable area can be estimated at about 50,000 ha. However in order to conduct further study on agricultural development in these tributaries, hydrological data of rainfall and runoff discharge or water level are required.

3.5.2 Land Use Plan

(1) Present Conditions

In the area for the rainfed agriculture development plan, main land use is wet season paddy, commonly submerged less than 0.5 m depth. Some forest land, bush, inundated bush and waste land, such as swamp, grassland, are partly distributed, too. Forest areas including bush and inundated bush have important functions in the supply of firewood, as the only energy and material source for rural people. Other land items, waste land, grassland, etc., are not used except for pasture land before and after flooding.

Many palmyra palms (*Borassus flabellifer L.*), which characterized Cambodian rural scenery, are planted on the paddy levee in the rainfed agriculture area. Rural people not only eat their fruits and endosperm, but also tap and make sugar, use their leaves and woods for roof/wall/fence and housing material. Due to the many uses, they are indispensable for the lives of rural people. Making sugar looks like a good agro-processing business but it needs about 20 years after planting before they can be tapped for sugar and a lot of firewood and processing equipment is needed so there are not so many farmers practicing it.

(2) Land Use Plan

Irrigation water will be secured by the development of water control facilities but the amount is limited in consideration of the present hydro-meteorological and natural conditions in the area. Accordingly, the present rainfed paddy area, occupying most of the concerned area, will not change in terms of its utilization pattern.

Forest land area still has important roles for rural people through supplying of energy and various living materials so it should not be the objective area for farmland reclamation, but instead should be preserved and developed. The farmland reclamation of non-utilized land such as swamp, grassland and waste land is not prohibited but lowland should be firstly examined the possibility to be developed the small-scale water control facilities. In Kampong Cham and Kratie, where the average titled land per farm is relatively small, the demand for reclamation of forest areas may be higher than other provinces but it should be avoided as much as possible due to the above mentioned reasons.

3.5.3 Agricultural Development Plan

(1) General

In the area concerned, wet season rainfed paddy is predominantly practiced. Rainfed paddy is generally defined as surrounded by levee and submerged for some period during growth period, not deeper than 0.5 m for more than 10 continuous days. There are usually no water control facilities on these rainfed paddy fields and the farmers can not control water level of the fields adjusting the growth stage and the climate condition. This means that it has much possibility to receive drought/flooding damage. Consequently, the farmers adopt the cropping patterns taking possible risks and various conditions into consideration and practice farming without using expensive input material but with self-keeping rice seed which are photo sensitive and of native varieties.

In general, the wet season rainfed paddy field is classified into five field types but their distribution in the area is not clarified. The five field types are as follows;

(a) Paddy field with good conditions

(b) Paddy field with frequent drought damage

(c) Paddy field with frequent flooding damage

(d) Paddy field with both frequent drought and flooding damage

(e) Paddy field with medium submergence

For type (a), the technology of dry season paddy cropping could be applied to some extent but for other four types, each needs the proper variety and technology.

Based on the Rural Socio-economic Survey, the upland crops introduction ratio of wet season paddy practicing farmer remains at low level, only 36% (83/232). In Kampong Cham, where paddy production may not be enough even for self-consumption judged from the average titled farmland, about half of wet season paddy practicing farmer (46%) introduces upland crops.

(2) Farming Plan

In the area, it is difficult to secure the large-scale water resource for large area, but the consecutive development of the small-scale water control facilities gradually increase the area of paddy field possible to control water level.

At present, farmers usually transplant seedlings in July/August, because rainfall is not reliable in the beginning of wet season and this may induce the flooding damage in September/October by high water level when the flood is bigger than the average. If some amount of water resource can be secured in May/June, some farmers can hasten the transplanting time and paddy production will be more stable. To hasten the transplanting time, it is also necessary to replace planted varieties from the predominant medium/late photoperiod sensitive native ones to the early photoperiod insensitive native or improved ones. Changing the varieties should be simultaneously programmed with the facility development. (Rainfed paddy is usually composed of the three native variety types; Early type : mature in less than 120 days, photoperiod insensitive-flowering before mid-October, Medium type : mature in 120 - 150 days, photoperiod sensitive-flowering between mid-October and mid-November or photoperiod insensitive, Late type : mature after 150 days, photoperiod sensitive-flowering after mid-December. Medium and late types occupy 30% of respective wet season planted area. [Annual Research Report 1993, 1994 Annual Research Report, Cambodia-IRRI-Australia Project])

The stable paddy production by the above mentioned hastening of the transplanting time depends on the availability of irrigation water during early wet season. If there are some tributaries in the area, the possibility of water control facilities will increase and the beneficial area will enlarge.

It is also possible to introduce upland crops in dry season, utilizing stored water during wet season. There are presently some farmers practicing dry season upland crops such as legumes by utilizing soil moisture or the stored water of small pond around their houses but they are still small-scale cultivation. With the development of water control facilities, the dry season upland cropping and the agricultural production will increase.

Some of the farmers do not have enough titled land or agricultural labor. It is difficult for those farmers to expand paddy cultivation but the production increase by the time shifting to cropping of upland crops is possible. Generally, upland crops consume less water than paddy so the introduction of upland crops is easier for the area with only small water resource.

3.5.4 Irrigation Development Plan

(1) Plan of Lowland Small Scale Agricultural Development

Farmers cultivate the wet season rice in the inundated rainfed area. In order to develop the area, the key point is how to keep flood water as long as possible before dry season comes. For irrigation development plan for the area, the following basic considerations are taken into account.

- Small streams and depression/ Pol Pot canal should be improved or rehabilitated as practical use of water source.
- Small pond with dimensions from 25 m^2 to 625 m^2 and depth of 3 m is planned for individual or public use.
- Storing water in borrow pits along road is also one of the important water sources.
- Related structure/facilities such as small canal and mobile pump may be required.

(2) Plan of Tributaries Agricultural Development Area

Run-off-river water of tributaries during dry season is very limited. Without any reservoirs and diversion weirs, therefore, irrigable area will be limited. To develop the agriculture in tributaries area, followings are necessary.

- Meteorological and hydrological observation system should be established and runoff study should be required.
- Repairing dikes along the tributaries and dredging river bed may be required to enlarge river capacity.
- Water intake facilities such as diversion weirs and pump stations may be needed to irrigate large scale area.
- Possibility of procurement of area for facilities such as reservoirs, intake and canal, should be studied.

(3) Institutional Capability Strengthening of GDIMH

Farm households are scattered widely in the Study Area. In the rainfed area, wet season rice farming is mainly practiced. But, paddy yields are lower than those of other areas. Rainfed area is widely distributed and several tributaries can be utilized as water resources. Agricultural development potentiality is very high if water resources are developed in the tributary basin. Role of GDIMH for agricultural development in this area is important. GDIMH has to develop many technical parts such as water resources development and flood protection along the tributaries. To develop agricultural areas around the tributaries, meteorological and hydrological observation system should be also established. Considering financial and staff constraints of the present institutions, strengthening the capacity of GDIMH in planning, design, construction and operation and maintenance through technical assistance is also necessary as mentioned in 3.4.3.

3.5.5 Rural Infrastructure Improvement

(1) Rural Road Networks

Rural roads in the rainfed agricultural area are at the average density level, but are still insufficient for improvement of agricultural production and rural living activities in transportation of agricultural products, materials and equipment. The roads are mostly unpaved and are not car-trafficable in wet season. Improvement of rural roads are made based on the following policy.

- In the first step, in order to activate farming, the existing roads with good access to the national and provincial roads are to be rehabilitated. At the same time, responsibility for road maintenance is to be specified and the public organizational system for the task shall be reinforced.
- In the second step, the existing roads connecting from the base villages for socio-economic activities to the other villages are to be rehabilitated.
- When it comes to the stage that improvement of agricultural production facilities and development of agricultural production are anticipated, construction of new roads for good access to the markets should be made.

(2) Rural Water Supply

Sources of domestic water in this area are dug-well, tube-well and rainwater. For supply of safe and hygienic water, installation of tube-wells is planned as follows.

- Installation of wells is targeted as mentioned in 3.7.7. The areas with low distribution density are given priority.
- Formulation of the improvement plan shall be made in cooperation with NGOs and with due consideration of their achievements in the past.
- A principle of well installation is participation by the residents. The know-hows for O&M are to be transferred to the residents through the installation work. For this purpose, cooperatives of water users are to be organized in each village and the responsibility for the management shall be borne by the cooperatives.
- Some public organization to give advises and guidance to the cooperatives, shall be specified and reinforced, and the organization shall also provide sanitary education. The cooperative shall hold some stock of spareparts to repair minor troubles by themselves, and present system shall be improved to do them.

3.5.6 Rural Community Development Plan

(1) Basic Concept for Farmers' Organization

More people settle in the rainfed agricultural area. People in this area are generally poorer than the other two areas. Social infrastructures are also poor as well as agricultural infrastructures. There are needs of improvement in all agricultural and social aspects in order to fill the gap between the other two development areas.

It is essential that promotion of rural development plan meets the real needs of rural people. The Rural Socio-economic Survey shows that rural people want provision of agricultural and social infrastructures such as irrigation and drainage, village roads, education, drinking water, medical care, post-harvest facilities, and electricity as listed below..

Irrigation facilities	87% (783 / 900 farm households)
Drainage facilities	63% (569 / 900)
Village to village roads	51% (463 / 900)
School	46% (412 / 900)
Domestic water system	25% (229 / 900)
Medical facilities	24% (215 / 900)
Sanitary facilities	23% (206 / 900)
Post-harvest facilities	18% (160 / 900)
Electricity	18% (159 / 900)
Farm roads	10% (94 / 900)
Others	bridge, pump, tractor, sprayer, transportation, well, ox

Improvement of irrigation and drainage facilities is considered as the top priority for rural development. After irrigation and drainage facilities are constructed in this area, their facilities should be operated and maintained by a water users' association established for each irrigation system as well as the other two areas. The concerned offices, GDIMH and Department of Technique, Economy & Extension (DTEE) under MAFF, shall start their activities to organize farmers in parallel with provision of the facilities. It is practical to set up a model organization in a district as well as in the other areas to demonstrate and disseminate activities of the organization for future development in the other rainfed areas.

It is necessary to promote women's participation into rural society to involve more positively in implementing rural and agricultural development. In order to do that, strengthening of the present institutions is necessary at provincial, district, and particularly village levels. Human resources shall be developed especially in Ministry of Women's Affairs. As for women's activities, extension workers shall work for all of the aspects of women's work.

NGOs have been serving rural population in quite wide fields. Many of them have experiences in organizing farmers into groups, understanding farmers' intention and establishing an organization. Among many NGOs working in the Study Area, a few examples are ACR (Australian Catholic Relief) in Takeo Province, MCC (Mennonite Central Committee) in Prey Veng Province, and JVC (Japan International Volunteer Center) in Kandal Province. On irrigation project, though hydrological offices at each administrative level are responsible for organizing farmers, the offices need to not only cooperate with such NGOs, but also utilize the NGOs' experiences for organizing farmers. And many local NGOs were organized to work for rural people. Their experiences and knowledge are hopefully to be combined with the development plan from planning to implementation.

(2) Social Infrastructure Improvement

1) Education

The present stage of education is still poor both in quantity and quality. Education development needs;

- Construction and rehabilitation of school buildings
- Quality improvement (environment, teacher, curriculum, textbooks, teaching aids, etc.)
- Informal education (literacy and basic education for unschooled children)
- Adult education (literacy and simple calculations)

2) Public health

It is necessary to keep hygienic conditions in the villages. For this purpose, medical facilities should be improved urgently. Improvement needs;

- Hygiene in a village (clean drinking water, sewage drains, toilet, etc.)
- Hospitals and health centers (physical & quality improvement, medical equipment, medicines, office supplies)

3) Electrification

Electrification in rural areas should be provided for rural people.

(3) Telecommunication

There are no telephones in the Study Area except Takhmau. It is very difficult to communicate with rural areas at present, though a radio communication is partly used. Telecommunication network is needed to facilitate development in rural areas.

3.5.7 Agricultural Supporting Services Development

(1) Agricultural Research and Extension Service

As mentioned in the 3.4.5, DOA manages 18 agricultural institutes, such as research station, agricultural development center, rural development center and state farm, and 12 of them set paddy as the main objective crop for research activity. Among them, there are six institutes in Kandal and one in Takeo.

In general, the wet season rainfed paddy field is classified into five field types as follows (refer to 3.5.3);

(a) Paddy field with good conditions

(b) Paddy field with frequent drought damage

(c) Paddy field with frequent flooding damage

(d) Paddy field with both frequent drought and flooding damage

(c) Paddy field with medium submergence

There are neither researches or surveys based on the above classification till now, nor distribution data by type. If the distribution by type is clarified on map, there are some countermeasures to reduce various damages. (For the area of (b) type paddy field, drought-tolerant varieties are recommendable and for the area of (c) type paddy field, submergence-tolerant varieties are recommendable.) In the future, land classification data should be collected through the field survey and analyzed in detail. For the collection of those data, well-trained field surveyors are indispensable but the present budget and staff of DOA are limited. So it is one option to train local able farmers and make them as field surveyors at some expenses.

For the rainfed agriculture development plan area, stable paddy production is the main target. To achieve the target, it needs both hastening the transplanting time and changing the varieties from the predominant medium/late photoperiod sensitive native ones to the early photoperiod insensitive native or improved ones. It is indispensable to improve and extend varieties adopted the rainfed paddy ecosystems in accordance with the development of water control facilities, cooperated with Cambodia-IRRI-Australia Project, accumulated much useful information about paddy.

Neighboring countries such as Thailand and Viet Nam, have similar conditions on wet season paddy production. Close cooperative and exchanging information with those countries are also an effective option for aiming at stable production.

(2) Agro-Processing and Marketing

This area can be characterized as paddy farming area under the rainfed condition. Therefore, milling paddy is the prevailing agro-processing activity in the area excluding medium and large scale processing factories in Phnom Penh city. Under the present condition, development of commercial basis agro-processing industries might be difficult excluding rice mills because current agriculture is basically extensive farming to meet self-sufficiency by producing paddy in the vast areas. However, some crops planted in this area could be applicable to processing value-added products as shown below, in particular, oil extraction will be worth studying. Small scale processing industries are recommendable at the first stage in considering supply of raw materials and financial difficulty of farmers.

Rice bran --------extraction of oil

Maize ----------animal feed

Mungbean -------noodles

Marketing of agricultural products has been done by individual farmers because of lack of agricultural cooperatives. Under the individual bargain, farmers are often put at a disadvantage. For more profitable marketing, agricultural cooperative should be set up. If some difficulties or opposition will be expected among farmers, continuous discussion and explanation must be required to explain the benefits of agricultural cooperatives. MAFF should take the initiative in this field.

(3) Agricultural Credit

Agricultural activity in this area is dependent on wet season paddy, excluding some areas of Prey Veng, in which double cropping can be practiced. Most of farmers plant paddy only once a year in a small farm size and this results in low living standard which means lower income than the poverty line. Institutional agricultural credit is, therefore, necessary to substitute rice deficit of poor farmers as well as facilitate and improve agricultural production. In Cambodia, NGOs' credit systems have been successfully running and gradually spreading into the rural people. Under the condition, Rural and Agricultural Development Advisory Group discussed the policy and strategy of rural credit and following were agreed on beginning of September 1996:

- giving farmer and poor people the ability to get credit,
- give credit for agricultural activities,
- this credit should be available throughout the country,
- allow private banks to support rural credits as much as possible,
- update rural development credit in keeping with the privatization principle,
- continue sourcing assistance for rural credit activities.

The government and authorities concerned to rural development are required to develop and promote institutional agricultural services in the whole country as soon as possible by involving ideas and experiences of NGOs.

3.5.8 Environmental Impact

The Study Area has high fluctuation of seasonal rainfall and surface runoff water. Some areas are lack of irrigation water in dry season and farmers have to depend on unreliable rainfall patterns for cropping. This result in farmers being poor or less production yield.

The rainfed paddy is cultivated on relatively higher lying lands than the other areas, which are not subjected to annual severe inundation and are far from water resources such as streams, springs, lakes, reservoirs, or ponds. Accordingly, the rice production is practiced during wet season only when rain comes.

When sufficient water for irrigation cropping is sourced from small scale reservoirs or ponds and pumps, cultivable season will stretch longer than the present, and it will lead to promote beneficial agriculture production and to use their land more efficiently without long fallow.

For a new reservoir or pond construction in or around existing cropping fields, however, it should be considered to prevent conflicts on water use among farmers.

In the case of water extraction from a tributary, it is required to take into account the hydrological influence on the downstream farmlands and fishing grounds, especially in weir construction plan.

In general, there are some cases that many irrigation works are not operated in a way which encourages efficient use of water due to lack of awareness on the important role of irrigation structures and proper water management. It is necessary for development area to promote some

measures which will lead farmers become more concerned about equitable and efficient distribution of water. Otherwise rehabilitated systems will breed no benefits and may degrade its functions again.

3.5.9 Anticipated Development Effects

Rainfed agriculture is practiced in the poor accessibility area to water resource, depending on inundation depth and duration, and rainfall distribution. With the implementation of development plan, the following development effects will be expected.

- Main development impact expected will be the creation of productive agricultural land with provision of irrigation and drainage system. The agricultural land will bring stable paddy production through the effective use of constructed irrigation facilities, inputs, and extension service conducted under the development plan.
- Creation of agricultural land will enable landless farmer or refugee to supply the land.
- By providing with rural and agricultural infrastructures, rural life will become stable.

3.6 Zoning for Agricultural Development Plan

3.6.1 Significance of Zoning

Agriculture in the flooded area is practiced depending on the water regime of Mekong river and rainfall distribution. The regional agriculture is characterized by some local factors, such as periodic cycle of flood and recession, rainfall pattern and agricultural infrastructures and socio-economic conditions. The intensity of three agricultural patterns of colmatage farming, lowland irrigation farming and rainfed agriculture, differs from in each province and district.

For planning purpose, the Study Area is divided into some zones based on the above consideration. Agricultural characteristics is compiled by divided zones based on the provincial and district ago-economic data, and natural conditions. Based on such characteristics, development direction and strategy should be developed by each zone. The proposed three development plans are developed by considering the development needs, water and land resources potentials of each zone. Development scheme will be projected by each area in each zone taking account of the development potentiality.

Based on the above consideration, zoning is planned to characterize the regional agriculture and to consider the regional agricultural development direction and its production target.

3.6.2 Zoning of the Study Area

The Study Area is divided into 13 zones, based on the agro-economic indicators such as population density, average paddy yield and farm income, and natural conditions such as road, river, inundation intensity and topography (see Figure 3.12).

Zone-1 ; This zone is located in the upper part of the Study Area, north of town of Kompong Cham, along the Mekong river. Inundation area is extended along the river.

Recession rice farming in the inundated area and upland cropping in the higher land is practiced.

Zone-2 ; Almost all of this zone is inundated through colmatage canals, preks and overflow of natural levees. Both of wet and dry season crops are practiced depending on the intensity of inundation.

Zone-3 ; This zone is located along the national road No. 7 to Kompong Cham, in which agriculture is influenced by intrusion of Mekong flood and rainfall distribution. Wet rice is the major crop.

Zone-4 ; Along the east boundary of this zone, road route 15 is running. The area is mainly characterized as rainfed agriculture land. Most of the area is distributed in the higher elevation not influenced severely by Mekong flood. Wet rice is the major crop.

Zone-5 ; This zone is located in the Prey Veng province, with widely inundation area formed by water intrusion from Tonle Toch and Mekong river. The inundated area is designated as the fishing lot area. Both wet and dry rice cropping are practiced.

Zone-6 ; Most of the area is located along the Mekong and Tonle Toch, so that the area is deeply inundated. In the zone, many permanent or temporary swamps and lakes exist. Most of zone is allocated to the fishing lot area. Both agriculture and fisheries are active.

Zone-7 ; This zone is located between and close to the Tonle Sap and Mekong rivers. Flooded water enters into the area through preks, canal and overtopping of banks. Fishing is active since most of the area is designated as the fishing lot area. Dry rice is more productive than wet rice in the area.

Zone-8 ; This zone is located along the right bank of Tonle Sap river. Inundation damage is not so severe that most of the area is characterized as rainfed agricultural area. But, dry rice cropping is practiced since some small tributaries come from hinterland of this zone.

Zone-9 ; This zone is located between and along the Mekong and Bassac rivers. Most of the area is inundated except for the higher natural levees. Colmatage farming is most active due to many colmatage canals and better transportation system.

Zone-10 ; In this zone, colmatage farming is active as same as in the zone-9. There are many small colmatage canals along the rivers. Swamps and lakes sprawls on the hinterland of river bank, which is designated as the fishing lot area.

Zone-11 ; This zone is located in the Takeo province. Inundation areas are distributed in the downstream of the Bassac river, which is designated as the fishing lot area. Some tributaries flow into the swamps and lakes of the zone. Both wet and dry rice cropping are active.

Zone-12 ; This zone is located in the narrow and long band area along the Mekong river. In the zone, Prek Trabek, one of tributaries of Tonle Toch, flows from north to south. Most of the area is in the fishing lot area. Dry season cropping is more active.

Zone-13 ; This zone is located in the south region of the national road No. 1. Heavy inundation occurs only along the Prek Trabek. Though dry rice cropping is active, most of the area is characterized as rainfed area.

3.6.3 Agro and Socio-Economic Characteristics

(1) Population Density

Zone 7 and 8 are highly populated with 658 and 541 persons/sq.km, respectively, because of its nearness to Phnom Penh, followed by Zone 2 which involves a part of Kampong Cham. On the contrary, Zone 1 and 12 are scarcely populated with the density of 127 and 110 persons per km^2, respectively.

(2) Land Use

1) Wet and dry paddy

Wet season paddy occupies about 70% of the paddy planted area in the Study Area. It generally means low crop yield. Dry season paddy, to the contrary, produces higher yield. Zone 6, 7, 9, 10 and 12, which are located along Mekong and Bassac rivers, have lower rate of wet season paddy compared to the other zones.

2) Crop diversification

Diversification of crops is one of the indicators of agricultural activity of the area. According to the ratio of crop diversification (upland crop's area/paddy area + upland crop's area), 13% of the planted area is diversified into upland crops. Among 13 zones, Zone 1, 2, 6, 7, 9, 10, 12 are diversified in upland cropping, which are located along the two rivers, Mekong and Bassac.

(3) Paddy Yield

Zone 9, 10 and 12 show higher paddy yield of more than 3 ton/ha, followed by Zone 6 and 7 yielding 2.7 to 2.9 ton/ha. These five (5) zones are located along Mekong and Bassac rives. Zone 4, 5, 11 and 13 produce 57% of total paddy production of the Study Area.

(4) Self-Sufficiency of Food

The Study Area produces about 1.04 million tons of paddy which is equivalent to about 40% of total paddy production of the country. As the whole, paddy production in the Study Area meets people's demand and has about 390,000 ton of surplus. However, eight (8) zones among 13 zones do not meet their self-sufficiency of paddy.

(5) Irrigable Areas

The areas irrigated by existing irrigation systems and colmatage canals are concentrated in Zone 2, 9, 10, 11 and 12. Colmatage canals are mainly distributed in Zone 10.

(6) Inundation Areas

Magnitude of inundation affects agricultural activities characterized by availability of irrigation water and fishing ground. It can be said that agriculture in the areas inundated for long time with much water are generally active and such areas have higher productivity of crops. Some 53% of the Study Area is inundated during wet season with more than 0.3 m in depth of water. Ratios of inundated area in the zones along Mekong and Bassac rivers are higher than those of the other zones far from both rivers.

(7) Comprehensive Evaluation of Zones

The evaluation of 13 zones were tried from socio and agro-economic viewpoints by using some selected indicators as mentioned above. Ultimately, the zones along Mekong and Bassac rivers have higher agricultural development potentiality (see Table 3.2 and Figure 3.13, details are referred to Appendix I).

3.6.4 Agricultural Infrastructures

(1) Existing Irrigation System

The numbers of lowland existing irrigation system to be rehabilitated in each zone are summarized below. Zone 1 has 69 systems or the most, while Zone 10 has 4 or the least.

Number of Lowland Existing Irrigation System in the Zones

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13
Small Scale	67	4	1	9	29	15	1	6	4	-	5	2	12
Medium Scale	2	3	9	12	19	9	5	13	16	4	24	8	8
Large Scale	-	-	1	0	3	-	0	-	0	-	1	-	-
Total	69	7	11	21	51	24	6	19	20	4	30	10	20

(2) Number of the Colmatage Canal in Each Zone

The colmatage canals are concentrated in Zone 9 and 10 which are located between the Mekong and the Bassac rivers in Kandal province.

Number of the Colmatage Canal in Each Zone

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13
No. of canal	25	30	23	-	-	9	4	-	96	154	10	35	-

3.6.5 Water and Land Resources Development Potentiality

(1) Water Availability in Each Zone

Water balance in each zone is calculated by the amount of irrigation water requirement and the available water based on the conditions mentioned in 3.4.3. According to this calculation, assuming that supply and demand are balanced as the whole area, amount of available water is much enough to irrigate the whole area. However, water balance differ by each zone. Seven (7) zones (Zone 1, 2, 6, 7, 9, 10, and 11) along the Mekong and Bassac rivers have enough water. Shortage occurs in four (4) zones (Zone 3, 5, 8 and 11), which are considered as the rainfed agricultural development areas. For the latter, large scale water diversion plan may be required to convey water from surplus zones.

Water Balance in Each Zone

Zone	Wet Paddy (1,000 ha)	Dry Paddy (1,000 ha)	Total (1,000 ha)	Water Requirement (MCM)	Available Water (MCM)	Water Balance (MCM)	Water Source	Remark
1	1	4	5	56	449	+393	Mekong	
2	3	2	5	38	272	+234	Mekong	
3	11	11	22	187	59	-128	Mekong	shortage
4	4	3	7	55	147	+92	No resource	
5	9	24	33	348	233	-115	Tonle Toch	shortage
6	5	6	11	98	220	+122	Mekong	
7	3	4	7	64	191	+127	Tonle Sap	
8	10	9	19	157	138	-19	TonleSap & Prek Thnot	shortage
9	1	11	12	147	436	+289	Mekong & Bassac	
10	0	9	9	117	369	+252	Mekong & Bassac	
11	1	35	36	459	247	-212	Stung Takeo	shortage
12	0	3	3	39	204	+165	Mekong & Tonle Prast	
13	8	2	10	58	60	+2	Prek Trabek	
Total	56	123	179	1,823	3,027			

Note ; - Irrigable areas for wet and dry season paddy are based on the irrigable area after existing irrigation systems are rehabilitated.
- Available water is based on the LANDSAT images in December, 1994

(2) Land Use Availability in Each Zone

Land use potential without/with implementation of three development plans is compiled by zone (see Table 3.3). According to the table, increment of cultivable area is expected at 60,000 ha. With the implementation of two development plans of colmatage and lowland irrigation rehabilitations, increment of irrigable area of about 23,000 ha in the wet season and 48,000 ha in the dry season can be expected. High potential of land use by irrigation rehabilitation is found in Zone 3 (Kampong Cham), Zone 5 and Zone 13 (Prey Veng). Little potential, less than 2,000 ha, is in Zone 1 (Kratie), Zone 2 (Kampong Cham) and Zone 12 (Prey Veng). As mentioned in

3.3.3, 4,500 ha of land can be irrigated by rotating from recession rice to upland crops, though there is no increase and decrease of farmland under irrigation.

3.6.6 Agricultural Development Target

Based on the statistical data of the districts concerned, the planted area and production data of each zone are estimated in accordance with its area distribution to the zone. The agricultural characteristics of each zone are derived from the modified statistical data and the thirteen zones are classified into five types by cropping pattern. They are as follows (see Table 3.4).

Type	Cropping Pattern	Zone
A	Paddy in Wet Season	3, 4, 8
B	Paddy in Wet or Dry Season	5, 11, 13
C	Paddy + Upland Crops in Wet Season	1, 2
D	Paddy + Upland Crops in Wet or Dry Season (Wet Paddy > Wet Upland Crops)	6, 7, 9
E	Paddy + Upland Crops in Wet or Dry Season (Wet Upland Crops > Wet Paddy)	10, 12

From the viewpoint of cropping season, Zone 1, 2, 3, 4 and 8 are highly concentrated on wet season farming. From the viewpoint of practiced crop, Zone 3, 4, 5, 8, 11 and 13 are highly concentrated on paddy.

As for land productivity, the yields of paddy and maize are computed by each zone. Some of the yields of other crops are not analyzed because it seems that the production amount are calculated from the multiplication of the cultivated areas and the fixed provincial yields. Generally, the yields of both wet and dry season paddy in Type D and E are higher than those of other areas. On the other hand, paddy monoculture areas, Type A and B, have the lower yields of both wet and dry seasons than the averages. Maize yield varies with cropping season and zone, but Zone 6 and 7 have higher yields of both wet and dry seasons than the averages (see Figure 3.14).

Some of the agricultural characteristics, derived from the Rural Socio-economic Survey and statistical data, are as follows;

(1) Kampong Cham has a lot of upland fields producing tobacco. This fact implies that there is fewer available irrigation water than in other areas.

(2) Vegetable is broadly cultivated in Zone 7 and 9 in both wet and dry seasons, but in Zone 6, mainly in wet season and in Zone 10, mainly in dry season.

(3) Although the average titled farmland per farm is affected by locality, the introduction rate of upland crops is largely influenced by the three farm types of paddy cropping season.

Based on the various data, the present agricultural characteristics of each zone, natural conditions and accessibility to the market and so forth, the basic farming development concepts are proposed as follows: (see Table 3.5).

- Projected cropping patterns will be same as the present five ones but their application to each zone/district varies with the development degree of agricultural facilities, in particular irrigation facilities.
- Although paddy is a staple food for Cambodia, the yield is still lower than in neighboring countries (Cambodia-1.79 ton/ha (1995), 1.06 (1994), Thailand-2.15 (1994), Laos-2.59 (1994), Vietnam-3.46 (1994) ton/ha, [Selected Indicators of Food and Agriculture Development in Asia-Pacific Region, 1984-1994, FAO, 1995]). This may come from the fact that the native varieties represent the majority of the wet season paddy planted area and keeping rice seed for themselves common among farmers. Accordingly, it is necessary for all zones to start variety improvement to develop the superior paddy varieties adapting local natural conditions.
- As for paddy production, the average yields of both wet and dry season paddy in the Study Area are higher than the national averages. Consequently, both average yields of the Study Area are set as the first attainable target for the zones which have lower yields (wet season paddy: Zone 1, 2, 3, 4, 11, 12, dry season paddy : Zone 1, 2, 5, 7, 11).
- Based on the results of the past research and survey, the target yield for short/medium term dry season paddy varies between 3.0 to 4.3 ton/ha depending on zone. That of wet season paddy is set as 1.85 ton/ha.
- Dry season paddy, with higher productivity than wet season paddy, should be expanded in the areas where there is possibility to develop water resource (Zone 1, 2, 6, 7, 9, 10, 12).
- In accordance with one of the national agricultural policies; crop diversification, the introduction of upland crops should be promoted in the whole Study Area but the introduction of vegetables should be limited for the areas around Phnom Penh (vegetables introduction : Zone 3, 6, 7, 8, 9, 11).

It is estimated that total paddy production of the whole zones, derived from the target yields and planted areas, is expanded to about 1.8 million tons (see Table 3.6).

3.6.7 Improvement Target of Rural Infrastructure

(1) Rural Road Networks

Improvement of the rural road networks in the Study Area will start with rehabilitation of the existing roads and construction of new roads. The targets of the improvement are shown roughly on the map "Scheme of Remanagement Road Network after War (enacted by the Public Works Research Center, MPWT)" by taking into account the present national and provincial road networks and by referring the road network maps and information in the provinces collected during the field study (see Figure 3.15).

Priority is given for the rehabilitation of the potential routes to activate marketing between the areas as well as to the area with less national and provincial road density. The roads for new construction are selected on the routes for mutual connection between the key national and

provincial roads for marketing and the improved roads, for by-passing the existing roads, and in the area with less key road density.

The target of the improvement, under such consideration, amounts to 404 km and 343 km for rehabilitation of the existing rural roads and construction of new ones, respectively. The targets for improvement by zone are in the following table:

Target of Rural Road Improvement by Zone

(unit : km)

Zone	Length of the Existing Road Improvement	Length of New Construction Road	Zone	Length of the Existing Road Improvement	Length of New Construction Road
(1)	44.3	9.2	(8)	32.3	23.1
(2)	57.2	18.4	(9)	9.2	28.6
(3)	13.8	12.0	(10)	60.0	44.3
(4)	11.1	16.6	(11)	32.3	71.9
(5)	19.4	32.3	(12)	18.4	26.7
(6)	73.8	19.4	(13)	18.4	23.0
(7)	13.8	17.5			
			Total	404.0	343.0

(2) Rural Water Supply

The target of tube-well installation is set by the Department of Rural Water Supply (MRD) at 200 pers./well, as mentioned in 3.3.7. To achieve the target, number of tube-wells necessary in the Study Area amounts to 9,872 as shown by zone in the table below.

Target of Tube-well Installation by Zone

(unit : place)

Zone	Number of Existing Well	Number of Necessary Well	Zone	Number of Existing Well	Number of Necessary Well
(1)	217	985	(8)	442	1080
(2)	182	839	(9)	524	1042
(3)	131	405	(10)	305	497
(4)	189	821	(11)	512	1113
(5)	308	1233	(12)	17	266
(6)	273	455	(13)	138	683
(7)	126	454			
			Total	3,362	9,872

Aside from this study, JICA is currently conducting a groundwater development study in the southern five provinces. The three provinces of Kandal, Takeo, Prey Veng are overlapped under both studies. The objectives of the JICA study are production of hydro-geographic maps, selection of sample villages (approx. 300) for survey and implementation of a pilot study project by installation of 20 test tube-wells.

Upon installation of the tube-wells in the subject Study Area, effective use of the results of the JICA study is expected in selection of locations, depths, etc.

3.7 Proposal of Agricultural Development Projects

3.7.1 Basic Concept

Three types of agricultural development plans should be materialized through the Feasibility Study (F/S) by the selected and specified area/zone, based on the characteristics and development targets of the area/zone. The F/S contains the formulation of detailed development plan based on physical and social characteristics of the selected area/zone, the possibility of farmers participation and the probable effects of development.

As the first step of development strategy of the three plans, some areas and zones are selected from the covered areas of the proposed development plans. Next, the project viability of the selected one will be studied as the agricultural development project. After the completion of viability study, the projects will be implemented as the higher development priority project.

Considering the development characteristics of the three plans, the rainfed agriculture development plan is divided into two categories; the small scale development plan and the tributary basin development plan as mentioned in 3.5. It is considered that some parts of covered area of small scale development plan will be included in the area of agriculture development plan harmonized with fishery. On the other hand, the comprehensive basin study is necessary for implementation of tributary basin development plan, which will require longer study period due to wide scope of works. Area of the tributary basin development plan, therefore, is not included in the area of proposed agricultural development project.

3.7.2 Colmatage Farming Improvement Project

The areas of colmatage farming improvement plan are distributed in the area of 1) Zone 1, 2, 3 and 7, 2) Zone 6 and 12, 3) Zone 9 and 10 and 4) Zone 11. Development priority area is selected considering the rehabilitation priority of their areas. As the results of the study, the following priority is given into the areas, taking account of some factors as mentioned in 3.6, such as agricultural characteristics, development potentiality and distribution of colmatage canals.

Area / Zone	Province	Number of Colmatage Canals	Rehabilitation Priority
1) Zone 1,2,3,7	Kampong Cham, Kandal	59	3
2) Zone 6,12	Prey Veng	44	2
3) Zone 9,10	Kandal	250	1
4) Zone 11	Takeo	33	4

The agricultural activity is active in all zones and especially, especially the area of 3), Zone 9 and 10 between the Mekong and Bassac rivers in Kandal is the best and the development

potential is highest. Therefore, it is supposed that Zone 9 and 10 is designated as the development priority area (see Figure 3.16). Implementation of the development plan in their zones is likely to be justified in consideration of the agricultural production and the various functions of colmatage canals.

Development project is consisted of various components such as rehabilitation of colmatage canals and strengthening of farmers' organization. For further promotion of the project after selection of priority area/zone, rehabilitation priority might be set on the each colmatage canal in the selected area/zone based on the characteristics of their service area and the deterioration of canal facilities. The project would be carried out on a canal basis, by setting up rehabilitation priority of the canal. (Further study is conducted as shown in Chapter 4. It is considered to be economically feasible. It is recommended to be implemented urgently).

3.7.3 Agricultural Development Project Harmonized with Fishery

The area is mainly distributed in the zones along Mekong and Bassac rivers while it is dispersed around lakes and swamps. The viability of the plan implementation depends on the result of the extensive study involved in physical and social characteristic and development possibility of marketing. It is indispensable that farmers and fishermen participate in development project from the initial stage of the project implementation in consideration of spreading development effect. Therefore, the project area is selected taking into account of significance and importance of the project implementation for the area/zone, possibility of achievement of development targets, possibility of farmers and fishermen participation, anticipated project scale, capability of implementation, operation and maintenance, and development effects. As the result of study, 20 areas among 292 lowland irrigated agriculture areas were selected as the priority development area (see Figure 3.16).

Based on the quick evaluation, the viability of the selected area is likely to be high. It is desirable to execute further detailed study for project implementation immediately by each selected area. Data and information for the areas were collected and compiled in this study. Based on the data compilation, preliminary study for conducting feasibility study was carried out (see Table 3.7).

3.8 Implementation Plan

To attain the production targets as mentioned in 3.2.1, the proposed three development plans should be implemented in each zone considering development potentiality, needs and urgency. For promoting development plans in each zone, institutional capability and farmers' interest and operation and maintenance capability should be also taken into consideration. Implementation plan, therefore, should be made based on the following considerations.

- There is no mechanism for development cost recovery and no system of collection on the operating cost of common use infrastructural facilities from beneficiaries at present. In case of large scale infrastructures project such as big pumping system, especially, farmers will be burdened with heavy operating cost. Development projects requiring direct responsibility of farmers should be promoted cautiously.

- Financial and institutional capability to run the development plans is very limited. For smooth implementation, strategic implementation scheme and close cooperation with related institutions and agencies is required.
- Development plans should be implemented based on farmers participation. In the implementation plan, therefore, farmers' interest and possibility of organizing farmers group should be considered.
- To recover and boost crop production, well-balanced approaches of expanding productive land and increasing crop yield, are required. On the other hand, the traditional farming infrastructures have been deteriorating due to the prolonged civil war. Assuming the significance of development benefits of crop production, rehabilitation and improvement of the present farming system is the most workable approach.

Considering the above conditions and the production targets required in each target year, the following approach should be undertaken.

3.8.1 Short and Medium Term Plan

Colmatage Farming Improvement Plan and Agricultural Development Plan harmonized with Fishery should be implemented in the short and medium term in order to achieve quick agricultural production target.

As the priority development projects, colmatage farming improvement project in Kandal province and agricultural development project with fisheries at 20 sites were proposed as mentioned in 3.7. These projects could not be implemented immediately because of financial limitation and capacity of implementation body, so that priority project(s) and area(s) might be selected as the pilot projects. Based on the results from the pilot projects, the proposed other projects may be implemented step by step. Pilot project area(s) should be selected from proposed two areas.

3.8.2 Medium and Long Term Plan

Maximum cultivable areas for agricultural use in the Study Area are limited to about 739,000 ha. At present cultivable land in the Study Area was estimated at about 679,000 ha, indicating that present land use has been nearing the maximum being able to be developed. This implies that increase in both paddy yield per hectare and expansion of paddy acreage will be required for increasing production. The efforts to increase yield should be more strengthened as the long-term plan.

Agricultural development should put more stress on increasing crop yield. To attain the long term production target, more intensive agriculture with more effective water management and active extension service are needed. Development attention should be put on creation of productive land and more intensive farming, taking into account the function of flood reservoir in preventing flood intrusion to the agricultural land.

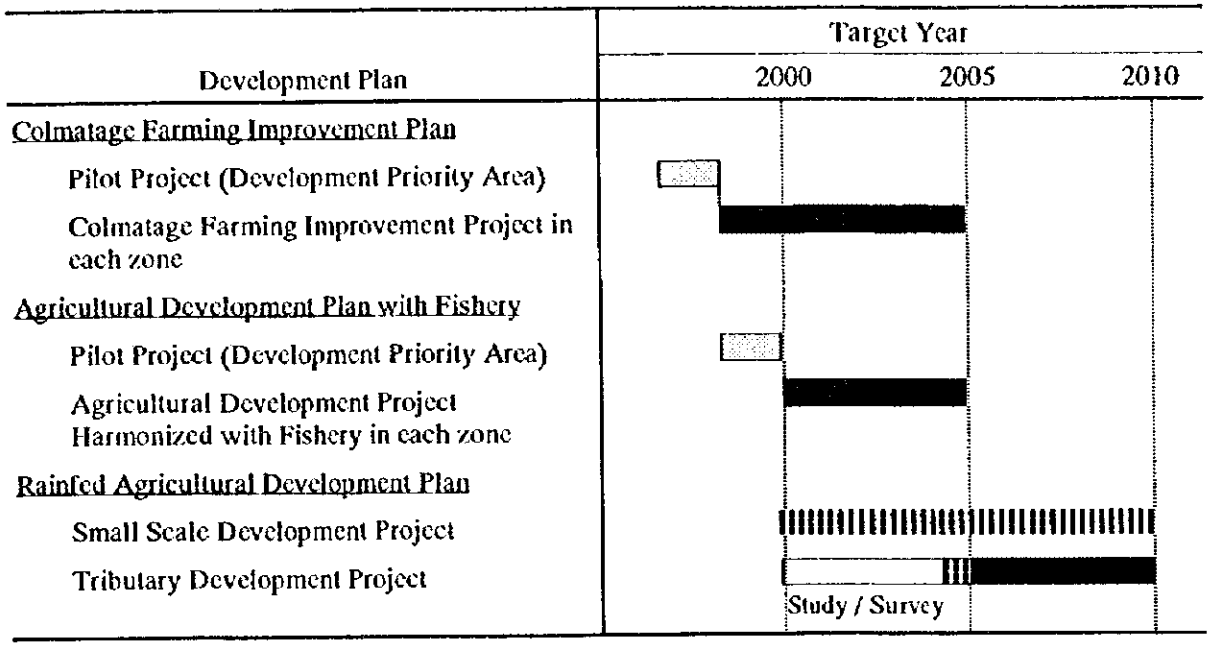
For such development direction, frequent heavy flood is the most biggest constraints since it does not allow most of farmers toward more intensive farming. Though the flood brings some benefits to the flooded area, it prevents from introducing more advanced farming. Therefore,

unexpected heavy flood will have to be prevented in order to further enhance productive and effective agriculture. In the development plan, however, a certain level of flood intrusion should be allowed to maintain the irrigation and fisheries resources.

As mentioned in 3.6.5, the amount of water resources is not enough to irrigate whole agricultural land of the Study Area although there are some tributaries of the Mekong rivers. To attain the development targets of crop production, rainfed agricultural areas will have to be developed by these tributaries putting stress on water resources development.

3.8.3 Implementation Agency

The proposed development plan will be implemented by Ministry of Agriculture, Forestry and Fisheries (MAFF) as the coordination and implementation body under close cooperation with related agencies and department of GDIMH, Ministry of Rural Development (MRD), Ministry of Public Works and Transport (MPWT), Ministry of Environment (MOE), etc. The participation of provinces, districts, communes, villages and related farmers are also necessary for project implementation in each area.



3.8.4 Issues for the Implementation of Medium and Long Term Plans

(1) Rainfed Agriculture Development in the Tributary Basin

The rainfed agricultural development plan, consisting of the small-scale development plan and the tributary basin development plan, is to be implemented over the long term. The former will be partly covered by the agricultural development plan harmonized with fisheries. As for the latter, it is necessary to determine the overall framework and policy directed at the actual implementation in the short/medium term. The following is the main tributaries in the area, for each of which development plan should be formulated. In the plan formulation, water resources potentiality is considered as the most important subject.

- Tonle Toch

This river has the function of flood diversion from the Mekong river to the flood plain. The measures to be taken for water resource development and flood control should be identified. They will possibly include river dredging and reshaping, construction of weirs and dike, rehabilitation of swamps. The river has a catchment area of about 3,063 sq. km, and length of 115 km.

- Prek Trabek

This prek is the tributary of Tonle Toch. Similar to the Tonle Toch, integrated approach will be required. The possibility of water diversion to Svay Rieng area to meet with both purposes of irrigation and flood diversion should be considered.

- Stung Takeo

This river comes from hinterland of flooded area of Takeo. Water resources development is the basic needs for developing rainfed area in Takeo province. Planning for the development of the area around this prek would have to cover the aspects of irrigation and drainage, and fisheries development covering sprawling area.

- Stung Prek Thnot

This river is the largest tributary flowing into the flooded area. Development study had been completed and the projects proposed in the study is expected to implemented very soon.

- Prek Anghor, Prek Phnau, Muk Kom Pul, Prek Kang Chak, Prek Chker Kaun

These preks function as dual purpose of irrigation and drainage. Some of them are involved in the development scheme of agriculture and fisheries development plan.

(2) Meteorological and Hydrological Observation Network Improvement

- Meteorological observation network

The existing meteorological stations, located mainly along Mekong river and around Tonle Sap Lake, provide quite a good coverage for Mekong ravine, the central plain and the area surrounding the Tonle Sap Lake. Setting up meteorological station in each provincial capital and synoptic posts in each of the major tributaries will complete the intense observation network necessary to give a good coverage of the whole country. The meteorological stations should cover all the basic meteorological elements and the synoptic posts should cover the major elements such as temperature and daily rainfall.

Except for rainfall, spatial variation of other meteorological parameters is relatively small. In planning and design, daily rainfall or rainfall of shorter duration such as hourly rainfall are vital. Since there were over 150 rainfall stations/synoptic posts in the '70's, restoration of some of the strategically located stations/synoptic posts should be the first priority.

At present, only mean monthly data for the basic meteorological elements are available at few main stations. And data at Pochentong are often used to correlate other stations in planning. Except for Pochentong Meteorological Station, continuous daily rainfall data do not exist or are

not easily available, not to mention hourly rainfall. Like hydrological data, meteorological data from the provincial stations, relayed daily or less frequently to Pochentong through radio, need to be checked and processed real-timely. The system of database and present method of collection and processing also requires improvement.

- Hydrological observation network

The primary stations - Stung Treng, Chrouy Changvar, Phnom Penh and Prek Kdam- along Mekong, Bassac and Tonle Sap river have been studied by the Mekong River Commission (Review of the Current Status of the Lower Mekong Hydrological Network, 1995). At these primary stations, monitoring of the basic parameters such as discharge, water level, water quality and sediment should function well since the activity has already been reactivated. They are operated under the direct supervision of the MRC Secretariat with the cooperation of the national agencies concerned.

Restoration and reactivation of other gauging stations is underway, following detailed studies on rehabilitation projects in recent years: Supported by AFFHC, a NGO has partially rehabilitated 9 stations and established a new station in Koh Khel. Future plans also include restoration of 24 of the 33 original stations in the network by 1997. Due to inadequate budget for operation and maintenance, measurement is conducted only at few rehabilitated and reactivated main stations at present.

Aside from physical restoration of the stations, station lineage and inventory, observation and database compilation, including data checking, sorting, accumulating and processing, need to be up-graded. Some of the past data need to be verified before use and the reference datum of the stations reworked, as they are vital to the accuracy of readings. These time-dependent data are the basics for planning and design, and the consistency of record period and accuracy of data will greatly affect the accuracy of study and planning. Effort is also needed to promote, at all levels, a better understanding on the importance of these sine-qua-non parameters.

The major difficulty in hydrological study, especially in more regional and localized area, come mainly from the lack of and inconsistency of daily data record. At present, observation and data accumulation for rainfall and water level are especially poor at provincial level and the basin of the major tributaries. To facilitate future development, it is necessary to also establish hydrological observation posts along the major tributaries.

(3) Other Issues

- Reinforcement of embankment

At present, flood intrusion by overtopping banks is the overriding phenomena. While not advocating to completely keep out annual flooding cycle in the flood plain, the relationship between flood level and embankment elevation can provide some useful cue on controlled flooding through colmatage and help to minimize undesired damages.

For the purpose of flood prevention, some flood reservoir construction plan have been proposed by the Mekong River Committee. If the plans would be promoted, the present flood damage would be reduced drastically while the original function as the flood reservoir could be shifted to the constructed reservoirs. If the construction plans would be implemented, farm production

system would be renovated for boosting crop yield. On the other hand, change of water regime might cause negative impacts on the inherent social and natural environment. The construction plans will be proceeded cautiously considering the environmental problems such that long study period is required. Considering the viability and implementation possibility of such plans, the long term development target in this Study might be conducted without any consideration of development of flood reservoir construction plan.

As another flood alleviation measures, reinforcement of embankment is considered. The development possibility should be studied. In this Study, preliminary analysis was conducted as follows.

Frequency analysis was performed for the gauging stations along Mekong, Tonle Sap and Bassac rivers to obtain the design flood levels. Figure 3.17 shows the longitudinal profile of the right and left bank of the rivers and the design flood levels for 1/2, 1/10 and 1/100 year return period. The plots shows that:

(a) Along the Bassac river, the right bank between Phnom Penh and Koh Khel is completely clear of the 1/2 and 1/10 flood level. The left bank is clear of the 1/2 level but is lower than the 1/10 level at 3 locations. Except for the right bank at Koh Khel, both banks are below the 1/100 level. The 1/2, 1/10 and 1/100 values downstream of Kho Khel were extrapolated and cannot be verified due to lack of information.

(b) Along the Tonle Sap river, the right bank is above the 1/2 and 1/10 flood level. Except for around Phnom Penh and Prek Kdam, the left bank is below 1/2 level for most of its length and is completely below 1/10 level. With the exception at 7 locations, the right bank is marginally above the 1/100 level.

(c) For the reaches between Phnom Penh and Neak Luong the right bank is above the 1/2 level while the left banks is below for quite a long stretch just downstream of Phnom Penh and at a few locations before Neak Luong. Except at 2 locations, the right bank is also above the 1/10 level and the left bank is below. Only at Neak Luong, both banks are marginally above the 1/100 level. The 1/2, 1/10 and 1/100 level after Neak Luong were extrapolated. Both banks are below the extrapolated 1/2, 1/10 and 1/100 values.

(d) For the reaches of Mekong between Chatomouk and Kampong Cham, the elevations of both banks are marginally higher than the 1/2 level, with the exception at few locations. Only the right banks at around Phnom Penh and Kampong Cham are above the 1/10 level. The banks in between the cities are all below the 1/10 and 1/100 level.

Figure 3.18 shows the stretches of banks along Mekong, Bassac and Tonle Sap rivers that are below the water level of 1/2 (a), 1/10 (b) and 1/100 (c) return period. It is evident that quite some stretches along the left bank of Mekong and Tonle Sap river are below the 1/2 return period (R.P.) level (a). Some locations of road No.1 between Phnom Penh and Neak Luong are below the 1/10 R.P. level and need to be raised (b). Most of the length of the roads along Mekong, Bassac and Tonle Sap river are below the 1/100 R.P. level (c).

It is important to note that these issues centered around the Mekong should be dealt with in close liaison with the Mekong River Commission.

- River dredging

The Tonle Sap river and lake is a part of the Mekong river basin. The lake is recognized as the richest fish ecosystem in the world and as a natural flood reservoir of the Mekong river system.

According to the development study already conducted, the entrance of the lake and river are exposed to serious siltation, so that the lake would be reduced in volume considerably. If no action will be taken, the specific environmental functions may deteriorate and negative impacts may adversely affect the fish habitat and other valuable ecosystems. The river dredging is the one of measures to maintain the original functions of river. Development study is required for further consideration on needs and possibility of development.

3.9 Environmental Impact

3.9.1 Initial Environmental Examination (IEE)

Initial environmental examination (IEE) was conducted to evaluate the environmental effects in case the proposed agricultural development plans were implemented. From the social and natural environmental aspects, it is predicted that implementation of the three plans has synthetically no negative impacts on the present way of social/economic life in villages or the natural conditions, either. One of the components in the plans, rehabilitation of the present agricultural infrastructure, will rather bring both stable agricultural production and conservation of social/economic environments. None of the proposed three agricultural development plans includes the change of the hydro-meteorological conditions of the Mekong river. Besides, based on the survey results of the Ministry of Environment, there seems to be no habitats of rare plants/animals to preserve in the Study Area until now. Consequently, it is predicted that the implementation of the three agricultural development plans has synthetically few negative impacts against the present ecosystem.

The above mentioned result of IEE is derived from the comprehensive examination of the three plans and the conditions of the Study Area. Implementation of the plans gives any influences in and around the project area, directly or indirectly, but the degree and contents of them are varied by the specific project areas. The specific project areas of the proposed agricultural development plans will be decided and be implemented after the completion of each feasibility study. In the process of embodiment of each specific project, it is possible to bring about the negative impacts on the social/economic or natural environments in and around the project area, partially or temporarily. In Kandal, there is the plan to set some parts of backswamp as conservation area (refer to 2.10.2). Accordingly, it is necessary to carry out environmental impact assessment (EIA) on the occasion of each feasibility study. Expected items for assessment in every project area are as follows; 1) social environment - adjustment between water right and fishing right, structural change of rural society, etc., 2) natural environment - vegetation change, confirmation of rare plans/animals.

3.9.2 Issues for Environmental Conservation

For the promotion of three agricultural development plans, the specific subjects to be considered are as followings from the viewpoint of environment conservation.

Rehabilitated colmatage canals will work more efficiently and stable flow convey fertile sediment on farmlands and into backswamps. This is useful for the increase of agricultural productivity and the conservation of fishing grounds. Rehabilitated irrigation systems and colmatage canals require well controlled operation and maintenance with water users' associations and supporting services.

As for the agricultural development plan harmonized with fisheries, irrigation systems are expected to encourage farmers to apply more intensive and steady farming system with sufficient water use. The availability of irrigation system enables farmers to use present farmland effectively without exploitation of flooded forests. It will lead to preservation of the existing flooded forests and fisheries resource grounds. Furthermore, renewal of water bodies could provide fresh water fisheries opportunities for fishermen and farmers. However, it will be arisen some environmental impacts on water bodies due to indiscriminate use of fertilizer and agrochemical in line with cropping intensification. Extension activities for farmers should be continuously conducted to prevent those impacts.

The infrastructure improvement plan of the rainfed agriculture development plan brings about the improvement of health and sanitation conditions in the Study Area. On the other hand, domestic waste water generally increases in accordance with the improvement of living standard and infrastructure. It is possible to effect a change of the water quality of neighboring fishing grounds. Both adequate domestic waste water treatment and enlightenment activities of public health will be required.

Cambodia is endowed with rich natural resources for human, agricultural and industrial use. Appropriate legislation focusing on specific issues is needed to solve the balance matter between resource conservation and economic activities. It is also indispensable to formulate strategic plan for appropriate resource management and interagency cooperation among the agencies concerned.

The flooded forests are the traditional source of nutrients necessary to sustain a large and varied aquatic biota with its ecosystem existing on the Mekong river system. Since its heritage has long provided people with a wealth of resources, a primary environmental challenge is to preserve biological diversity for future use. Fisheries represent a critical source of protein and valuable economic asset for Cambodia.

The vast inundated area also provides an ideal environment for propagation and dissemination of a wide variety of aquatic species. However, intensive fisheries has led to reduction in catches of some large size fish species. Their development and management should be carried out in a manner of consideration for the environment if production is to be sustainable.

Waste water, sanitation and solid waste management are environmental issues affecting the urban and its suburb environment. The policy for sound urban environment should involve strengthening local institutions to better manage infrastructure, public service functions and the financing of local infrastructure.

3.10 Impact of the Agricultural Development Plan

3.10.1 Short and Medium Term Agricultural Impacts

The implementation of the plan/project will impacts on the total agricultural production, farm income, land use and so on. Farmers will be enlightened on intensive and productive agriculture through agricultural extension services, agricultural credit services, activities of the water users' association and so forth. The agricultural impacts can be summarized as shown below:

- Cropping intensity in the areas of the colmatage farming improvement plan will be increased by the rehabilitation of the existing facilities and strengthening of farmers' organization. Crop yield will be increased through irrigation and agricultural extension services and crop diversification will be promoted.
- Irrigable areas will be expanded by 47,500 ha for dry season and 22,700 ha for wet season, respectively, by the implementation of the agricultural development plan harmonized with fisheries. Rainfed area will decrease by about 10,100 ha with the expansion of irrigable areas and cultivable area will increase, by the implementation of the three plans, by 60,100 ha from 679,100 ha to 739,200 ha. As a result, total paddy production will be increased by about 790,000 ton.
- Farm income will be expected to increase through promotion of the plans and farmers will be enlightened through the establishment of farmers' organization, especially, water users' association.

Quantitative benefits by the implementation of plans can be summarized as below.

Development Items		Without Project/Plan	With Project/Plan	Expanded Area
Irrigated Area (ha)	Wet	59,200	81,900	+ 22,700
	Dry	128,800	176,300	+ 47,500
Rainfed Area (ha)		491,100	481,000	- 10,100
Rice Production (million ton)		1.04	1.83	+ 0.79

3.10.2 Social Impacts

As mentioned above, the effect of increased agricultural production is a quantitative benefit brought about by the implementation of proposed agricultural development plans. Apart from the quantitative benefits, it is supposed that the non-quantitative benefits are also expected. The increase of agricultural production will bring self-sufficiency of food and stable rural life. The creation of new agricultural land is connected with the supply of land for farming and living to refugees and landless farmers. The formation of stable village through the stable agricultural production and the improvement of infrastructure will bring the settlement of farmers in the rural area. As the result, it will also control the concentration of population in Phnom Penh that is becoming a social problem.

Although the inland fishery in flood plain contains a lot of problem, contradictory with agricultural development, the harmonious activity with agriculture will be possible by the implementation of the plans. Further, the plans will improve the conservation of fish resource and bring the sustainable inland fish production.