3. MASTER PLAN LEVEL STUDY ON PROJECTS REHABILITATION

On the basis of data and findings obtained from works in Ghana as well as the study made at this stage, the master plan level study on the 12 existing irrigation projects is made as presented in this Chapter. The study covers the main component of the Project such as rehabilitation plan of the project facilities, and agricultural and institutional development plans in connection with the projects rehabilitation. The study will also be the basis for evaluation of each project as well as for selection of priority projects discussed in Chapter 6 of this Annex.

3.1 Constraints to Profitable Agricultural Development

The strategy and policy for successful implementation of the proposed agricultural development in the reactivated projects hinge on the elimination or alleviation of various constraints and should reflect the key policies in the MTADP. Various constraints are discussed in Chapter 2 and may be classified into the following three categories such as physical (available water resources and deterioration of project facility), technical (lack of technology transfer and improved materials for farming) and institutional constraints. Each of these constraints does not affect the present low productivity independently, but relates closely each other.

3.1.1 Physical Constraints

(1) Available Water Sources

The existing water sources for project operations are the rivers for five (5) projects, the Volta lake for two (2) projects and the existing reservoirs for five (5) projects. In case of four (4) projects served by the Volta lake, Volta river and the reservoir such as Amate, Kpando-Torkor, Aveyime and Weija, there are no problems and constraints in terms of available water for irrigation purpose, even if the present irrigated land in these projects is expanded in connection with the projects rehabilitation. Therefore, no water balance study is made for these four (4) projects.

However, the remaining eight (8) projects may have some problems of water shortage, when year-round irrigation with 80 % dependability is applied, and the extent of water shortage depends on the hydrological conditions of the existing water sources and cropping patterns to be applied for the respective projects. Then, an analysis of potential water sources in each of the projects for year-round irrigation with 80 % dependability is made through the water balance study for each of the eight (8) projects.

For this purpose, the runoff study on the existing water resource at each project site is made at first by applying tank-model analysis and using daily rainfall data obtained from the nearest synoptic meteorological station to each project. Then, water balance study on five (5) reservoir projects such as Ashaiman, Afife, Mankessim, Bontanga and Okyereko is made on 10-day basis, using the runoff thus estimated and irrigation water requirements calculated on the basis of proposed cropping pattern for each of these projects (refer to Sub-section 3.4.2 "Delineation of Project Area through Water Balance Study).

The water balance study shows that Bontanga project could supply sufficient irrigation water to 450 ha of land even under the condition that irrigation requirements with 80 % dependability are applied, when the present command area is kept as it is.

However, the remaining four (4) reservoir projects could not supply sufficient irrigation water to serve the present command area unless some countermeasures are taken, as shown below :

Project	Potential Area (ha)	Developed Area (ha)	Cropping Pattern*1	Irrigable Area (ha)*2	Case Study
Ashaiman	148	130	Rice/Okra	44	
Afife	880	880	Rice/Rice/Okra	465	Case 1*3
	880	880	Rice/Rice/Okra	535	Case 2*4
Mankessim	256	17	Vegetables	295	
	256	17	Rice/Rice	115	
Okyereko	111	40	Rice/Rice	32	Case 1*5
	111	40	Rice/Rice	111	Case 2*6

*1 : Proposed cropping patterns (refer to Sub-section 3.3.1)
*2 : Irrigable area in case that year-round irrigation with 80 % dependability is applied for.
*3 : In case that supplemental reservoir, Agali, is not used.
*4 : In case that the existing two reservoirs are fully used.
*5 : In case of existing reservoir only
*6 : In case that supplemental water supply by pumping from the Ayensu river is available.

As seen in the above table, a high water shortage will be foreseen in Ashaiman project. The main reason for such a high water shortage seems to be (i) small catchment area against the present project area and (ii) low runoff coefficient which is observed by IDC. As discussed in the following Sub-section 3.4.4 "Irrigation Facility", even if the storage capacity of the reservoir is increased by heightening the crest elevation of spillway or dam, the increased amount of water would be consumed mostly by evaporation due to increase in water surface area in the reservoir. Also, Afife project could not serve the whole command area even in case that the supplemental existing reservoir is fully used.

In case of Okyereko project, GIDA has a plan to provide the supplemental water source by installing pumps on the Ayensu river which is located near the project. Then, the study of an alternative plan is made so as to include new pump station in the proposed rehabilitation work of this project (refer to Sub-section 3.4.3 "Alternative Plan").

The water balance study is also made for Akumadan, Tanoso and Subinja projects. The study shows that all of them will have water shortage problem in case of year-round irrigation with 80 % dependability. This means that possible irrigable area in these projects will be restricted to less than their potential areas (refer to Sub-section 3.4.2 "Delineation of Project Area through Water Balance Study").

(2) Deterioration of Project Facility

Most of the existing irrigation projects are suffering from low productivity due to various constraints. The major constraints are represented by deterioration of the project facilities, particularly those for irrigation in the projects served by pumps. Most of them in these projects are deteriorated and are not able to supply sufficient irrigation water to the field at present because of the lack of proper maintenance and long time use for 15 to 20 years. The rehabilitation or replacement of the existing pump stations as well as water distribution system such as pipelines and sprinkler is urgently needed in order to recover their performance and thereby productivity. They are Subinja, Tanoso, Akumadan, Amate, Kpando-Torkor, Mankessim and Weija projects.

Although the existing dams and reservoirs in Bontanga, Afife, Ashaiman, Mankessim and Okyereko projects are maintained in good condition, irrigation canals and related structures have some problems mainly due to water leakage from the canals and damaged canal structures caused by poor maintenance and long time use. The canals and structures in Ashaiman and Okyereko projects are severely damaged and not functioning due to much water leakage, which result in higher operation costs. In addition, Aveyime project where pump is used for tapping water from the Volta river stops completely the project activities at present due to severe damage of pump, canals and structures. These projects also need rehabilitation or replacement of the facilities.

In addition to the irrigation facilities, the maintenance of other project facilities such as drains, farm roads, buildings and those for farming is generally poor, and some rehabilitation works and construction of additional facilities are required to recover their productivity.

Besides, there exist technical problems in O&M of the projects. The major problems are the lack of basic technical information of irrigation practice. Most of the projects has no technical data and information to estimate irrigation requirements, and to prepare irrigation schedule including water management at farm level. In addition, no records on how much irrigation water is actually supplied to the field, which is indispensable for efficient use of available water, are not available in most of the projects.

3.1.2 Technical Constraints

Most of the constraints which are crucial to profitable agricultural development with irrigation in the project areas are due to insufficient agricultural services for the farmers that should be provided by the government institutes concerned as well as by the GIDA. These constraints are summarised as follows :

(1) Information and Technology Transfer

Despite the fact that the existing irrigated lands in the project areas have a potential of increasing crop yields, package development of farming techniques is still not sufficient, based on field trials of various crop varieties, appropriate planting time and harvest, fertiliser practices, etc. under irrigation suited to the differences in the physical conditions. In addition, the present extension activities by the MOFA are concentrated on staple food crops such as maize, cassava, yam, cowpea and soybeans in rainfed area, and there are almost no services to the existing irrigation projects. As a result, credible extension services for increase in crop production by farmers could not be provided sufficiently by the GIDA for good and profitable farm management. It is therefore expected that IDC should play more important role in strengthening the research activities for improving irrigation farming and its training to the extension offices as well as farmers in the project areas.

(2) Improved Materials for Planting and Agricultural Supply

Most of farm inputs required for irrigated agriculture such as improved seeds, fertiliser and agro-chemicals are supplied from the private companies, and the government supplies only new varieties of seeds. Most of farmers in the project areas obtain necessary seeds from markets, other farmers or products when harvested at last season. The shortage and high prices of these farm inputs are one of the constraints to the increase in crop production.

3.1.3 Institutional Constraints

Through the field investigation and study on data and information collected from various institutions, the following constraints and problems are identified :

1) The final target of the Project is to improve farmers' living standard through the introduction of proper irrigation farming. In order to achieve this final target of the Project, the agricultural support services are crucial factor. With the exception of Weija, Afife and Subinja projects, the PM offices have a weak co-ordination with the related agencies of the agricultural support services, especially with the agricultural extension offices of MOFA.

2) A farmer's society has been established in each project area. As far as the articles of

the present bye-laws are reviewed, all these societies are general agricultural co-operatives which aim to promote the economic interests of members, and there is no article on the O&M of irrigation facilities in their bye-laws. In the case of bye-laws as the water users' association, it is necessary to enact the specific articles such as the right of collection of irrigation service charge and application of sanction to the members who use irrigation water illegally. As those regal basis, it also be needed to enact some laws at the national level.

3) The strengthening of the existing societies is the prerequisite factor to make successful handing over, but GIDA itself has no function for promoting societies. All such promoting services have been entrusted to the Department of Co-operative, but this department has almost no experience in the support services to the water users' association. In addition, a weak co-ordination is shown between them at site, as well as the extension services.

4) GIDA has a weak organisation and staffing as the executing agency of the handing over of O&M, as well as the promoting services to the societies. The Project Management Division under the Department of Project Operations is responsible for the handing over, and its direct implementation is undertaken by the PM offices. The Project Management Division has only two (2) officers. In addition, the front line staff in the PM offices has however insufficient experience in the handing over of O&M. These offices should therefore be strengthened before the implementation of the handing over programme.

3.2 Basic Concept for Projects Rehabilitation

Overall development strategy and policy for profitable agricultural development in connection with the projects rehabilitation is discussed to formulate the basis for the Master Plan Study on the existing twelve irrigation projects. The discussions are made on the basis of all the study results obtained from both Phase-I field and home office works such as data collection, field investigation and findings as well as from analysis of various data and information. In addition, data and information obtained through the investigation of other existing irrigation project recently rehabilitated are fully used in this discussion.

3.2.1 Agricultural Development Strategy and Policy

The final target of the proposed agricultural development in the reactivated projects can only be achieved through comprehensive development of not only direct measures for increase in agricultural productivity of the projects but also other supporting measures such as strengthening and improvement of the GIDA as well as the existing farmers' organisations, particularly in terms of efficient O&M of the projects and provision of sufficient support services to the farmers, and improvement of linkage with other government institutes concerned. This suggests that the Master Plan Study be formulated in a form of " the integrated and balance agricultural development". The essential policies to be taken for this purpose will be as follows :

1) Increase and stabilisation of agricultural productivity
2) Rehabilitation and improvement of agricultural production infrastructures

(1) Increase and Stabilisation of Agricultural Productivity

The increase and stabilisation of agricultural productivity through elimination or alleviation of various constraints that currently exist in the project areas is considered to be the most important factor in contributing to the achievement of the key policies in the MTADP. The essential policies to achieve this purpose will be (i) intensification of farming and crop

production, (ii) extension of improved farming and (iii) crop diversification. The direct measures in line with these policies will include :

1) establishment of an integrated agricultural base station or more effective use of existing station such as IDC for field trials of crop variety, fertiliser use, pest and disease control, etc. as well as for demonstration of improved farming practices for the purpose of increasing crop production in both lowland and upland area;

2) promotion and extension of crop diversification particularly in lowland rice field; and

3) improvement and strengthening of extension services, especially for transfer of packaged farming information and technology, necessary actions on how to encourage the farmers for increase in crop production, and on how to promote the farmers' participation in crop diversification.

(2) Rehabilitation and Improvement of Agricultural Production Infrastructures

The rehabilitation and improvement of the existing agricultural production infrastructures should also have a high priority. The rehabilitation and grade-up of the existing project facilities, particularly irrigation and drainage system, are the basic requisite for increase and stabilisation of crop production.

As already mentioned, most of the existing project facilities need the rehabilitation including some improvement works, except for the dams and reservoirs. The facilities to be rehabilitated will be the irrigation and drainage system, farm road network and project buildings for both O&M woks and farming. The rehabilitation plan and preliminary design of the facilities should be prepared, taking into consideration the following :

1) Elimination or alleviation of constraints to smooth O&M of the existing system.
2) Expansion of project area in the light of the original plan, if any.
3) Maximum use of the existing facilities for cost-saving.
4) Easy operation and maintenance of the project facilities
5) Application of design discharge estimated in a logical manner
6) Soil erosion control measures for steep topography areas in connection with the drainage system

3.2.2 Basic Concept for Institutional Development

The objectives of the institutional development plan are to establish successful and sustainable O&M of irrigation facilities by the farmers themselves and improve farmers' crop production through the strengthening of agricultural support services. The major concepts to achieve these objectives are as follows :

1) Prior to the handing over of O&M, GIDA should be strengthened as its executing agency. For this strengthening, the number of staff and facilities necessary to implement handing over of O&M and support services to the farmers should be minimised as much as possible, taking into account the restructuring plan of GIDA.

2) The managing system of O&M and its supporting system by GIDA should be simplified in order to make the related activities efficiently and smoothly.

3) The implementing period of handing over should be set up to the Project, taking into account the actual situations of the societies' activities, farmers' ability and the experience of GIDA's front line staff.

4) The successful and sustainable O&M by the farmers needs a lot of support services from the various agencies concerned. The institutional plan should therefore be covered to improve and co-ordinate all these activities involved in O&M.

5) In order to ensure the sustainable O&M by the farmers, a farmers' participatory implementation should be adapted in the handing over plan of O&M, with the establishment of a monitoring system in the executing agency.

6) The strengthening of agricultural support services such as marketing and credits is also prerequisite factor as well as the rehabilitation of irrigation facilities. These support services should also be strengthen in order to achieve the final target of the Project.

7) The O&M by the farmers should be realistic and possible in financial view point. Within this in view, the O&M cost should be minimised as much as possible.

8) In order to arouse the farmer's sense of belonging and responsibility to the O&M of facilities, all lands in the project areas should be allocated permanently to the farmers, in accordance with L.I. 1350 of GIDA and traditional custom for land holding in the country.

3.3 Agricultural Development Plan

3.3.1 Proposed Crops and Cropping Pattern

(1) Proposed Crops

A variety of crops are already grown in the project areas, though continuous cultivation of one to two crops is seen in some of the projects. They are paddy rice, maize, cowpea and vegetables. The production of rice in Ghana still does not satisfy the increasing national demand. Maize and cowpea are food crop for the people, and vegetables are cultivated mostly for earning cash income. Basically, the crops to be proposed for the reactivated projects will therefore be selected from the present varieties of crops. Crop diversification is proposed particularly in lowland rice area. Details of the proposed crops for each of the projects are shown in Table A-23.

(2) Proposed Cropping Patterns

The main issues for preparation of cropping patterns to be proposed for the reactivated projects will be (i) full and effective use of existing farmland particularly in the rainy season, (ii) elimination or alleviation of crop damages due to continuous cultivation, and (iii) appropriate combination of food and cash crops to expect higher returns which result in the increase in farm income of the farmers.

The present cropping intensity is still low, 1.0 or less, in most of the projects, except for Weija, Akumadan and Tanoso projects. The proposed cropping patterns are therefore prepared so as to use fully the possible irrigable area delineated through the water balance study in both rainy and dry seasons. Consideration is also paid for elimination or alleviation of crop damages due to continuous cultivation as well as to ensure higher crop yields and qualified production, especially for tomato, pepper, egg plant and okra. It is recommended to cultivate these vegetables once in every three to four years.

In order to increase farm income, appropriate combination of a variety of crops is taken into consideration in preparing the proposed cropping patterns, particularly in the lowland rice cultivation areas such as Ashaiman, Aveyime, Bontanga and Okyereko projects.

The proposed cropping patterns thus prepared for each of the projects are presented in Figures A-15 to A-26.

3.3.2 Proposed Farming Practice

Land preparation should be made carefully for both lowland and upland crops. Since paddy rice will be sown directly, land preparation, particularly plowing, harrowing and land leveling, is important in order to ensure effective use of irrigation water and to assist weed control, and uniform germination and seeding growth. Careful land preparation will also be required for maize, cowpea and groundnut to ensure uniform germination and growth.

Weeding is also one of the important farming practices to expect higher crop yields. Manual weeding should be practiced especially when crops are at young growing stage, which will also be effective for control of the incidence of diseases and insect pests.

Harvest at optimum time is essential to reduce the field loss of products in cereals, legume crops and vegetables, particularly for paddy rice and cowpea which are easily fall down when they are over-ripened. Care should also be paid for harvesting time of vegetables to ensure qualified products.

The proposed application rate of fertiliser for main crops on N:P:K kg/ha basis, and compound and nitrogen on kg/ha basis are shown in Table A-24. The proposed split application time for main crops is also in Table A-25. In the first application, compound fertiliser will be applied as the basic fertiliser. In the second and third application, nitrogen fertiliser will be used as side dressing fertiliser. The proposed application rate of agro-chemicals such as insecticide, herbicide and rodenticide is shown in Table A-26.

3.3.3 Anticipated Crop Yield and Production

Anticipated crop yields in the reactivated projects would increase through introduction of improved irrigation farming, effective use of farm inputs as well as more intensive supporting services from IDC and other government institutes concerned. The anticipated yields of main crops are estimated as follows, based on the analysis of the present crop yields and data available from the institutes concerned.

Crop	Present Yield (ton/ha)	Anticipated Yield (ton/ha)
Paddy rice	4.5	5.5
Maize	2.6	3.0
Cowpea, groundnut	1.5	1.5
Tomato	8.2	15.0
Egg plant	12.8	15.0
Pepper	5.3	10.0
Okra	7.9	12.0
Onion	14.5	18.0
Tinda	14.6	18.0
Cluster bean	6.2	8.0

Anticipated crop production in each of the projects is estimated based on the proposed cropping area and anticipated crop yield, as shown in Table A-24.

3.3.4 Post-harvest, Agro-processing, Storage and Marketing

Drying floor is available in most of the projects where paddy rice is cultivated.

However, broken rice after threshing and milling is often seen in these projects, probably because of over-drying on the drying floor. In other projects where upland crops are cultivated, no drying floors are available, and the farmers have to bring the products to their houses. It is therefore recommended that drying floors be constructed in the projects where maize, cowpea and groundnut are proposed as the main crop.

Since the existing threshers and millers in the rice growing projects are generally deteriorated, they should be replaced by new ones. Because there are no factories being operated for processing of vegetables in and around the project areas, it is advisable to provide the floor with simple roof for selecting marketable products with good quality of tomato, egg plant, onion, okra, etc. Although some storage houses are available in most of the rice growing projects, no storages are provided in the projects where upland crops are mainly grown, and the farmers usually store the products in their houses. The storage house is required for these projects.

Presently, most of farm products are sold at farm gate to middlemen, market mammy in most case, in the projects. The market prices of farm products vary with the seasons as well as the location of markets. Particularly, the prices of cash crops such as vegetable fluctuate with the demand-supply situations and are the basic information in order to decide the crops and varieties to be planted, cropping area, crop calendar, and rotation patterns. Therefore, the market research is essential for marketing of farm products as well as farm inputs. Under the free market system, it is also essential to produce the products with good quality and appropriate quantity to meet the market requirements, and to ship constantly and/or timely every year according to the market situations. For these purposes, more active services by the existing farmers' societies will be required to control quality and quantity of products so that the farmers can negotiate with the middlemen on appropriate prices of products as well as of inputs through the societies.

3.4 Rehabilitation Plan of Project Facility

3.4.1 Irrigation Plan and Water Requirements

(1) Proposed irrigation method

Of the 12 projects, seven (7) projects of Weija, Amate, Kpando-Torkor, Mankessim, Akumadan, Tanoso and Subinja where upland crops are cultivated, are irrigated using the sprinkler system. The remaining five (5) projects where the main crop is paddy are of gravity type. In the former projects, a study is made on possibility for application of furrow irrigation. Application conditions of sprinkler and furrow irrigation are tabulated below :

	Description	Furrow Irrigation	Sprinkler Irrigation
1	Influence of topography	Large	No
2	Land reclamation	Needed	No
3	Soil condition (basic intake rate)	Less than 50 mm/hr.	No limitation
4	Application loss	Large	Less
5	Water management in field	Difficult	Easy
6	Influence of wind	No	Less than 5m/s
7	Soil erosion	High possibility	Less possibility
8	Need of labour for water supply	Large	Less

According to the results of cylinder intake rate test, Mankessim and Akumadan projects have a high basic intake rate, more than 50 mm/hr, and therefore application of furrow irrigation could not be recommended. Also in Amate, Kpando-Torkor, Tanoso and Subinja projects, it is difficult to apply furrow irrigation because of high possibility of soil erosion by steep land slope ranging from 1/30 to 1/50, when the present irrigated agriculture is intensified in the future.

Especially, it is remarked that Tanoso and Subinja projects do not allow large application loss from a viewpoint of effective use of limited water resource. Although it is possible to apply furrow irrigation for Weija project in terms of its topography and soil condition, the project is presently well operated using sprinkler system, and any problem is not found in the use of sprinkler system, except its deterioration. From these findings and study results, sprinkler system is recommended to be applied for these seven projects as they are.

(2) Irrigation Water Requirements

1) Proposed cropping patterns

The proposed cropping patterns under the "with-project" condition for respective projects which are discussed in Sub-section 3.3.1 are presented in Figures A-15 to A-26.

2) Estimation of reference evapo-transpiration (ETo)

There are many methods to estimate crop evapotranspiration. Among them, the modified Penman method is proposed for this study, since it is likely to provide the most satisfactory results and is adopted for many projects in estimating the reference crop evapotranspiration. The modified Penman equation is as follows :

$$ETo = C \times \{W \times Rn + (1-W) \times F(u) \times (ea - ed)\}$$

where,

ETo	:	Reference crop evapotranspiration in mm/day
W	:	Temperature-related weightage factor
Rn	:	Net radiation in equivalent evaporation in mm/day
F(u)	:	Wind-related factor
(ea-ed)	:	Difference between the saturation vapor pressure at mean air temperature and the mean actual vapor pressure of the air, both in m bar, and
C	:	Adjustment factor to compensate for the effect of day and night weather conditions

Details are described in FAO Irrigation and Drainage Paper No.24. Table A-27 shows the potential evapotranspiration (ETo) calculated using the above equation and the meteorological data at respective sites discussed in Sub-section 2.2.1. In addition, ETo estimated by the Blaney-Criddle is also given in the same table for reference. ETo estimated by the modified Penman method is slightly higher than that by the Blaney-Criddle. The monthly ETo for respective projects is summarised below :

(Unit : mm)

Project	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1 Ashaiman	155	151	174	165	158	123	121	127	138	161	156	146	1,775
2 Weija	158	160	180	174	158	129	133	146	153	164	153	149	1,857
3 Amate	127	123	140	135	136	105	96	102	105	124	123	121	1,437
4 Afife	155	157	180	168	158	132	133	136	150	171	162	152	1,854
5 Aveyime	143	148	167	153	146	117	121	127	126	140	135	130	1,653
6 Kpando-Torkor	149	143	158	150	146	117	112	112	117	140	144	136	1,623
7 Mankessim	136	134	155	147	143	114	112	109	117	143	141	130	1,580
8 Akumadan	164	168	180	159	152	126	118	118	114	127	135	136	1,697
9 Tanoso	164	168	180	159	152	126	118	118	114	127	135	136	1,697
10 Bontanga	211	216	233	201	186	147	140	130	129	161	132	186	2,071
11 Subinja	164	168	180	159	152	126	118	118	114	127	135	136	1,697
12 Okyereko	136	134	155	147	143	114	112	109	117	143	141	130	1,580

3) Consumptive use by crop

The consumptive use of water by crops is estimated as a product of the reference crop evapotranspiration (ETo) and crop coefficient (Kc) at a given growing stage. The crop coefficients of respective crops are determined with reference to the FAO Irrigation and Drainage Paper No.24 as shown in Table A-28.

4) Deep percolation loss and intake rate

In this study, deep percolation loss in paddy field is assumed to be 1.3 mm/day which was obtained through field tests by IDC. The intake rate measurements were executed at respective sites, the results of which are discussed in Attachment. The average basic intake rates are given below :

- Ashaiman	: 10.8 mm/hr.
- Weija	: 7.1 mm/hr.
- Akumadan	: 278.4 mm/hr.
- Kpando-Torkor	: 19.3 mm/hr.
- Mankessim	: 58.4 mm/hr.
- Subinja	: 13.8 mm/hr.
- Tanoso	: 35.3 mm/hr.
- Bontanga	: 11.1 mm/hr.

These basic intake rates are used for determination of irrigation intensity by sprinkler irrigation.

5) Puddling water and pre-irrigation requirements

Puddling water requirement depends on soil type, moisture content, ground water table, etc., and varies from season to season, and place to place. In this study, the puddling water requirement is assumed to be 200 mm. Pre-irrigation requirement for upland crops is to be 60 mm.

6) Effective rainfall

Effective rainfall varies with rainfall intensity and distribution, permeability and water holding capacity of soils, amount of irrigation water supply, irrigation management practices, type of field plot and topography of land, etc. In this study, the effective rainfall in paddy field and upland is separately calculated as explained in the following paragraph :

(a) Paddy field

The effective rainfall in paddy field is separately calculated on the basis of the daily water balance using daily rainfall data determined in Sub-section 2.2.3. A daily balance study is made on the following assumption :

- Ineffective rainfall	: less than 5 mm/day
- Maximum depth of tank	: 150 mm
- Minimum depth of tank	: 50 mm

Based on the results of the daily water balance, correlation between the 10-day rainfall and effective rainfall is estimated for the purpose of calculating the long term assessment as shown in Figure A-32. The relation can be expressed as follows :

Project		T1(mm)	T2 (mm)	R10 < T1	T1 < R10 < T2	R10 > 150
1	Ashaiman	15	156	ER10=0	ER10=0.9R10	Er10=140
2	Afife	10	156	ER10=0	ER10=0.9R10	Er10=140
3	Aveyime	10	167	ER10=0	ER10=0.9R10	Er10=150
4	Bontanga	15	122	ER10=0	ER10=0.9R10	Er10=110
5	Okyereko	15	156	ER10=0	ER10=0.9R10	Er10=140

Note : ER10 : 10-day effective rainfall in mm, R10: 10-day rainfall in mm

(b) Upland

The U.S.Department of Agriculture Soil Conservation Service has developed a procedure for estimating effective rainfall by processing long term climatic and soil moisture data from 50 years of rainfall records at 22 experimental stations. A daily balance in the soil profile is carried out, and the following relationship is derived from monthly rainfall and crop consumptive use.

$$ER = 0.2 \times R^{0.95} \times Cu^{0.31}$$

Where,
ER : Effective rainfall in mm
R : Rainfall in mm
Cu : Crop water requirement in mm

The effective rainfall should not exceed consumptive use by crop. Therefore, the lower value should be either the calculated ER or Cu.

7) Irrigation efficiency

Overall irrigation efficiency is made up of farm application, conveyance and operation losses and varies depending on soil conditions, type of canal regulating structures, water management practices, etc. Generally, the irrigation efficiency in the rainy season seems to be lower than that in the dry season, because it is difficult to operate the regulating facilities quickly to respond to unfavourable rainfall events. However, due to the difficulties to evaluate difference in the dry and rainy seasons, irrigation efficiency is uniformly applied throughout the year in this study.

As mentioned in Attachment, canal seepage rate measurements were carried out in four (4) projects such as Ashaiman, Afife, Bontanga and Okyereko for which gravity irrigation is applied. Out of them, lined canals show 0.85 lit/s/1000 m^2 to 4.61 lit/s/1000 m^2 of seepage rate, and then canal conveyance loss is roughly calculated to be 0.6 % to 4 % of design discharge. Taking into consideration these results and size of canal, conveyance efficiency for main canal and lateral is assumed to be 10 %, respectively. In addition, conveyance loss of pipeline and field application loss for paddy field and upland crop field are assumed as follows, considering soil condition and water distribution method :

Irrigation Efficiency	Paddy	Upland Crops	
		Furrow/basin	Sprinkler
Delivery efficiency	81 %	81 %	90 %
Main canal	(90 %)	(90 %)	(95 %)*
Lateral/sub-lateral	(90 %)	(90 %)	(95 %)*
Application efficiency	75 %	60 %	80 %
Overall efficiency	61 %	49 %	72 %
Proposed efficiency	60 %	50 %	70 %

* : Pipeline

8) Irrigation water requirement

The irrigation water requirements for respective projects are calculated for 10-day period using the rainfall data as discussed in Sub-section 2.2.3. Table A-29 shows 80 % probable water requirements on 10-day basis for respective projects.

(3) Proposed Irrigation System

1) Paddy

(a) Water supply method

Of the 12 projects, five (5) projects of Ashaiman, Afife, Aveyime, Bontanga and Okyereko are mainly cultivated with paddy. Irrigation water is supplied to each field by gravity system after intake. At present, it is reported that continuous supply of irrigation water is practiced in Ashaiman project and that irrigation water supply in the remaining four projects is made intermittently. However, water demand is not calculated logically as mentioned previously, and also water supply is not made based on reasonable irrigation calendar.

Except Aveyime, other projects have rather limited water resources. Although Aveyime project has rich water resource, irrigation water is tapped using pumps. This means that water supply should be made carefully to minimize water loss for efficient pump operations. In case of limited water resource, rotational irrigation is sometimes employed, but it requires some conditions such as definite irrigation calendar and active water users association, especially for open canal network. If conditions are not matured, it would bring about more water loss and thus water conflicts among farmers, too.

Water supply system should be simple. Taking into account the present situations surrounding the projects, it is proposed to apply the continuous water supply method, but the rotational water supply is executed at puddling time.

(b) Irrigation system

The irrigation system for four (4) projects for gravity irrigation, except Afife, consists of intake facilities, main canal and lateral canal. One lateral canal covers about 5 ha of land. The system for Afife project is composed of intake facilities, main canal, lateral canal and sub-lateral canal because of its larger command area. This system will be used as it is. In Aveyime project, however, a farm pond will be provided after pump facilities, to adjust discharge at off-peak time.

2) Upland crops

(a) Water supply amount at one time

Water supply amount at one time is calculated on the following assumptions in this study :

- Effective root depth : 30 cm
- Soil moisture extraction pattern : Standard type (4 layers of 75 mm each)
- Available moisture : 20 %

From these assumptions, Total Readily Available Moisture (TRAM) is calculated to be 40 mm which correspond to water amount at one time.

(b) Irrigation interval

Daily consumptive use is computed to be 6 mm/day in Weija project. With this daily consumption and TRAM mentioned above, irrigation interval is calculated at 6 days.

(c) Sprinkler system

In this study, the following sprinkler system is proposed, taking into consideration the existing system, easy operation, topographic condition, soil condition, etc. :

- Semi-permanent system
- Arborescent pipeline system (galvanized steel pipe)
- Intermediate sprinkler
- Extent of sprinkling (18 m x 18 m)

Typical sprinkler system is given in Figure A-33.

(4) Proposed Irrigation Plan

The irrigation plans for respective projects are prepared based on the preliminary study results as shown in Table A-30. The preliminary irrigation distribution diagrams for the potential area of respective projects are given in Figure A-34.

3.4.2 Delineation of Project Area through Water Balance Study

(1) Water Balance Study

A water balance study is made for each of Ashaiman, Afife, Mankessim, Akumadan, Tanoso, Bontanga, Subinja and Okyereko where available water resources are limited to serve potential irrigable area. Then, water balance study is carried out under the following conditions :

- A water balance calculation is executed on 10-day basis.
- A water level in the reservoir is full water level when calculation is commenced.
- Equation of water balance study is expressed as follows :

$$Q_S = Q_{S1} + Q_{in} - Q_{out} - Q_{ep} - Q_s - Q_l$$

where,

Q_s	: Storage volume (m^3)
Q_{S1}	: Storage volume in previous 10 days (m^3)
Q_{in}	: Inflow to reservoir (m^3)
Q_{out}	: Water release for irrigation (m^3)
Q_{ep}	: Evaporation (m^3)
Q_s	: Spilled discharge (m^3)
Q_l	: Other losses (m^3)

(2) Delineation of Project Area

The results of water balance study thus obtained are used for probability analysis to delineate the possible irrigable area with 80 % irrigation dependability in each of the projects, as shown below :

Project		Potential Area (ha)	Developed Area (ha)	Possible Irrigable Area (ha)
1	Ashaiman	148	130	44
2	Weija	220	220	220
3	Amate	203	101	203
4	Afife	880	880	535
5	Aveyime	150	63	150
6	Kpando-Torkor	356	40	356
7	Mankessim	256	17	176
8	Akumadan	65	65	31
9	Tanoso	115	64	30
10	Bontanga	450	450	450
11	Subinja	121	60	70
12	Okyereko	111	40	111
	Total	3,075	2,130	2,376

3.4.3 Alternative Plan

As for Mankessim and Okyereko projects, there are alternative irrigation plans as mentioned below :

(1) Mankessim Project

According to the original plan, Mankessim project is planned to be developed for both paddy and upland crops cultivation. Total potential area covering 256 ha of land is classified into 80 ha for paddy and 176 ha for upland crops, respectively. In the original plan, paddy field is located at lowland area along the Ochi river. Presently, this lowland area is severely inundated about one (1) meter high every year by flood from the Ochi river. Flood analysis of the river indicates that 255 m^3/s of flood would attack the river with a once in 10 years probability. Judging from the cross section of the river near the area, this flood would bring more than two (2) meters of inundation in the lowland area. In order to protect the area from the flood, a flood protection dyke is considered as one of the countermeasures. It would need about US$ 340,000 of investment, equivalent to US$ 1,330/ha. When paddy is cultivated in this area, in addition, total irrigable area of the project would be restricted to 115 ha instead of 256 ha of potential land, according to water balance study. From such study results, it is proposed that this lowland area be excluded from the project area and that the project rehabilitation should be made, aiming at cultivation of upland crops which would be more profitable than rice.

(2) Okyereko Project

Okyereko project was developed for cultivating paddy in 111 ha of command area. Since its water resource is Okyereko reservoir fed by rainfall only, the irrigated area is severely restricted at present. In fact, the irrigated area in the past five years from 1991 to 1995 ranges from 7.3 ha to 30.9 ha and averages 21.6 ha only. In addition, water balance study also shows that irrigable area with 80 % irrigation dependability would only be 11 ha, out of 111 ha. GIDA has already been aware of this water shortage, and has a plan to provide the supplemental water source by installing pumps on the Ayensu river which is located near the project. Then, the study of an alternative plan is made so as to include new pump station in the proposed rehabilitation work of this project.

3.4.4 Irrigation Facility

For the purpose of selecting the priority projects, the rehabilitation plan of existing

project facilities is prepared based on the results of inventory survey and irrigation plan mentioned above. Rehabilitation plan for respective projects which is given in Table A-31 is summarised below, although these plans for the selected priority projects should further be studied at the next stage.

(1) Ashaiman Project

According to water balance study, there would be no spilling water from the dam, when 44 ha of land are covered with paddy. Even if the storage capacity of the reservoir is increased by heightening the crest elevation of spillway or dam, in addition, the increased amount of water would be consumed mostly by evaporation due to increase in water surface area in the reservoir. From these, the heightening of spillway or dam crest will not be proposed. Since dam itself is in good condition, no rehabilitation will be required. As for improvement of existing intake valve, a new valve is proposed to be installed at the outlet of the existing conduit, considering the life time of existing conduit and easy construction. Although the estimated irrigable area would be restricted to 44 ha of land, this project has various facilities not only for irrigation but for agricultural research activities under the guidance of the IDC. In addition, it is strongly expected that the IDC should play more important role in strengthening the research activities for improving irrigation farming and its training to the extension offices as well as farmers in the irrigation projects. Besides, the existing project facilities are already provided so as to serve the whole developed area, that is 130 ha. Because all irrigation canals and related structures are severely damaged, these facilities will therefore be rehabilitated totally. Main canals and laterals are proposed to be lined with concrete mainly for easy maintenance. Canal layout will follow the existing one without any modification.

(2) Weija Project

At present, there are two (2) intake pumps and four (4) booster pumps for irrigating 220 ha of land. These pumps which were installed in 1983 are often out of order mainly due to difficulty in procurement of spareparts and troubles in electric facility. These are proposed to be replaced by new ones. Main canal is in good condition and requires partial repairs only. All pipes and sprinklers are proposed to be replaced by new ones due to water leakage. Layout of pipeline will leave as it is, because there have not found any problem in it.

(3) Amate and Kpando-Torkor Projects

All pumps, pipes and sprinklers are highly deteriorated. These are therefore proposed to be replaced by new ones. In connection with replacement of pumps, those for Kpando-Torkor project will be electrified to lower the operation cost as well as for easy operation. But for Amate project, they will be of engine-driven type, because no electricity supply line exists nearby. For both projects, consideration is also paid for stable supply of irrigation water regardless of the fluctuation of water level in the Volta lake as shown in Figure A-35. It is then proposed that a set of pump and motor should be mounted on movable stand and be moved on the sloped concrete slab, according to fluctuation of water level. A delivery pipe will be installed on the sloped slab and be equipped with hydrants in proper interval, to which pump delivery pipe will be connected. The project area will be divided into two to three blocks, and each of them will be served by one complete set of pump, pipeline and sprinkler system, instead of commanding the whole project area by one large-scale pump set, in order to avoid the risk in case of out-of-order of the facility.

(4) Afife Project

No rehabilitation will be made for dam, but intake gate will have to be repaired to eliminate water leakage. As for the canal system, main canal will leave as it is, but measuring

devices such as broad crested weir and parshall flume should be installed for efficient water management. Laterals will be partially repaired, and sub-laterals should be totally re-shaped.

(5) Aveyime Project

Because pump, main canal, laterals and related structures are seriously damaged, no irrigation services were provided in 1995. These irrigation facilities should be rehabilitated. In connection with the rehabilitation of these facilities, a farm pond will be proposed to be provided after intake by pump in order to adjust in-flow and out-flow of irrigation water. Canal layout will be worked out, following the existing one.

(6) Mankessim Project

Out of 176 ha of project area excluding 80 ha to be developed for rice cultivation, the project has developed only 17 ha of land so far. Therefore, the required facilities will newly be provided so as to serve 176 ha of project area. Dam itself will be left as it is, but a bridge on spillway will have to be constructed. There are two intake gates on both banks of the dam. Since the right intake gate is installed at higher position, water could not be tapped effectively from dam. It is therefore proposed to connect the both after intakes.

(7) Akumadan, Tanoso and Subinja Projects

The existing weir in Akumadan project will be replaced by new one with bridge and crossing pipe for easy operations of both right and left bank pumps. The bridge will also be used for transportation of the inhabitants. Weir for Subinja project will be renewed, since the existing one is severely damaged, but that for Tanoso project is left as it is. All pumps, pipes and sprinklers will be replaced by new ones because of serious deterioration.

(8) Bontanga Project

Intake gates, laterals and related structures such as turnout, check and measuring device will be repaired, but others will not require any rehabilitation work.

(9) Okyereko Project

Dam and spillway will be as they are, but main canal, laterals and related structures will totally be rehabilitated because of severe damages. In order to supply water to the reservoir from the Ayensu river located nearby, it is proposed to construct a pump facility including electric supply line, delivery pipe and pump station as mentioned above. Typical sections of the lined canal and flume are given in Figure A-36.

3.4.5 Drainage Plan and Drainage Requirements

(1) Proposed Drainage System

There are existing drainage systems in six (6) projects such as Ashaiman, Weija, Afife, Aveyime, Bontanga and Okyereko. These drainage systems do not function well at present due to much sedimentation and grasses as mentioned in Sub-section 2.5.3. If maintenance works such as removal of sedimentation and grasses are carried out properly, these drainage systems, except those in Afife and Bontanga projects, will serve as originally designed, because there is no any constraint to smooth evacuation of excess water from farmland. The light salinity concentration observed in Ashaiman, Aveyime and Okyereko could also be settled by proper

execution of such maintenance works. In order to maintain the drainage canals, it is proposed to procure some O & M equipment such as backhoe and grass cutter.

Afife project is presently suffered from backwater effect due to lagoon during rainy season. Although drainage gates are provided at tail portion of the drainage system in order to avoid the intrusion of excess water from outside area, mechanical drainage system is required when outside water level becomes higher. According to the field investigation and interview with the project in-charge, inundation would occur in two blocks, i.e. Block 10 and Block 11 every year by backwater from outside area. On the other hand, a water balance study shows that only about a half of 880 ha of land already developed could be irrigated throughout the year with 80 % dependability as discussed in Section 4. In fact, it is found that presently cultivated areas are nearly the same as those in the results of the above study. From these study results, it is proposed that these inundated two blocks will be left as it is, without provision of any project facility, which could be used as retarding areas.

In the rainy season, the downstream lowland area in Bontanga project which is cultivated with paddy, is inundated for about one week by backwater from the branch of the White Volta river. Because the inundation situation is not so severe, it is proposed only to install a gated culvert and flood protection dyke in and along the main drain so as to protect this area from the backwater effect. This main drain is used not only for drain of excess water from farmland but for spilling water from the dam, and proper dam operation is required to minimize the spilled water from the dam.

Weija project is suffering from flooding from the natural river which flows along the project area. According to the flood analysis of this river, a 25-year probable flood is estimated at 62 m^3/s. Taking into consideration the scale of river, river morphology, land use of riparian area, it is proposed to construct a flood protection dyke of 2 km long.

In the upland irrigation projects such as Amate, Kpando-Torkor, Mankessim, Akumadan, Tanoso and Subinja, there is no existing drainage system because of steep and undulated topography. It is likely that severe soil erosion will occur in these projects as mentioned in Sub-section 2.9.2. It is therefore proposed to provide proper drainage system consisting of intercepting drain and collector drain, in connection with soil erosion control measures.

(2) Rainfall Analysis

In order to estimate the drainage requirements for respective projects, daily rainfall data to be used are determined through probability analysis as shown below :

(Unit : mm)

	Project	Observation Site	Observation Period	Probable Rainfall					
				Daily Rainfall			3-days Conse. Rainfall		
				2 yrs	5 yrs	10 yrs	2 yrs	5 yrs	10 yrs
1	Ashaiman	Tema	1985 - 1993	68	87	99	78	101	120
2	Weija	Weija	1985 -1993	76	99	116	100	140	172
3	Amate	Koforidua	1985 - 1990	89	116	133	115	143	159
			1991 - 1994						
4	Afife	Afife-Weta	1980 - 1982	72	98	118	88	134	170
			1986						
			1989 - 1994						
5	Avcyime	Akuse	1980 - 1982	69	85	95	86	114	137
			1984 - 1991						
			1994						
6	Kpando-Torkor	Kpando	1985 - 1994	87	124	153	121	172	216
7	Mankessim	Saltpond	1985 - 1994	106	138	155	127	162	183
8	Akumadan	Wenchi	1985 - 1994	86	116	135	104	129	145
9	Tanoso	Wenchi	1985 - 1994	86	116	135	104	129	145
10	Bontanga	Tamale	1981 - 1990	87	111	126	104	140	165
11	Subinja	Wenchi	1985 - 1994	86	116	135	104	129	145
12	Okyereko	Saltpond	1985 - 1994	106	138	155	127	162	183

(3) Estimate of Drainage Requirements

1) General

The drainage system is designed based on need to remove excess irrigation and rainfall water from the fields. Drainage requirements are estimated for the following cases :

- Internal drains for paddy field
- Internal drain for upland crop field
- Natural streams

2) Paddy field

The drainage requirements for internal drain are calculated through a simple water balance calculation under the following conditions :

- Initial depth of water on fields: 50 mm
- Design rainfall : 3-days consecutive rainfall with 1 in 10 year probability
- Allowable submergence depth : 150 mm

The water balance calculation is made using the following equation :

$$Hu = 50 + (Rd \times t)/3.0 - Qd \times t \times 8.64 \quad \text{for } t \leq 3 \text{ days}$$
$$Hd = 50 + Rd - Qd \times t \times 8.64 \quad \text{for } t > 3 \text{ days}$$

where,

Hu : Submergence depth of water for 3 days (mm)
Hd : Submergence depth of water from 4th day (mm)
Rd : Design rainfall (mm)
Qd : Drainage requirement (lit/s/ha)
t : Period (day)

The calculation procedure and results are given in Figures A-37 to A-41. Drainage requirements for the corresponding projects are tabulated below :

- Ashaiman project : 1.0 lit/s/ha
- Afife project : 2.5 lit/s/ha
- Aveyime project : 1.5 lit/s/ha
- Okyereko project : 3.0 lit/s/ha
- Bontanga project : 2.5 lit/s/ha

3) Upland crops field

In this study, drainage water requirements are estimated using the 10-year probable daily rainfall and the MacMath equation which is similar to the rational equation. In the use of this equation, rate of hourly rainfall is derived from the said daily rainfall data using the "Maximum Rainfall Intensity-Duration Frequencies in Ghana", Ghana Meteorological Services Department, Departmental Note No.23. Runoff coefficients for respective projects are determined from vegetation, soils and topography. Study results are given in Table A-32 and are summarised below :

- Weija : $Qd = 0.104\ A^{4/5}$
- Amate : $Qd = 0.138\ A^{4/5}$
- Kpando-Torkor : $Qd = 0.159\ A^{4/5}$
- Mankessim : $Qd = 0.131\ A^{4/5}$
- Akumadan : $Qd = 0.147\ A^{4/5}$
- Tanoso : $Qd = 0.147\ A^{4/5}$
- Subinja : $Qd = 0.147\ A^{4/5}$

Where,
Qd : Drainage discharge (m3/s)
A : Drainage area (ha)

(3) Natural Streams

Drainage requirements for natural streams related to the projects are discussed in Sub-section 2.2.4.

(4) Proposed Drainage Plan

The drainage plan for respective projects is summarised in Table A-33. The preliminary drainage diagram for respective projects are shown in Figure A-42.

3.4.6 Drainage Facility

As mentioned above, drainage facilities are provided only for six (6) projects such as Ashaiman, Weija, Afife, Aveyime, Bontanga and Okyereko. These facilities do not function properly due to much sedimentation and grasses. It is therefore essential to remove them and to keep the steady maintenance work.

In Bontanga project, a gated drainage culvert and flood protection dyke are proposed to avoid water stagnant in the lowland area due to backwater from the branch of White Volta river.

Weija project is suffering from inundation by overtopping from the drainage river flowing along the project area. In order to protect part of project area from inundation, it is proposed to construct a flood protection dyke, about 2 km in length.

In upland irrigation projects such as Amate, Kpando-Torkor, Akumadan, Tanoso, Subinja , intercepting drains and collector drains are proposed in connection with soil erosion

control measures as mentioned in Sub-section 3.7.2. Intercepting drain will generally be provided in the same direction along contour line, and be connected with collector drain. As collector drain will run crossing contour line, it will be lined with concrete to avoid erosion of inside surface of canal and to minimize canal flow section.

Rehabilitation plan of drainage facility is shown in Table A-31. Typical cross section of drain is given in Figure A-36.

3.4.7 Farm Road Network

All farm roads are generally poor and will require improvement works for proper operation and maintenance of the project facilities and for conveyance of agricultural products. The road surface will be smoothened after grass cutting, and be paved with gravel for main road and with laterite for lateral road. A preliminary estimated length of each road to be improved would be as follows :

	Project	Main Road (m)	Lateral Road (m)	Total (m)
1	Ashaiman	5,000	11,000	16,000
2	Weija	0	14,000	14,000
3	Amate	2,000	15,000	17,000
4	Afife	9,000	25,000	34,000
5	Aveyime	7,000	7,000	14,000
6	Kpando-Torkor	2,000	27,000	29,000
7	Mankessim	3,000	12,000	15,000
8	Akumadan	3,000	6,000	9,000
9	Tanoso	2,000	4,000	6,000
10	Bontanga	17,000	19,000	36,000
11	Subinja	3,000	8,000	11,000
12	Okyereko	2,500	4,500	7,000

3.4.8 Buildings and Related Facility

The buildings and related facility required for respective projects are listed in Table A-31, and are briefly explained below :

(1) O & M Office

The project offices, except for those in Ashaiman, Weija and Bontanga projects, are so poor. These offices are therefore proposed to be totally replaced by new ones. A new O & M office should be designed, taking into account the farmers' participation in the project operations.

(2) Pump House

The existing pump houses, except Weija project, are in poor condition. In addition, all pump facilities also need replacement due to deterioration. From these situations, it is proposed to replace them with new ones. Especially, a pump house for Subinja project should be constructed at the suitable site free from flood from the Subin river.

(3) Post-harvesting Facility

Post-harvesting facilities such as store house, sorter house, dry yard and garage are not sufficient in most of the projects. The required number of these facilities, which are preliminary estimated from the proposed crops and anticipated crop production, is tabulated below :

	Project	Store House	Sorter House	Dry Yard	Garage
1	Ashaiman	Not need	1 No.(300 m2)	Not need	Not need
2	Weija	1 No.(200m2)	2 Nos.(600 m2)	Not need	Not need
3	Amate	2 Nos.(400m2)	2 Nos.(600 m2)	Not need	1 No.(300 m2)
4	Afife	Not need	Not need	10 Nos.(3000 m2)	1 No.(300 m2)
5	Aveyime	1 No.(200m2)	1 No.(300 m2)	1 No.(300 m2)	1 No.(300 m2)
6	Kpando-Torkor	1 No.(200m2)	4 Nos.(1200 m2)	Not need	1 No.(300 m2)
7	Mankessim	3 Nos.(600m2)	3 Nos.(900 m2)	Not need	1 No.(300 m2)
8	Akumadan	3 Nos.(600m2)	1 No.(300 m2)	Not need	1 No.(300 m2)
9	Tanoso	1 No.(200m2)	1 No.(300 m2)	Not need	1 No.(300 m2)
10	Bontanga	5 Nos.(1000m2)	5 Nos.(1500 m2)	5 Nos.(1500 m2)	Not need
11	Subinja	2 Nos.(400m2)	1 No.(300 m2)	Not need	1 No.(300 m2)
12	Okyereko	2 Nos.(400m2)	Not need	1 No.(300 m2)	1 No.(300 m2)

3.5 Water Management and O & M of Project Facility

3.5.1 General

At present, water management activities for all the projects do not reach the satisfactory level. The constraints to the proper water management activities which have been found through field investigation, are (i) unclear responsibility between GIDA and farmers' organisation, (ii) lack of experience of the staff, (iii) lack of basic data, (iv) no proper measuring devices, (v) poor conditions of the project facility, and (vi) insufficient activities of water users association. It is essential to eliminate these constraints for successful operation and management of the projects after rehabilitation of the project facilities. Since basic institutional development plan for proper water management and O & M works including staffing required is discussed in Sub-section 3.6.6, the discussion on this matter in this Section is made from technical point of view, as mentioned below :

3.5.2 Water Management

Water management activities are largely divided into two portions; one is to prepare and determine a proper water delivery and application programme, and the other is to execute the water supply in line with this programme. In this Sub-section, the former issue, which is regarded as "software" in water management action, is discussed and the latter issue in the next Sub-section.

In general, a water delivery and application programme is prepared based on the various data and information, because it should be well-fitted to the local and current conditions. As mentioned in Sub-section 2.5.5, however, no basic data and information are available for preparation of water delivery and application programme in the projects, except Ashaiman project. Even in Ashaiman project, these are still limited. Thus, water supply to each farm plot is presently made on the farmers' demand basis only, and any logical water supply is not made. In order to improve this situation and to realize effective water use, such data and information as listed below should at first be prepared and/or collected.

- Detailed topographic maps (1/1000 or 1/2000) showing canal routes, field ridges, road, etc.
- Detailed soil maps (1/1000 or 1/2000)
- Cropping patterns and cropped areas
- Available water sources
- Physical conditions of soils such as water holding capacity, basic intake rate,etc.
- Meteorological data such as rainfall, temperature, related humidity, sunshine, wind speed.
- Canal conveyance loss

- H-Q curve for each measuring device

In order to collect data and information, it is proposed that IDC should provide technical assistance for all the projects.

Irrigation requirements for respective projects which are very important factor for preparation of water delivery and application programme are estimated using the same procedure as mentioned in Sub-section 3.4.1.

In water management, another important issue is to monitor, analyse and evaluate the actual activities, and to reflect the results on the water delivery and application programme in the next year. Hence, staffing and organisation should be ensured for effective execution of a monitoring activity. Details of monitoring work are described in Sub-section 3.6.2.

3.5.3 O & M of Project Facility

(1) Operation of Project Facility

Operation of the project facility in irrigation project means the execution of water management programme mentioned above. It includes activation of pumps and gates so that the desired discharge can be supplied at the appropriate time, which is considered as the "hardware " of the water management action.

In this study, a continuous water supply method is proposed for paddy except puddling time, and a rotational one for upland crops, though further study should be made on the selected priority projects at the next stage. At puddling time for paddy field, a rotational water supply method will be applied for mitigating peak demand and farm labour force. In water supply for upland crops, water supply amount of 40 mm and irrigation interval of 6 days are provisionally employed for selection of the priority projects, as discussed in Sub-section 3.4.1.

In the continuous water supply method, supply amount will be regulated by opening and closing the gates in the light of water delivery and application programme. To simplify the gate operations, a measuring device is indispensable, and it should be provided for respective projects, if not available at present.

Water supply for upland crops will be conducted using pipes and sprinkler system. The water supply amount will be controlled by time. Therefore, moving and setting of lateral pipes and sprinklers should smoothly be executed in line with water delivery and application programme. In this study, irrigation time at one time is calculated to be three (3) hours based on one time water supply amount and basic intake rate measured at field.

(2) Maintenance of Project Facility

In parallel with proper operation, suitable and continuous maintenance of the project facility is indispensable to secure proper and stable function of the facility as well as to ensure the realization of economic life of the facility. The maintenance work broadly consists of :

- regular maintenance work which is carried out regularly to maintain and improve the project facility,
- periodic maintenance work including repair of minor damages,
- emergency repair work which is conducted to repair the occasional damages of the project facility caused by flood, heavy rainfall or other causes, and
- annual maintenance which involves a large work quantity or requires special skill.

The maintenance work at the project level is briefly explained as follows :

1) Regular maintenance

Regular maintenance refers to the day-to-day maintenance of the project facility. It includes routing repair of pumps, pipes, embankment, measuring device, weeding , filling of holes on the inspection roads with earth and gravels, oiling of gates, etc. Satisfactory implementation requires an intensive daily inspection of the project facility.

2) Periodic maintenance

Periodic maintenance is defined as repair of minor damages which do not cause immediate danger or malfunction to the water supply system. However, the periodic maintenance work should be carried out by skilled workers and mechanics in order to protect the system from further damages. Minor improvements of the water supply system are also included in this periodic maintenance.

3) Emergency repair

Damages to the project facility will hamper the normal practices of irrigation. Therefore, repair of damaged facility should quickly and effectively be carried out under the category of the emergency repair. Since the damage is not predictable either with respect to the time of occurrence or to scale of damage, the agency concerned should always be ready to confront the occurrence of damage. The damages to the project facility may be resulted from (a) flood, (b) heavy rainfall, (c) careless operations of the facility, (d) violation acts, and (e) destruction by animals and vehicles.

4) Annual maintenance

Maintenance work which involves a large work quantities or requires special skill should be carried out under the category of annual maintenance. This maintenance work may be executed by the contractor(s) to be selected through open tendering.

3.5.4 O & M Equipment

In order to operate and maintain the projects satisfactorily, the following O & M equipment is tentatively proposed for the purpose of selecting the priority projects through economic evaluation, although further study will be made for the selected priority projects.

Project	Vehicle (4 x 4)	Tractor(45 Hp)	Backhoe (0.3m3)	Grass cutters	Radio-Communi.
1 Ashaiman	1 No.	1 No.	1 No.	3 Nos.	1 Set
2 Weija	1 No.	1 No.	1 No.	3 Nos.	1 Set
3 Amate	1 No.	1 No.	-	4 Nos.	1 Set
4 Afife	2 Nos.	3 Nos.	1 No.	8 Nos.	1 Set
5 Aveyime	1 No.	1 No.	-	3 Nos.	1 Set
6 Kpando-Torkor	1 No.	1 No.	-	4 Nos.	1 Set
7 Mankessim	1 No.	1 No.	-	3 Nos.	1 Set
8 Akumadan	1 No.	1 No.	-	2 Nos.	1 Set
9 Tanoso	1 No.	1 No.	-	2 Nos.	1 Set
10 Bontanga	1 No.	2 Nos.	1 No.	4 Nos.	1 Set
11 Subinja	1 No.	1 No.	-	3 Nos.	1 Set
12 Okyereko	1 No.	1 No.	1 No.	3 Nos.	1 Set

The equipment necessary for extension services is mentioned in Sub-section 3.6.4.

3.6 Institutional Improvement Plan

3.6.1 Organisations for Project Executing Agencies

The implementation of the Project is divided into three stages; (i) rehabilitation works, (ii) handing over of O&M, and (iii) O&M by the farmers. The organisations of executing agencies of the former (i) and (ii) are proposed as follows, and the letter is described in Sub-section 3.6.3.

(1) Executing Agency for Rehabilitation Works

GIDA under the Ministry of Food and Agriculture (MOFA) would be the executing agency for the rehabilitation of irrigation projects. GIDA would co-ordinate all activities of the relevant Government agencies and regional administrative organisations in connection with the projects implementation. The Department of Project Development under the GIDA would have direct responsibility for the project implementation including both the engineering and the construction works. The Regional and PM offices would manage and co-ordinate the construction of the Project at the district level on behalf of the Department of Project Development. The main tasks of GIDA and these offices would be listed as below.

1) Financial arrangements needed for the engineering and construction works of the Project.
2) Design and construction supervision of all the implementation works.
3) Co-ordination between the Government authorities concerned with implementation of the Project.
4) Personnel arrangements for staff to be required during the detailed design and construction stage.
5) Land acquisition
6) Progress and quality controls of the rehabilitation (construction) works
7) Preparation of O&M manual

(2) Executing Agency for Handing Over of O&M

After completion of the rehabilitation works, all project facilities will be transferred to the Department of Project Operations, GIDA, which is responsible for the handing over of O&M to the farmer's societies. The PM offices have direct responsibility for its handing over, at the project site under the management and instruction by the Department of Project Operations. The organisation of these two offices should be strengthened in order to make successful implementation of its handing over. The proposed organisational structure and staffing of both offices are presented in Table A-34 and Figure A-43 with supporting agencies involved in O&M.

1) Department of Project Operations

The proposed organisation consists of three divisions; (i) an O&M Division, (ii) a Monitoring and Evaluation Division, and (iii) an Extension Division (see Figure A-43).

The O&M Division comprises five officers; i.e., an irrigation engineer, a civil engineer, a mechanical engineer and a mechanic under a deputy director. This Division undertakes the following activities :

- Overall engineering services for O&M through the PM offices
- Training on O&M to the officers in the PM offices and the societies
- Improvement of water management and its dissemination
- Movable services for pumps and equipment to the societies, etc.

The Monitoring and Evaluation Division monitors all of project activities, and the Extension Division undertakes agricultural extension activities. These activities are described in Sub-section 3.6.2 (4) and Sub-section 3.6.4 (1), respectively.

2) PM Offices

Two types of organisations and staffing are proposed in accordance with the development stages; (i) O&M during the transition period until handing over and (ii) O&M by the farmer's society after handing over (see Figure A-43). The main tasks of the PM offices are summarised as below.

a) Transition Period

O&M Officer
- Joint operation and maintenance of facilities with the farmer's society
- Training on O&M
- Handing over of O&M, etc.

Extension Officer
- Agricultural extension services
- Administrative services to the society

Co-operative Officer
- Necessary arrangements to establish agricultural co-ordinating committee
- Strengthening of farmer's society and training to the society
- Improvement of marketing and agricultural credits, and promotion of women's activities, etc.

Monitor
- Monitoring works, etc.

b) After Handing Over of O&M

O&M Officer
- Technical guidance of O&M to the society
- Follow-up training on O&M
- Machinery services to O&M of the society

Extension Officer
- Agricultural extension services
- Supporting and follow-up services for marketing, credits, women's activities, etc.

Monitor
- Monitoring works, etc.

In addition to the above strengthening and reorganising programmes, it is proposed to establish the following task force and committee to make successful implementation of rehabilitation works and handing over of O&M.

1) Establishment of Task Force for Project Implementation

As an executing agency of the Project, it is recommended to establish a task force in the GIDA's head office during the period of rehabilitation works and transition of O&M. The members of task force will consist of the Chief Executive, the Deputy Chief Executives and the Directors of the Departments and IDC in GIDA. All activities on the rehabilitation works and handing over of O&M will be monitored. And the problems and constraints identified through this monitoring will be settled immediately by the task force.

2) Agricultural Co-ordinating Committee

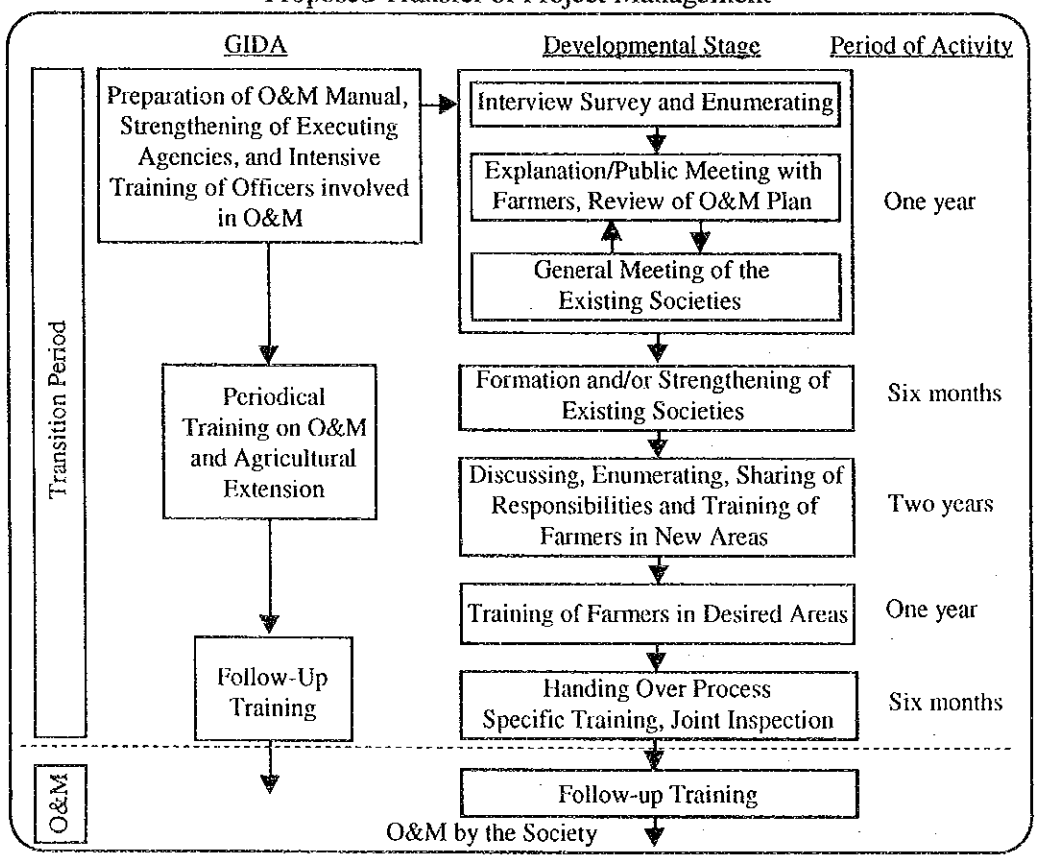
In order to keep a close co-ordination between the agencies related to the agricultural support services, it is proposed to establish an Agricultural Co-ordinating Committee in each project area. The members of Committee will consist of the representatives of the following agencies: (i) the Farmer's Society; (ii) PM office of GIDA; (iii) district offices of Agricultural Extension Services (PPMED, PPRS and Crop Services); (iv) district office of the Department of Co-operative; (v) Banks; and (vi) NGO, etc. The Department of Project Operations, GIDA, will make necessary arrangements to establish this committee.

3.6.2 Project Implementation and Management by GIDA

(1) Handing Over of O&M

At present, GIDA has a plan on handing over process. In this plan, an implementing period to hand over to the farmers has been set at three (3) years. Although the contents of this plan can be adopted basically to the Project without problems (see Table A-14), the period should be set up, taking into account the actual situations of societies' activities, farmers' ability and the experience of GIDA's front line staff who implement directly handing over. As a reasonable period, it is proposed to set about five (5) years, based on the result of field investigation and referring the progress of the Dawhenya Irrigation Project[7]. The proposed handing over process are shown below.

Proposed Transfer of Project Management



[7] The training programme about O&M to the farmer's society was implemented by the consulting expert s during the 4 years from 1991 to 1994.

In addition to the GIDA's handing over process, the following matters are recommended from the standpoint of farmers' participation to the Project.

1) Farm Interview Survey

Before the detailed design, the interview survey to the farmers in the project areas is proposed to be carried out by the PM offices, in order to grasp the farmers' intention to the agricultural development and handing over of O&M. Based on the result obtained through this survey, the plan for rehabilitation and handing over is reviewed by GIDA.

2) Explanation Meeting (Public Meeting) to Farmers

Based on the result of farm interview survey and review, explanation meeting with beneficiaries is held by GIDA in co-operation with the Department of Co-operative. The contents of meeting are as follows : Attendants of this meeting are all beneficiaries, leaders of existing farmer's society and GIDA's offices involved in handing over of O&M.

- Details of the rehabilitation project and O&M by the farmer's society
- Necessity of the O&M by the societies and its merit and demerits
- Duties of farmer's society and GIDA
- Necessity of irrigation service charge and its proposed collecting system
- Enactment of articles and by-laws for O&M
- Contents of the Government's support services and training programmes to be implemented to the farmers
- Schedule of handing over
- Land allocation

Through the explanation meeting, GIDA takes full understanding from the farmers for the implementation of projects rehabilitation and handing over plan .

3) General Meeting of Farmer's Society

After the explanation meeting, the general meeting should be held by existing farmer's society, and all these items mentioned above are acknowledged officially by the society and farmers. Then the projects rehabilitation is authorised by both parties, GIDA and the society. The PM office should make necessary guidance to the society for holding this meeting.

4) Joint Inspection to the Facilities

To the handing over of O&M, it is recommended to carry out joint inspection by GIDA and the farmer's society. All facilities to be handed over should be inspected by both parties, and then these facilities will be transferred to the society without problems and claims from the farmers.

(2) Land Allocation

All lands in the irrigation project areas are allocated to the farmers, in accordance with L.I. 1350 and traditional custom for land holding in the country. The land allocation procedure is as follows; i.e., (i) land acquisition by GIDA, (ii) establishment of the Land Allocation Committee and (iii) land allocation to the farmers by the Committee.

For the land allocation, the Committee gives a priority to the following farmers: (i) who have been displaced as a result of the construction of the Project; (ii) who are resident in the surrounding villages; or (iii) who are resident in other villages and wish to settle near the Project

and accept small holdings. As for the area of a plot to be allocated to a farmer, GIDA will suggest its optimum area based on the farm budget analysis and the labour balance study, but its final decision is entrusted to the Land Allocation Committee.

(3) Training Programme for O&M and Strengthening of the Farmers' Society

Prior to the handing over of O&M, the existing societies should be strengthened through forced training programme. For this strengthening, a wide scale training programme will be introduced. Namely, the training programme is implemented not only to the farmers in the project areas and the officers of GIDA, but also to the officers involved in O&M and the people including the district offices of the Department of Co-operative, the extension offices of MOFA, village chives and elder groups in villages, because the O&M by the society needs a lot of co-operation and support from them.

The O&M Division and the Extension Division are responsible for the conducting of training. The training programme is divided into five (5) courses depending on training contents and trainee's educational background; i.e., Course-A, -B, -C, -D and -E. The details are shown in Table A-35. The Course-A is for senior officers of GIDA and the other agencies involved in O&M; the Course-B is for officers in the PM office and the head office of GIDA; and the Course-C is for farmer's group including leaders of the societies, gate operators, pump attendants, farmers, etc. The courses-D and -E are conducted only to the officers of other agencies and the people in the village. The training contents consist of O&M and strengthening of the society, but some other contents such as new agricultural extension system and promotion of the women in development are also included in this training programme, because the officers and the people involved in the O&M and strengthening of the society should have those basic knowledge.

The lecture is made visually by the use of overhead projector, TV, etc., and the training should be implemented periodically during the transition period. After handing over of O&M, follow-up training on specific items is conducted occasionally to the above officers and people. It is proposed that the training of the Courses-A, -B and -D is conducted at both project site and IDC, and the Courses-C and -E are mainly at the project site.

(4) Establishment of Monitoring System

To sustain O&M by the farmer's society, and to make further improvement of O&M and agricultural production after handing over, it is proposed to establish a monitoring system in GIDA. The monitoring items necessary for these purposes are listed below.

1) Meteorological data including rainfall, temperature, evaporation, humidity, etc.
2) Water management
   - Data on water level and discharge of the relevant reservoirs and rivers
   - Records of daily releasing discharge from the water souses
   - Data on planted crops and cropped area under irrigated condition
   - Data on canal conveyance losses of canals
   - Records of pump operation hour
   - Records of spilling times
3) Operation and maintenance of the facilities
   - Reports on periodic inspection
   - Reports on damages of project facilities
   - Records on repairing of facilities
   - Records on operation costs
   - Records on regular, periodic and annual maintenance

- Records on emergency repairs

4) Farmers society
   - Data on irrigation service charge
   - Annual appraisal reports on financial status

5) Agricultural production and farmer's economy

As for the monitoring of agricultural production and farmer's economy, it is recommended to carry out "Bench Mark Survey (BMS)." This BMS consists of a detailed survey and a seasonal survey, and those outlines are as follows :

1) Detailed BMS
   a) Period of survey : Befor constrcution and three years interval after construction
   b) Survey items
      - Size of household, land holding size and land tenure
      - Cropped area, production, crop damage and production cost
      - Farm inputs and labour requirement
      - Social infrastructure and living situation
      - Livestock raising and holding of farm machinery and equipment
      - Marketing of products and seeds
      - Off-farm income, living expenses, credits and loan repayment
      - Irrigation water supply and O&M of irrigation facilities
      - Farmers' intention for improvement of farming and farmer's association
      - Farmers' intention for O&M and its handing over to the beneficiaries, etc.

2) Sesonal BMS
   a) Period of survey : To each cropping season
   b) Survey items
      - Cropped area, production, crop damage and production cost
      - Farm inputs and labour requirement
      - Marketing of products and seeds
      - Off-farm income, living expenses, credits and loan repayment
      - Irrigation water supply and O&M of irrigation facilities

As an executing body of these monitoring works, it is proposed to reorganise the existing Monitoring and Evaluation Division in the Office of Planning and Management or to establish a new Division in the Department of Project Operations (see Figures A-30 and A-43). The operation and management of this monitoring system are undertaken by this Division, and linked closely with IDC. The PM offices have a direct responsibility for field survey and observation on the above monitoring items. In each PM office, a monitor is appointed to manage monitoring works at the field level (see Figure A-43). These PM offices are now preparing the following four documents; (i) monthly report, (ii) quarterly report, (iii) mid-year report, and (iv) annual report. All data should be reported in these documents, and processed by the Monitoring and Evaluation Division and IDC by the use of computers. The data will be feed back to improve O&M and agricultural production in the project areas. The evaluation and assessment of the project effects and environmental protection are also studied based on these data. The monitoring manual including forms necessary to take data will be prepared with the O&M manual at the detailed design stage.

3.6.3 Farmer's Society

As the basic approach, the O&M should be handed over to the existing societies which are already established in each project area, and no consideration is paid to establish newly any other society, though reorganisation of the existing societies is made, if necessary. The strengthening of the existing societies should be undertaken by GIDA, in co-operation with the Department of Co-operative. The proposed strengthening plan to the existing farmer's societies is described as follows :

(1) Objectives of Farmer's Society

The main objective of the farmer's society is to operate and maintain the irrigation facilities. In addition, other objectives such as marketing and credit services are also included in order to meet with the farmers' intention and to improve present agricultural support services. The result of interview survey indicates that many farmers have requested such agricultural support services by the farmer's society (see Table A-1, Question Item Q-18).

(2) Organisation and Activities

At present, a farmer's society has been established in each project area, but all these societies have no function on O&M of the irrigation facilities. These existing societies should therefore be reorganised to new societies which have the functions of O&M with the agricultural support services such as marketing and credits. The proposed organisation consists of Type-A and -B, as shown in Figure A-44. Both types have almost the same structure, and the difference of two type is as follows :

1) Type-A is for the small projects having less than 100 farmers, and the farmers link directly with the executive committee.

2) Type-B is for the larger projects over 100 farmers. In this type, the farmers are divided into several groups by each irrigation block or each village, and each group links separately with the executive committee. A farmers' group elects a representative who is the member of the executive committee.

The adoption of these types is entrusted to the society. But it is recommended that size of a farmers' group should be less than 100 farmers, so that one of the prime requirements to activate society is "face to face" communication between the executive committee and the farmers.

The society consists of the following four (4) components; i.e., (i) general meeting, (ii) executive committee, (iii) audit, and (iv) service sections including O&M, agriculture, marketing and credit, and women's group. These main functions and activities are as follows :

1) General Meeting

The general meeting is held at least annually, and has the following main activities :

- Election of the members of executive committee and auditor,
- Acknowledgement of the result of auditing,
- Acknowledgment of the annual management plan and budget,
- Determination of the amount of irrigation service charge,
- Revision of the irrigation service charge,
- Revision and enactment of articles and by-laws,
- Specific items requested from the members and committees, etc.

2) Executive Committee

The committee is comprised of the following members; chairman, vice chairman, general secretary, treasurer, and several members who are representative of the service sections. In the case of Type-B, several representatives of the farmers' group are included as the committee members. In addition, one or several porters who are volunteers are appointed in the committee in order to make close communication among the members and between the committee and the farmers. Main tasks of the committee are (i) to prepare annual management plans and budget, (ii) to instruct and supervise activities which are implemented by the service sections, (iii) to manage complaints and grievance from the farmers, (iv) to arrange

and appoint volunteers employed in service sections (v) to manage accounting and general affair, (vi) to co-ordinate with other agencies and associations, and so on. The committee members take part of portion of these works. The regular meeting is held monthly for implementing these activities.

3) Service Sections
Under the instruction and supervision of the executive committee, the routing service works are implemented by the following four sections; (i) O&M, (ii) agriculture, marketing and credit, and women's group. These sections employ several volunteers, and these main activities are as follows :

a) O&M Section

- Preparation of irrigation schedule,
- Operation and maintenance of irrigation facilities,
- Estimation of irrigation service charge,
- Management of co-operative works such as canal clearing and maintenance of farm roads,
- Security service for irrigation facilities, etc.

b) Agricultural Section

- Transmission and notification of information for extension implemented by the PM office,
- Information services for new farming practices and varieties,
- Arrangement of farmers' meeting on agricultural extension,
- Providing machinery services,
- Promotion, arrangements and leading for group farming such as co-operative control of pests and diseases, transplanting and harvesting, etc.

c) Marketing and Credit Section

- Implementation of co-operative purchasing and shipping,
- Storing arrangements of farm inputs and products,
- Agricultural credit services,
- Exploitation of new marketing channel, etc.

d) Women's Group

- Promotion for women's agri-business and cottage industry,
- Promotion for homestead development,
- Improvement of social welfare and health care of the farmers,
- Educating activities on home economy and management, etc.

4) Audit Section

At present, the staff of an society consists of chairman, vice chairman, secretary, treasurer and several members of the executive committee as mentioned earlier, and no auditor is commonly assigned. Namely, the society has no auditing system in their accounting works, and this is one of the society's problems. To solve this problem, it would be proposed to have the auditing system.

(3) Office and Facilities

An office of the society shares the floor space in the PM office. All necessary administrative works including typing, printing, photo copying, communication, etc. should be supported by the PM office with transportation services.

(4) Training of Farmers' Society

The PM office prepares the training programme and trains periodically the leaders of the farmers' society and the farmers, in co-operation with the Department of Co-operative. In order to dissolve the problems and constraints encountered during the transition period of O&M, the PM office should monitor intensively all the society's activities. The training items required for the society's management are to (i) administrative works including book keeping, (ii) accounting works, (iii) marketing and credit services, etc. For these training, a co-operative officer is appointed in each PM office during the transition period

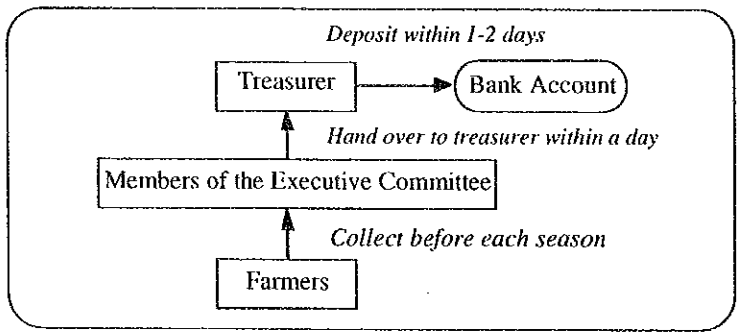
The training is divided into two (2) courses; intensive course and follow-up course. The former is implemented during the transition period of O&M and includes all items mentioned above. The latter is done after the handing over of O&M, and carried out for several specific items depending on their activities.

(5) Irrigation Service Fees

All O&M costs of irrigation facilities are covered by the irrigation service charges (ISC) collected from the farmers. The amount of ISC is estimated by each farmer's society, and includes the following items :

a) Operation cost
b) Maintenance cost
c) Personnel cost for gate operators/pump attendants
d) Replacement cost of facilities and equipment
e) Collecting cost (transportation cost of collectors and treasurer)

The proposed collecting procedure of ISC is as follows: ISC is collected before each cropping season. All members of the executive committee collect ISC directly from the farmers, and collected amount is deposited immediately in the society's bank account. The treasurer manages all these transactions.



To achieve a good progress on collecting ISC, it is recommended to adopt the following punishment rule and incentive to the farmers.

1) To the farmers who are not able to pay on time, the society fines them some percentage of total ISC per month during the non-payment period.

2) When farmers pay full amount and on time, some percentage of its full amount is reimbursed to him as an incentive.

The executive committee is responsible for management and operation of ISC. For the payment of O&M, there are two types. One is the recurrent costs such as electric charge and personnel costs, and the other is for the costs of emergency and specific O&M works. The former is paid by the treasurer after approval of the chairman and the general secretary, as a

routine of the society's works. For the latter, a committee meeting is held to asses its necessity and released its fund to such emergency works.

(6) Articles and Bye-Laws

A standard article and bye-laws of the farmer's society have been prepared by the Department of Co-operative. But this is for the general co-operatives, and articles necessary to the new societies which are responsible for the O&M of the project are not included at all. Although this standard articles and by-laws are adopted basically to the new societies, it is necessary to enact several new articles. These are listed below.

1) The society has the right to collect ISC from the beneficiary who received irrigation services from the society, and the beneficiary has the duty to pay its ISC to the society.
2) The society inflicts a punishment on the beneficiary who uses irrigation water and facilities illegally and is not able to pay ISC.
3) The beneficiary has the duty to participate in the co-operative works on O&M which are planned by the society.
4) The tenant beneficiary has a right to join the society with the election to the executive members, and is in duty bound to pay ISC and membership fees, as well as the owner beneficiary .

In addition to these articles, it also be needed to enact some laws at the national level as those regal basis.

(7) Irrigation Meeting

The production activities of crops are linked with various agricultural support activities including machinery services, supply of farm inputs, credit services, etc., which are implemented by the Government and private sectors, and all these should be co-ordinated closely with the farming. In this context, it is proposed to hold an irrigation meeting under the presidency of the farmer's society. The meeting is held before each cropping season, and comprised of the following members :

a) All farmers
b) Members of the executive committee of the farmer's society
c) PM, GIDA
d) District extension offices, MOFA
e) District office of the Department of Co-operative
f) Banks and private sectors such as owner of farm machinery and dealer of farm inputs.

The agricultural co-ordinating committee makes necessary support to hold this meeting by the society. In this meeting, the following items are discussed among the attendance. Based on the result of these discussions, the society requests to the related agencies the necessary support services.

a) Recommended crops to be cultivated in the season
b) Cropping schedule including land preparation, seeding, transplanting, harvesting, etc.
c) Irrigation schedule
d) Required quantity of farm inputs such fertilisers and agricultural credits, and those supplying periods, etc.

All farmers confirm the irrigation schedule through this meeting, and the society commence the O&M based on the result of the meeting.

3.6.4 Agricultural Support Services

(1) Extension Services

For the extension activities, there are two agencies at present; MOFA for staple foods and GIDA for irrigation farming. As the basic approach to the study of agricultural extension, the strengthening of GIDA's activities is considered in this Project. The proposed extension system is described as follows :

The proposed organisational structure and the number of subject matter officers (SMO) required for the Project are summarised as follows, and the details are shown in Figure A-43. The qualified staff should be appointed in this new system.

Staffing of Extension System

Position	Subject Matters	Head Office	PM Office	Total
SMO*1	Crops	1	-	1
SMO	Co-operative, Marketing and Credits	1	-	1
SMO	Women's activities	1	-	1
SMO	Training	1	-	1
Extension Officer		-	1	12

*1 Subject Matter Officer

The agricultural extension services to the project areas are undertaken by the Project Management Division under the Department of Project Operations, GIDA. At present, two (2) agronomists are attached to this division to deal all subjects including paddy, vegetables, and plant protection. In addition, it is suggested to appoint more two (2) officers. Their main subject matters are as follows, and they take charge of a portion of these matters

1) Crops

a) Identifying problems specific to the crop cultivation and help them to solve these problems.
b) Prepare proposed cropping calendar, plant protection practices and fertilisation.
c) Distribution of improved varieties in co-operation with IDC.
d) Dissemination of specific farming practices including the use of animal power, organic fertilisers, mulching cultivation of vegetables, etc.
e) Promotion of post harvest improvement such as storing and processing.
f) Dissemination of the Pest Management Project, etc.

2) Co-operative, Marketing and Credit

a) Identifying problems specific to the co-operative, marketing and credit, and help them to solve these problems.
b) Promotion of group loan, co-operative purchasing and shipping.
c) Supporting to the society's accounting and its auditing.
d) Providing marketing and price information, etc.

3) Promotion of Women's Activities

a) Identifying problems specific to the women farmers and house hold and help them to solve these problems.
b) Identify and implement income generating activities based on agriculture.
c) Carry out home garden development programme.
d) Pass post harvest technology information to women farmers, etc.

4) Training

a) Identifying areas of subjects which are relevant to many farmers and prepare mass media training programmes to the farmers.
b) Preparation and implementation of training programmes to extension officers in the PM offices.
c) Supporting to issuing of a monthly or bi-weekly news bulletin.
d) Preparation of training aids, etc.

Forced training programmes should be implemented for the GIDA's officers as well as the farmers, in order to enable them to carry out their duties effectively. It is well understood that field level extension officers should be competent to understand the farming as a whole, and posses diagnostic skill, and able to identify appropriate action. The extension officers in the project areas have however not so much experience in the irrigation farming. The necessary training programmes for the officers are listed below. These programmes are managed by the Extension Division in co-operation with IDC, Ashaiman.

1) Training on programme development process: all agricultural officers in the head office and the PM offices should be trained on problem identification and need assessment to programme design and its implementation. Before the implementation of the new extension system, it is necessary to educate all levels of the extension staff and get their views.

2) Training programmes for communication: it has been observed that most of the extension officers in the project areas are very poor on communication skills. A good communication skill training programme should therefore be conducted with the implementation of the new extension system.

3) Pre seasonal training: the pre-seasonal training programmes will be conducted by SMOs of the Project Management Division with IDC. The training priorities will be strictly on the extension programme of the coming season. The extension officers in all PM offices will participate in these programmes.

4) Specific Matter Training: this training will be conducted occasionally by SMOs of the head office and researchers in IDC. For the specific items such as irrigation method and planting practices, the extension officers are trained and skilful through this training.

5) Specialised Training Programs: SMOs in the head office require more in-depth training in their subjects. They should participate in all the relevant specialised courses conducted by other agencies such as MOFA and CRI.

As for the extension system, the "T&V" system adopted by MOFA is proposed to be introduced in the project areas. The farmers form a group who consists of 8-15 persons, and the extension officer go round at least a group once a week.

In order to make extension activities more efficiently, the following points would be recommended:

1) It would be recommended to organise at least two or three demonstration farms in each project. The extension officer in the PM office appoints several excellent farmers for demonstration activities, who cultivate crops with advanced and suitable practices, and demonstrate them to neighbouring farmers in the project area. The extension officer always contacts with them and provides technical and managing guidance with some farm inputs (recommended varieties, etc.).

2) In order to make effective extension works and take a good and easy understanding

of farmers for recommended practices, it is proposed to issue farming calendar which is mentioned visually as well as the leaflet issued by MOFA at present. A sample of proposed farming calendar is presented in Figure A-45 The main proposed practices during the period from sowing to harvesting are mentioned in one paper with calendar, and important practices are mentioned visually by figures and tables. In order to simplify the practice adopted by the farmers, the units of quantity are indicated by bag and bottle, and figures of required quantity are mentioned by 0.2 to 0.5 ha indent. The farmers will paste this paper on wall and show every day with calendar. They cultivate crops according to the proposed practices mentioned visually on the paper. If farmers have questions on farming practices, the extension officer explains to them based on this calendar.

3) It is recommended to issue local newspaper or bulletin for agricultural extension to the farmers, which are issued bi-weekly or monthly. The main contents of these papers consist of articles on marketing and credits information, recommended practices and introduction of new varieties, water management news, homestead development news, co-operatives' activities, official notice from the Government agencies, and so on. All subscripts are written by easy word and simple sentence, because the papers are mainly for farmers.

At present, all PM offices have almost no extension equipment and facilities. The following equipment will therefore be recommended to be provided in each PM office, in order to make effective extension activities.

a) Printing machine (electric stencil cutting machine and rotary mimeograph)
b) Photo copy machine
c) Overhead projector
d) Video and TV set
e) Several pick-ups for transportation of seeds and farm inputs to be provided to the demonstration farmers, and to ensure adequate mobility and effectiveness of the services.

The printing and photo copy machines are for the preparation of leaflets, farming calendar and news paper. The extension officer prepares such handmade and original papers which connect closely with the local farming and living in co-operation with all staff in the PM office and the farmer's society. The related agencies such as the extension offices of MOFA and the district office of the Department of Co-operative will also be involved in these works. Video and TV set are for the visual training to the farmers.

(2) Research Activities on Irrigation Farming

In order to achieve final target of the Project and make further development of agricultural production in the project areas, it is proposed to strengthen agricultural research activities for irrigation farming. Main activities necessary for the Project are listed as below. It is expected that these activities are undertaken by IDC, Ashairnan.

1) Crop adaptability and variety tests
2) Research data on water management (deep percolation rate, holding capacity, effective root depth, etc.)
3) Water management and irrigation methods (proper irrigation interval, supply amount of water, etc.)
4) Fertilisation by each crop (proper application quantity, sprit dressing, etc.)
5) Pest and diseases control
6) Specific cultivation techniques such as mulching practices for vegetable cultivation and preparation of organic fertilisers
7) Seed production, etc.

(3) Improvement of Agricultural Credits

At the initial stage of the Project, the farmers need a considerable amount of loan for purchasing farm inputs for crop cultivation, especially for vegetables. At present, several credits have been let by the Banks in and around the project areas. These credits have however serious problems as discussed in Sub-section 2.6.3. To overcome these problems, several counter measures are proposed to the project areas; i.e. (i) agricultural credits with technical guidance, (ii) adoption of ceiling to loan amount, and (iii) group loan. This is a comprehensive programme including marketing, agricultural credit, technical guidance, and so on. Outline of the group loan system is as follows, and a schematic figure is presented in Sub-section 3.6.4 (4).

1) The loan is limited only to purchase farm inputs, and set its ceiling amount depending on crops.
2) For borrowing loan, the farmers make a group and select a representative. The members of group are jointly and severally responsible to repay loan of defaulter.
3) Farm inputs requirement is estimated by the group with required loan amount. At this time, the extension officer in the PM office gives technical guidance such as recommended fertilisation and pest and diseases control with recommended agro-chemicals to them.
4) The bank provides a loan for the group in a lump or dividing into two portions, after the examination. The groups purchase farm inputs in one lot.
5) The bank releases the loan amount only to the supplier of farm inputs, and the group receives farm inputs from the supplier. Namely, the group and its representative do not touch cash money, except for the bank cheque to be issued to the supplier.
6) The PM office provides transportation services to them, if necessary.
7) The representative collects the loan from each farmer, and repay it to the bank in a lump. The bank does not collect the loan from individual farmer.

A characteristic of the group loan is a system closely connecting with the farm guidance, improvement of farm inputs supply and strengthening of farmer organisations, and this loan has following merits :

1) The lending operation is very simple and easy as compared with it to individual farmer, though it is a matter of course that a field officer of the bank must carry out an inquiry into the credit standing of the group.
2) The loan collection is also very easy, because collection from individual farmer is carried out by the representatives, and the bank stays only in contact with him for its loan collection.
3) The introduction of joint and several liability by the farmers living in same place brings a good result to improve loan repayment.
4) The farm inputs suppliers can allow a large discount for a blanket purchase, and the group under the loan system can purchase farm inputs on these discount prices.

This group loan system is proposed to be managed by the societies. At present, the societies in Tanoso and Akumadan have borrowed some loans from the Banks under the joint and several liability of the members, which is similar with the proposed loan system. It seems that all societies can manage such a new credit system without problems.

(4) Improvement of Marketing

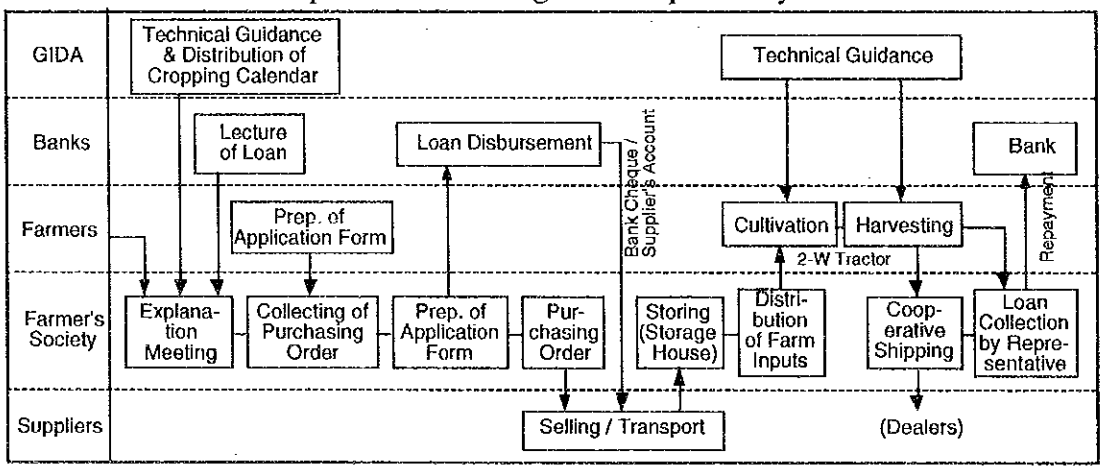
Timely supply of farm inputs such as fertilisers and agro-chemicals is one of the important factors for improving crop yields as well as the dissemination of improved irrigation farming. To make smooth supply of farm inputs, a co-operative purchasing system is recommended to be introduced in the project areas. This system is closely connected with loan services, technical guidance and organisations' activities as mentioned earlier, and has the

following merits :

1) Through this system, the farmers can arrange all necessary farm inputs before the crop season, and they can use those inputs on time according to those necessity;
2) By a blanket purchase, the farmers can purchase farm inputs at discount prices;
3) Transportation services will be available from suppliers and/or the PM offices; and
4) By the direct purchasing from suppliers, the farmers can obtain necessary and enough quantity of farm inputs.

Overall flow of co-operative purchasing to be introduced to the societies is presented as follows with the group loan system. For successful management of this co-operative purchasing, the following matters are essential; i.e., financial and technical supports from other agencies such as the banks and the PM office of GIDA and a close co-ordination between them.

Co-operative Purchasing and Group Loan System



Thus the farm inputs such as fertilisers and agro-chemicals would be supplied smoothly by the private suppliers through this system. As for the seed supply, the result of interview survey carried out by the Survey Team shows that most of the farmers in the project areas have no problems to purchase seeds at present. It is therefore entrusted to MOFA for cereals and the private sector for vegetables so far. The supply of qualified seeds will however be necessary to increase crop yields in near future. It is expected that IDC produces such qualified seeds and provides to the farmers through the GIDA's extension system.

At present, the dealers (market mummy) have handled a lot of farm products in the project areas. Their marketing activities covers all over the country and have been connected from village to village and urban areas. With the exception of the Mankessim project, no information on marketing problem is available from the project areas. In the case of Mankessim, the project area is under the buyer's market, and the farm gate prices of products have been wrongfully controlled by the dealers who come from the Mankessim market. To overcome such a problem, the farmers in the Mankessim project have sold their products directly to another market near Accra. It seems that the other projects have also such a problem more or less. As one of the countermeasures, it is proposed to introduce a co-operative shipping system managed by the society.

3.6.5 Women in Development

The Project will induces to activate and strengthen the crop production, marketing of farm inputs and products, post harvest, transportation, society's services, etc. In parallel with such economic and social development in the rural area, the farmers' women will have much opportunity to join these activities. The following points will be proposed for the women in development.

1) In order to encourage greater participation of women in public affair, it would be recommended to appoint women's leaders in the farmer's societies. As the leaders of the societies, the appointment of woman's auditor is ideal.

2) The groundnuts and tomatoes are recommended in the cropping pattern. To solve the unemployment problem of women in the Project area and improve their income source, it would be proposed to promote value-added processing of these crops by women's group. The PM office provides technical guidance for them, and the society makes necessary arrangements for the bank loan to purchase the extracting and processing equipment.

3) In addition, the homestead development and a wide scale livestock raising of chicken, rabbit, etc. by the women's group are also proposed for the women in development.

The farmer's society should play an important role in promoting these activities, and the GIDA should provide necessary guidance to them. In this context, the establishment of women's group is proposed in the society as mentioned in Sub-section 3.6.3 (2) and (3). A representative of the women's group joins the executive committee as its member, and participates in all society's management. In addition, the appointment of a subject matter specialist to promote these activities mentioned above is also proposed to the Project Management Division in the head office of GIDA (see Sub-section 3.6.4 (1)). At the field level, intensive promoting activities are undertaken by the co-operative officer stationed in the PM office during the transition period of handing over, and after the handing over of O&M, the extension officer conducts some follow-up services to them.

3.6.6 Staff and Facility Required for O&M

The staff and facility which are required for the implementation of O&M are summarised as follows and the details are presented in Table A-34.

Staff and Facility Required for O&M Stage

Projects:		ASH	WEI	AMA	AFI	AVE	KPA	MAN	AKU	TAN	BON	SUB	OKY	Total
Development Area	(ha)	44	220	203	535	150	356	176	31	30	450	70	111	2,376
Staffing of PM Office	(Persons)									*1		*1		
(1) Transition period of O&M		11	15	11	22	11	14	11	12		19		12	138
(2) After handing over of O&M		7	7	6	9	6	6	6	5		8		7	67
Office and Buildings														
a) PM Offices														
- Rehabilitation	(m2)	106	305	-	228	-	-	-	-	114	200	101	-	1,054
- Construction	(m2)	-	-	175	-	175	175	175	80	-	-	-	175	955
b) Store houses*2	(No.)	1	2	2	-	1	4	3	1	1	5	1	-	21
Vehicles and Equipment										*1		*1		
(1) O&M Equipment	(Set)	1	1	1	1	1	1	1	1		1		1	10
(2) Equipment for Extension, Monitoring and Cooperative Activities	(Set)	1	1	1	1	1	1	1	1		1		1	10
(3) Office equipment	(Set)	1	1	1	1	1	1	1	1		1		1	10

*1 The Akumadan, Tanoso and Subinja projects are managed by the Regional Office, Techiman, and these staff and equipment are stationed in the Regional Office.

*2 For agriculture.

In parallel with the rehabilitation works, the existing PM offices in the project areas should be reorganised and strengthened as the executing agency of the handing over of O&M.

The existing buildings in the Ashaiman, Weija, Afife and Bontanga are rehabilitated completely and used continuously as the PM office. In the five (5) projects of Amate,

Aveyime, Kpando-Torkor, Mankessim and Okyereko, a new building is constructed in each project, which has a floor space of 175 m^2 including an engineering room (25 m^2), an extension room (25 m^2), a monitoring room (25 m^2), a co-operative room (25 m^2), a meeting rooms (50 m^2) and others (25 m^2). Each PM office has one set of necessary vehicles and equipment for providing support services such as O&M and agricultural extension to the societies.

As for the Akumadan, Tanoso and Subinja, it is proposed that these three projects are managed by the Regional Office in Techiman, because they have a small area and locate within easy access to the Regional Office. Therefore, it is planned to construct a small office building including a co-operative room (25 m^2), a meeting room (50 m^2) and others (5 m^2) in Akumadan project which has no office at present, and to rehabilitate the existing buildings in Tanoso and Subinja projects for the use of the farmer's society. The Regional Office has one set of vehicles and equipment with necessary staff to provide the support services for the societies in these three projects.

The total number of staff who are stationed in the PM offices is estimated to be 138 persons during the transition period and 67 persons after the handing over of O&M to the farmers.

3.7 Environment Conservation Plan

3.7.1 Basic Approach

The model development approach is proposed as the environment conservation procedure, since the environment problems identified in the IEE study are not only particular problems in the project areas, but also they can be found in the whole country of Ghana. Through the fields trials/demonstration, the farmers can learn and understand easily the conservation technologies. This approach is based on the philosophy that the farmers readily adopt to new methods, if they are shown on how to do and results are readily observed. The adoption should be further encouraged through extension services. Therefore, this Project should be placed as a model development one for the future sustainable development. The following paragraph explains the basic concepts for conservation plans of the major future environmental issues.

3.7.2 Soil and Land Conservation

(1) Farm Land

There are three types of control measures for soil degradation and erosion, namely (i) vegetative measures, (ii) structural measures, and (iii) cultural measures. The description of soil erosion control measures and the merits and demerits are summarized in Table A-36. In general, vegetative measures are easy and less expensive to establish and repair compared with structural measures. In addition, vegetative measures can improve the soils, when nitrogen fixing trees are used for hedgerow and the leaves and branches are used as green manure and mulching materials. On the other hand, they are less effective in very steep slopes and difficult to attain erosion control effect immediately after the establishment. The structural measures have the characteristics almost opposite to vegetative measures, i.e. difficult and expensive to construct and maintain, but become effective right after the establishment. The cultural measures are the ones already or potentially mingled in the vegetative and structural measures. These measures should be adopted together for the effective soil conservation. However, the significant consideration should be paied for the suitability of each measure according to the site conditions.

In addition, it is recommended to introduce the revegetation and plantation of tree along the shore to reduce the deposition in the watershed area, especially around the reservoir.

(2) Administrative Plan

In order to effectively transfer and disseminate the technologies to the farmers, it is proposed to establish a research and monitoring station or centre. It is recommended that this station will have a function of research of land conservation, monitoring of soil erosion and the effects of protection measures, extension to farmers, and producing and providing tree seedlings for farmers.

This station is installed in the areas which have a high potential of land degradation, such as Kpando-Torkor, Tanoso, Akumadan and Subinja. The GIDA should have a responsibility for the operation and maintenance of the proposed research and monitoring centre. To establish and provide the integrated conservation measures for the farmers, the station should be operated with cooperation of other agencies, especially the Department of Forestry.

3.7.3 Incidence of Water-borne Diseases

In case of Aveyime project, the water resources of irrigation is already infested by Bilharzia as mentioned above. The countermeasures for reduction of the expansion should be considered not only in the project area but also along the upper stream of the Volta river. The contaminated area is so wide that the adoption of chemical treatment is not effective. The following health programme is recommended to be taken :

1) monitoring of condition
2) education of local people
3) installation of sanitary facility, if required

The maintenance works for clearing of weeds in canals and field bunds should also be required for reduction of the snails' habitat and feed in the project area.

3.7.4 Deforestation

The main reasons for deforestation in and around the project areas are bushfires, illegal cultivation, tree cutting by farmers for firewood, forest cutting for export, and slash-and-burn cultivation. Therefore, the necessary actions by the government are not only the land use restriction, but also the integrated government support services to improve the present conditions. Therefore, the installation of irrigation facilities is one of the effective measures through the stabilization of farmer's life to expect the effects on reduction of slash-and-burn cultivation, illegal cultivation and charcoal production. In addition, the following approaches are proposed to be considered to reduce the deforestation :

1) Energy development

   As mentioned above, firewood cutting is one of the main reasons for forest degradation, since the local people mainly use firewood and charcoal for their energy source. The improvement of cooking stove of local people is one of effective measures for sustainable energy development. The introduction of biogas system as an alternative energy source is also useful. In addition, it has another usefulness that the residue (slurry) of biogas can be used as soil improvement materials.

2) Establishment of forest

   Plantation of trees and establishment of forests are also essential for the forest conservation. Therefore, the government should support the local people by providing tree nursery and training them. If the local people understand the

importance of forest management and get the technology, they can produce their own energy source in the certain land permanently. At present, the IDC has been implementing the extension work of reforestation around the Ashaiman reservoir from 1993 on trial. The Department of Forest, Ministry of Forest has also a programme to encourage the local people for establishment of community forest. Due to the lack of staff and fund, however, the effect is still limited.

4. PROJECT COST

4.1 Conditions of Cost Estimates

The Project cost for respective projects is estimated on the basis of the following conditions, mainly for the purpose of economic evaluation of each project :

1) Exchange rates used for the estimate are US$ 1 = Cedi 1,400 = Yen 100 as of December 1995.

2) Costs for civil works are estimated by updating those in the contract documents used for the Dawenya Irrigation Project where similar rehabilitation works to this Project were completed in 1993.

3) Costs for pumps, pipes and sprinkler equipment are estimated at CIF Accra.

4) Administration costs for the executing agency of the Project are estimated at 5 % of the direct construction costs.

5) Costs for engineering services are estimated at 10 % of the direct construction costs.

6) The Project cost includes physical contingency which is estimated at 10 % of the direct construction costs, but does not include price contingency because of the recent high inflation.

4.2 Estimated Project Cost

The construction cost for the respective projects are estimated as shown in Table A-37. The cost of O & M equipment and agricultural supporting equipment is given in Table A-38. The following is a summary of the respective project costs thus estimated, and details of the cost estimates are given in Table A-39:

(Unit : Cedi 1,000)

Project	Project Cost	Project Area (ha)	Cost/Ha*2
(1) Ashaiman*1	2,219,000	148	15,000
(2) Weija	7,524,000	220	34,000
(3) Amate	6,330,000	203	31,000
(4) Afife*	6,475,000	880	7,000
(5) Aveyime	2,961,000	150	20,000
(6) Kpando-Torkor	11,253,000	356	32,000
(7) Mankessim	4,811,000	176	27,000
(8) Akumadan	1,442,000	31	47,000
(9) Tanoso	1,143,000	30	38,000
(10) Bontanga	2,666,000	450	6,000
(11) Subinja	2,113,000	70	30,000
(12) Okyereko	2,466,000	111	22,000

*1 Rehabilitation work is planned to be executed for whole area because there is existing facility.
*2 Round number.

4.3 Replacement Costs

Some of the facilities such as pump and accessories, pipes, sprinkler, gate, and o & M equipment have a shorter durable period than the project life and thus will require replacement

during the proposed 50 year life of the Projects. The costs and durable period of them are given in Table A-40.

4.4 O & M Costs

The O & M costs for the project operated facilities broadly consist of (1) administration cost, (2) pump operation cost, (3) cost for operation and maintenance of O & M equipment, and (4) lavor and material costs for repair and maintenance works. These costs are provisionally estimated as shown in Table A-41.

5. PROJECT EVALUATION

5.1 General

The objective of the project evaluation is to assess the economic feasibility of the Rehabilitation of Irrigation Projects and get projects' priorities right. For the economic evaluation, three measures of project worth, namely, economic internal rate of return (EIRR), benefit-cost ratio (B/C) and benefit minus cost (B-C) were examined. The project evaluation was based on the following basic assumptions:

a) The useful life of the Project was taken as 50 years from project implementation;
b) For the calculation of EIRR, only direct benefits were counted, and no indirect and intangible benefits were taken into account;
c) The exchange rate of Ghanaian Cedi to US. Dollar (US$) was taken to be Cedi.1,400 equivalent to US$ 1.00 (as of November-December, 1995);
d) Constant prices at 1995 level were used in the economic evaluation; and

5.2 Project Costs

The project costs for economic evaluation would consist of construction cost, annual operation and maintenance (O&M) cost, and replacement cost, and these economic costs can be obtained by applying standard conversion factors (SCF) and specific conversion factors to the financial costs. These factors used to convert financial into economic costs are presented in Table A-42.

The construction cost for implementation of the Project includes the costs for (1) direct construction cost, (2) procurement of O&M equipment (3) engineering services, (4) administration cost, and (5) physical contingency. These total costs are presented in Table A-43.

The annual O&M cost for project facilities was estimated as shown in Table A-44. The O&M cost would be initially disbursed from second year when operation would be commenced after the rehabilitation works. Regarding the replacement cost, the steel gates, pump and O&M equipment installed in the project facilities would be replaced several times during the entire period of the project life. Their useful lives were estimated to be 20, 15 and 10 years, respectively (see Table A-45).

Land acquisition costs and price contingency were excluded from the project economic costs. Production foregone earmarked for negative benefits was evaluated, instead of the land acquisition cost. Since EIRR of the Project is measured at constant prices, provision for price contingency was excluded from the project costs.

5.3 Project Benefits

5.3.1 Economic Prices of Farm Inputs and Outputs

Economic prices of farm inputs and outputs were estimated in order to evaluate the expected project benefits. Economic prices of trade goods such as rice, maize and fertilisers were estimated on the basis of the projected world market prices of these commodities forecast by the World Bank in the long term range for the period from 2000 to 2005. The details are shown in Table A-46. Non-trade goods such as vegetables and yam were valued at financial prices which were estimated on the basis of current market or farm gate prices prevailing in the Project areas in December 1995. As for farm unskilled labour, it was valued at a shadow wage rate which is estimated at 0.5 (see Table A-42).

5.3.2 Project Benefits

The project benefits consist of irrigation benefits and negative benefits. The irrigation benefits will accrue primarily from increased crop production owing to stable irrigation water supply. Negative benefits will occur on lands to be occupied by the project facilities.

(1) Irrigation Benefits

The irrigation benefits are defined as the difference in net return from crops between the future with and the future without project conditions. The net return per ha for each crop under the future with and the future without project conditions was estimated as shown in Tables A-47 and A-48. Applying the net return per ha for each crop to those harvested area, the total net return to accrue from crop production was calculated on both the future with and without project conditions. Annual irrigation benefit at full development stage was estimated by each project as shown in Table A-49. The benefits would start to accrue from second year after completion of the rehabilitation , and would gradually increase up to the 5th year.

It was assumed that total net return under the future without project condition would remain at present level. The reasons of present low yields are due mainly to water shortage. This problem in the area can't be solved radically without the implementation of the rehabilitation works. Moreover, almost no change in cultivation area of crops would be expected under the future without project condition, because it would be difficult to expand more its area from the present level without exploitation of new water resources.

(2) Negative Benefits

For the economic assessment, the opportunity cost of the lands to be installed project facilities is evaluated in distinction from the land acquisition cost which is used in the financial assessment. These negative benefits are already counted in the estimate of irrigation benefit by deducting these areas from the paddy field under the future with project condition. Regarding the bush and grass lands, no opportunity cost in a national economic sense was evaluated, since there were no potential alternative.

5.4 Economic Evaluation

In order to compute the EIRR, B/C and B-C, the annual economic costs and benefits flows were firstly prepared as shown in Table A-50. From this table, the EIRRs of the projects were estimated from -3.4 to 20.2%. The Kpando-Torkor project indicates the highest EIRR and the lowest one is the Tanoso project. In addition, the B/C and B-C at the discount rate of 10% were also estimated (see Table A-50).

Project	IRR (%)	B/C*1	B-C*1 (Cedi Million)
Ashaiman	4.2	0.54	-861
Weija	6.9	0.81	-1,432
Amate	16.9	1.50	3,207
Afife	16.3	1.60	3,236
Aveyime	13.6	1.31	808
Kpando-Torkor	20.2	1.81	8,680
Mankessim	16.0	1.48	2,146
Akumadan	0.4	0.48	-756
Tanoso	-3.4	0.43	-694
Bontanga	17.7	1.68	1,649
Subinja	7.1	0.82	-400
Okyereko	13.0	1.23	540

*1 Discount rate: 10%

6. EVALUATION AND SELECTION OF PRIORITY PROJECTS

6.1 Evaluation Method

In addition to the project evaluation in terms of the economic internal of return (EIRR), benefit-cost ratio (B/C) and benefit minus cost (B-C), another evaluation is also carried out for the need of urgent rehabilitation, strengthening of institutional improvement, and the effect of environment, by the following six (6) parameters selected on the basis of the findings obtained from the site investigations and the master plan study on the existing 12 projects :

(a) Parameter 1 : Deterioration and Problems of Present Project Facilities
(b) Parameter 2 : Effect to the Downstream Area
(c) Parameter 3 : Present Participation in O&M of Project
(d) Parameter 4 : Present Activity and its Performance of Farmer's Organisations
(e) Parameter 5 : Present Farmers' Economy
(f) Parameter 6 : Environmental Effects

The evaluation of each of these parameters is made by a scoring method. Further explanation of these parameters is given below :

(1) Deterioration and Problems of Present Project Facilities

This parameter is used for evaluation of need of urgent rehabilitation of project facility by grasping the extent of deterioration and problems of the following facility groups, and the works and equipment to be required for their rehabilitation.

(a) Dam and reservoir (dam embankment, intake and outlet structures including gates)
(b) Weir, pump station, pumps including auxiliary equipment
(c) Irrigation network (sprinkler system, canals and canal structures)
(d) Drainage network (drains and related structures)
(e) Farm road network and need of access to the main road
(g) Buildings for O&M of the project and farming (offices for project and farmer's organisation, garage, repair shop, storage, drying yard, etc.)

The following scoring is applied for each facility group included in this parameter:

Deterioration & Need of Rehabilitation	Score
Very high or no facility exists	5
High and facility not functioning	4
Moderate and small rehabilitation	3
Low and minor repair	2
In good condition and no need	1

(2) Effect on Downstream Area by Additional Use of Available Water

This parameter is used for evaluation for adverse effects on the existing water supply service schemes or other irrigation schemes located in the downstream of a project due to additional use of available water for irrigation to the expanded area including increase of crop intensity.

The following scoring is applied for this parameter:

Water Availability	Score	Adverse Effects	Score
Much more than Req'ts	5	None or negligible	5
More than Req'ts	4	Very small	4
Equal to Req'ts or so	3	Moderate	3
Less than Req'ts	2	High	2
Much less than Req'ts	1	Very high	1

(3) Present Farmer's Participation in O&M of Project

This parameter is used to evaluate the present farmers' participation in their partial O&M works of the projects and the needs for strengthening of farmers' organisation for proper O&M of the rehabilitated projects by themselves. The evaluation of this parameter is made mainly on the basis of findings obtained from site investigations and questionnaire survey. The following scoring is applied for this parameter:

Participation in their O&M Work	Score
No participation or very limited	3
Partly participate	2
Full participation	1

(4) Present Activity and its Performance of Farmer's Organisation

This parameter is used for evaluation of the present activities and their performance of the farmer's organisation in each project, and at the same time evaluation of needs for strengthening of the organisation for achievement of more profitable irrigated agriculture is made, using the findings from the questionnaire survey. The scoring applied for this parameter is as follows:

Activity and Performance	Score
Nearly no activity	5
Slightly active and low	4
Moderate	3
Active and good	2
Very active and very good	1

(5) Present Farmers' Economy

This parameter is taken as one of the parameters in order to evaluate the present farmers' living conditions in the projects, which will be useful for project evaluation in terms of increase of their living standard by the projects rehabilitation. The following scoring method is applied for this parameter:

Present Living Condition	Score
Very poor	5
Poor	4
Moderate	3
Good	2
Very high	1

(6) Environmental Effects

It is reported that there would be six impacts on the environment and human health,

which are (i) soil erosion in the watersheds, (ii) decrease of wildland, (iii) effects on water quality and ecology due to agricultural intensification, (iv) spread of water-borne diseases due to expansion of irrigated land, (v) decrease of firewood forest, and (vi) decrease of grazing areas. Although analysis of data on these effects due to the projects rehabilitation is still under way, this parameter is taken up as one of the main parameters because of its importance. The scoring in this parameter is as follows:

Environmental Effect	Score
None or negligible	5
Very small	4
Moderate	3
Large	2
Very large	1

6.2 Result of Evaluation

The evaluation of each project is made, using the above six (6) parameters, and the economic evaluation expressed in EIRR. The evaluation of each project expressed in figure is thus made as presented in Table A-51, and the economic internal rate of return (EIRR) of each project is shown in Table A-50. The following is a summary of the evaluation :

Parameter	Ash.	Wej.	Amt.	Afi.	Avy.	Kpd.	Mnk.	Aku.	Tan.	Bon.	Sub.	Oky.
1. Facility	19	16	20	12	21	21	23	20	21	13	21	20
2. Water	5	5	5	5	5	5	5	4	5	5	5	5
3. Participation	5	2	3	3	3	3	3	3	2	3	2	3
4. Activity	3	3	5	4	5	5	5	5	3	4	4	5
5. Economy	4	2	3	4	3	3	3	5	4	4	5	4
6. Environment	1	4	2	4	3	2	3	2	2	4	2	4
Total Point	**36**	**32**	**38**	**32**	**40**	**39**	**42**	**39**	**37**	**33**	**39**	**41**
EIRR (%)	**4.2**	**6.9**	**16.9**	**16.3**	**13.6**	**20.2**	**16.0**	**0.4**	**-3.4**	**17.7**	**7.1**	**13.0**

6.3 Comments on Evaluation and Selection of Priority Projects

On the basis of the above Table A-50 and the economic viability (EIRR) of each project, the first selection of priority projects proposed for the finalisation through discussion with GIDA is made, also taking into account the following characteristics of the projects :

As seen in the above table, the highest score (42 points) is given to Mankessim project and followed by Okyereko project (41 points), and their EIRR is 16.0 % and 13.0 %, respectively. The present cropped area with irrigation is 26 ha in Mankessim and 22 ha in Okyereko, despite of 176 ha and 111 ha of irrigable area, respectively. The water for irrigation use is available for both projects to serve the irrigable area, though additional supply of water from the Ayensu river should be made for Okyereko. According to questionnaire survey, in addition, gross farm income per family and farmer's living standard in the projects are low as compared with those in other projects. It is then proposed that these projects be selected for the feasibility study.

Aveyime project is given the third high point (40 points), and EIRR is 13.6 %. At present, its activities of Aveyime project are mostly stopped because of high deterioration of most of the project facilities. Consideration will be given to these situations. In addition, any other physical negative factors could not be found in terms of the project rehabilitation.

In case of Kpando-Torkor project, actual cropped area with irrigation is only 13 ha at

present because of high deterioration of pumps and sprinkler system, despite of the fact that the project has 356 h of irrigable land and ample water for irrigation use. EIRR of Kpando-Torkor is 20.2 %. Although the economic evaluation at this time is still tentative and only for the purpose of selecting the priority projects, the EIRR would be acceptable. In addition, this project could be used as a model for extension of improved irrigation farming with sprinkler system in gentle sloping area after rehabilitation.

Then, two projects of Aveyime and Kpando-Torkor are proposed for further discussion and feasibility study.

The lower point (36 points) is given to Ashaiman project, and EIRR is also low, 4.2 %. Although the needs of rehabilitation are very high because of high deterioration of the irrigation and drainage networks, the main problem of this project is high water shortage. The water study shows that irrigable area under irrigation with 80 % dependability would be 44 ha. However, consideration should be paid for the existence of IDC in this area. The main activities of IDC are rice and horticulture experiments, soil research and agro-environmental research. As mentioned in Section 4.6 "Institutional Improvement Plan", various plans and programs are proposed for institutional improvement of GIDA as well as the existing farmer's societies. In this framework, the function of IDC will be very important for successful implementation of projects rehabilitation, transfer of O&M to the society as well as their flow-up works. It is therefore expected that IDC should play more important role in strengthening research activities for improving irrigation farming and its training to the extension officers and farmers in the reactivated projects. Then, this project is proposed for feasibility study.

As a result, the above five (5) projects, Ashaiman, Kpando-Torkor, Aveyime, Mankessim and Okyereko, are proposed for further discussion and feasibility study.

Amate project is also given higher point (38 points), and EIRR would also be acceptable with 16.9 %, but the main problem is that the access roads to this project site from both the northern and southern sides are very poor, which will make the construction of rehabilitation works, marketing of farm products and timely supply of farm inputs difficult. Rehabilitation of access road will be the basic requisite for this project.

Weija project is given the lowest point 32, and EIRR would be on the lower line. In addition, the project is well operated, though some rehabilitation works will be required, and the gross farm income and living standard of the farmers are very high among the projects.

Total point given to Afife and Bontanga is nearly the same and on the marginal line, but EIRR of both projects is high, 16.3 % and 17.7 %, respectively. However, the existing facilities in both projects, particularly the main facility such dam and main canal, are well maintained, though some rehabilitation works will be needed, and the works would be rather small in construction quantity.

For these situations in Amate, Weija, Afife and Bontanga, they are proposed as a candidate for rehabilitation at the future stage.