GHANA IRRIGATION DEVELOPMENT AUTHORITY
MINISTRY OF FOOD AND AGRICULTURE
THE REPUBLIC OF GHANA

BASIC DESIGN STUDY REPORT ON THE PROJECT FOR REHABILITATION OF IRRIGATION IN THE REPUBLIC OF GHANA

MARCH 1998

JAPAN INTERNATIONAL COOPERATION AGENCY
NIPPON KOEI CO., LTD.
TAIYO CONSULTANTS CO.,LTD.

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PREFACE

In response to a request from the Government of the Republic of Ghana the Government of Japan decided to conduct a basic design study on the Project for Rehabilitation of Irrigation and entrusted the study to the Japan International Cooperation Agency (JICA).

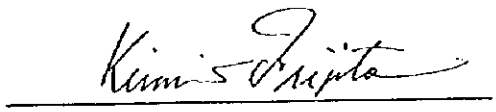
JICA sent to Ghana a study team from November 22 to December 21, 1997.

The team held discussions with the officials concerned of the Government of Ghana, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Ghana in order to discuss a draft basic design, and as this result, the present report was finalized.

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

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Ghana for their close cooperation extended to the team.

March, 1998



Kimio FUJITA

President
Japan International Cooperation Agency

March, 1998

Letter of Transmittal

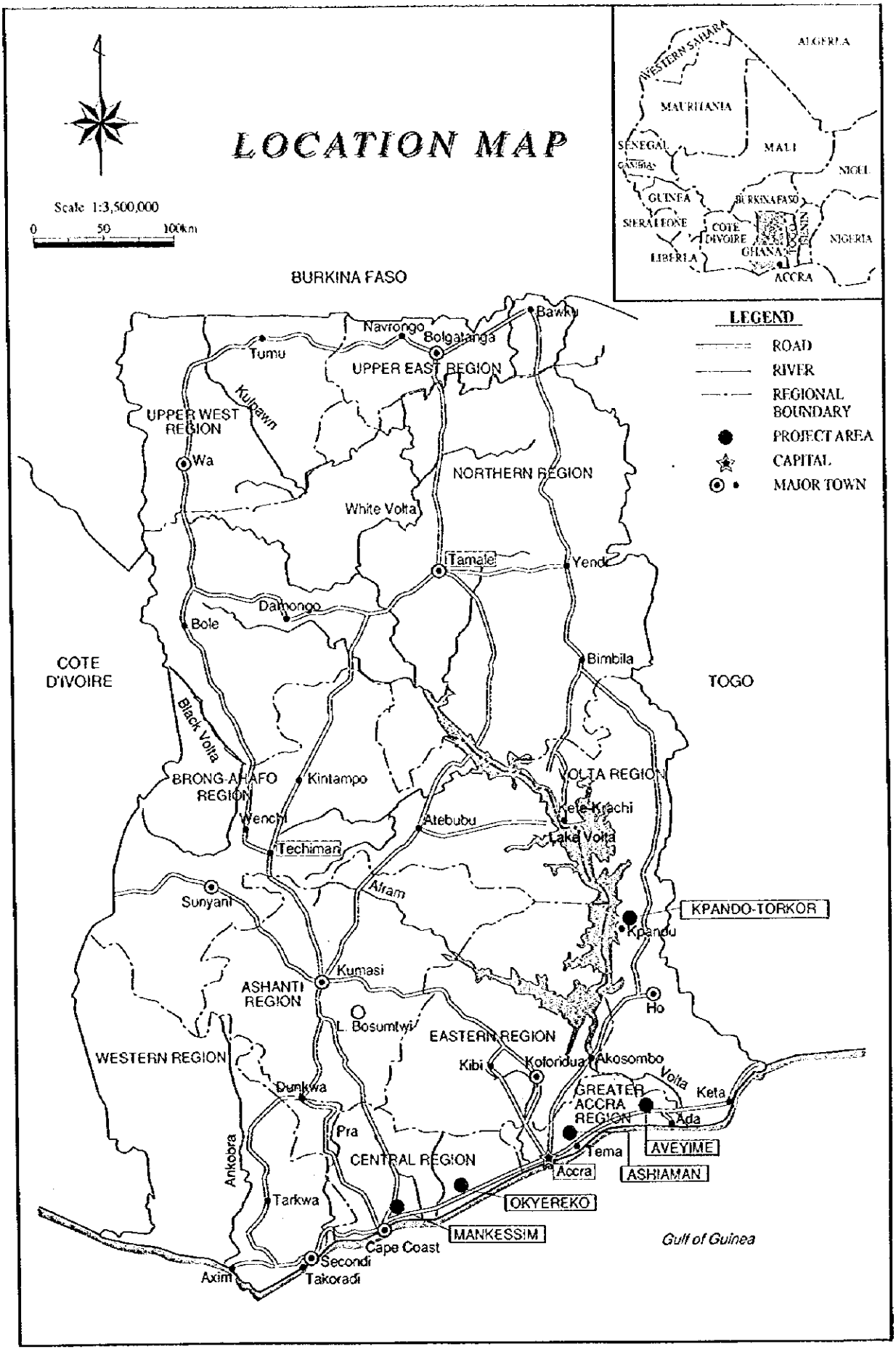
We are pleased to submit to you the basic design study report on the Project for Rehabilitation of Irrigation in the Republic of Ghana.

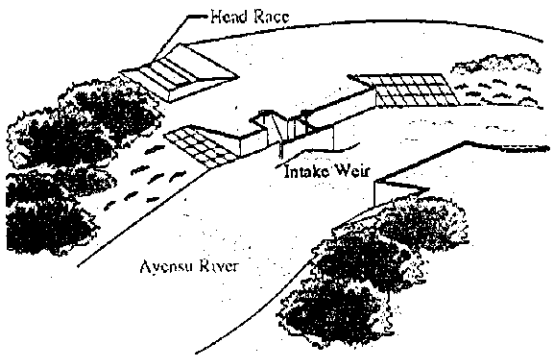
This study was conducted by Nippon Koei Co., Ltd. and Taiyo Consultants Co., Ltd., under a contract to JICA, during the period from November 19, 1997 to March 31, 1998. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Ghana and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

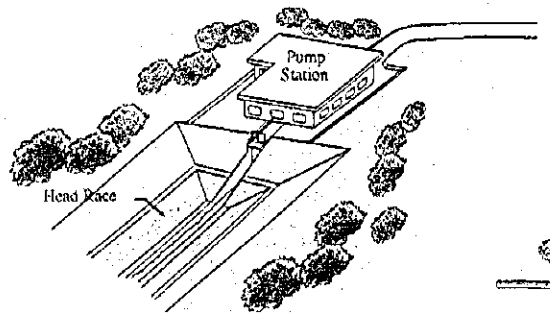
Very truly yours,

Kunio IRIE
Project manager,
Basic design study team on
the Project for Rehabilitation
of Irrigation
Nippon Koei Co., Ltd.

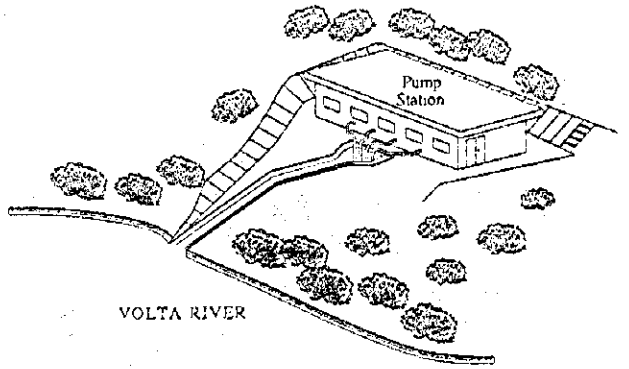

LOCATION MAP
Scale 1:3,500,000
0 50 100km
BURKINA FASO
COTE D'IVOIRE
TOGO
Gulf of Guinea
LEGEND
ROAD
RIVER
REGIONAL BOUNDARY
PROJECT AREA
CAPITAL
MAJOR TOWN
Navrongo
Bolgatanga
Bawku
Tumu
UPPER EAST REGION
Kulpawn
UPPER WEST REGION
Wa
NORTHERN REGION
White Volta
Tamale
Yendi
Damongo
Bole
Bimbila
Black Volta
BRONG-AHAFO REGION
Kintampo
Wenchi
Techiman
Atebubu
VOLTA REGION
Lake Volta
Afram
Sunyani
KPANDO-TORKOR
Kpandu
Kumasi
ASHANTI REGION
Ho
L. Bosumtwi
EASTERN REGION
WESTERN REGION
Kibi
Koforidua
Akosombo
Volta
Keta
Dunkwa
GREATER ACCRA REGION
Ada
Pra
Ankobra
CENTRAL REGION
Tema
AVEYIME
ASHIAMAN
Accra
Tarkwa
OKYEREKO
MANKESSIM
Cape Coast
Secondi
Takoradi
Axim
ALGERIA
WESTERN SAHARA
MAURITANIA
SENEGAL
GAMBIA
MALI
NIGER
GUINEA
BURKINA FASO
SIERRA LEONE
COTE D'IVOIRE
GHANA
NIGERIA
LIBERIA
ACCRA



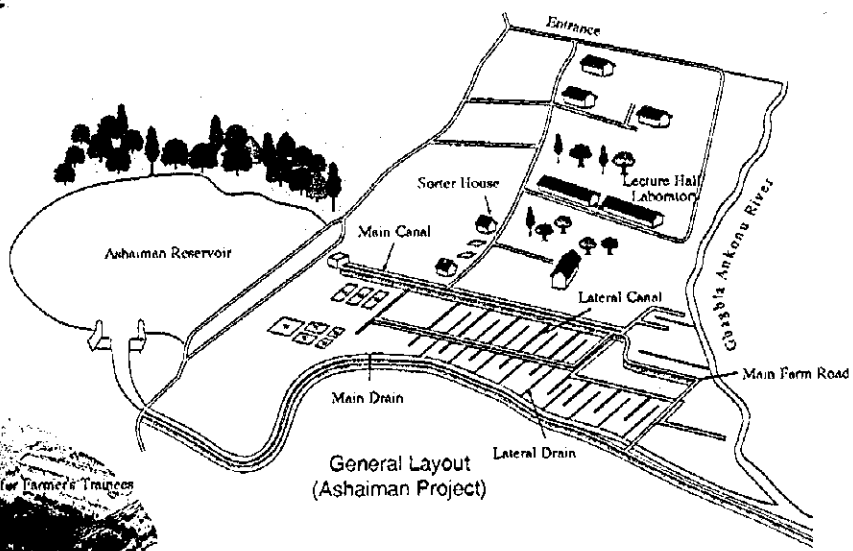
Intake Weir
(Okyereko Project)



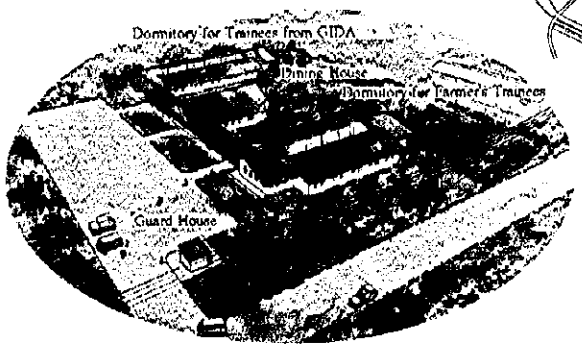
Kpando-Torkor Project



Aveyime Project

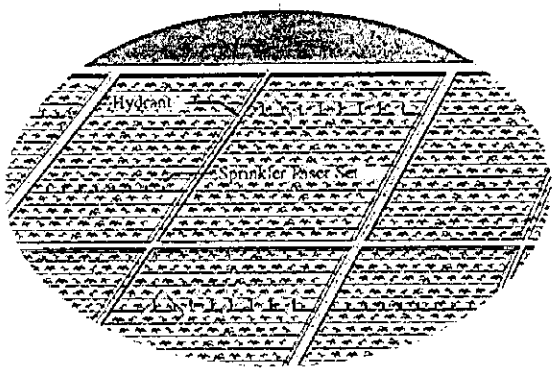


General Layout
(Ashaiman Project)



Training Buildings
(Accra)

Sprinkler Irrigation System
(Mankessim Project)



PERSPECTIVE

ABBREVIATIONS

1. Organisations/Names

ADRA	Adventist Development and Relief Agency
AGSAC	Agricultural Sector adjustment Credit
ASRP	Agricultural Services Rehabilitation Project
CEDEP	Centre for the Development of People
CIDA	Canadian International Development Agency
COCOBOD	Ghana Cocoa Board
CUSO	Canadian University Students Overseas
DA	District Assembly
DCA	Development Credit Assembly
DFR	Department of Feeder Road
DPBU	District Planning and Budgeting Unit
DWM	December 31st Women's Movement
EAP	Environmental Action Plan
EIRR	Economic Internal Rate of Return
EPC	Environmental Protection Council
ERP	Economic Recovery Program
FY	Financial or Fiscal Year
FAO	Food and Agriculture Organisation of the United Nations
GAPVOD	Ghana Association of Private Voluntary Organisations in Development
GDP	Gross Domestic Products
GEPC	Ghana Export Promotion Council
GFDC	Ghana Food Distribution Corporation
GIDA	Ghana Irrigation Development Authority
GOG	Government of Ghana
GTZ	Ghana Technical Cooperation Agency
IAPSO	Inter-Agency Procurement Services Office
ICOUR	Irrigation Company of the Upper East Region
ICR	Implementation Completion Review
JICA	Japan International Cooperation Agency
MLG	Ministry of Local Government and Rural Development
MOF	Ministry of Finance
MOFA	Ministry of Food and Agriculture
MRH	Ministry of Road and Highways
MTADP	Medium Term Agricultural Development Strategy
MTR	Mid-Term Review
NORRIP	Northern Region Rural Integrated Project
NPV	Net Present Value
ODA	Overseas Development Administration of UK
PAMSCAD	Program of Actions to Mitigate the Social Costs of Adjustment and Development
PCC	Project Co-ordination Committee
PCU	Project Co-ordination Unit
PNDC	Provincial National Defence Council
PPMED	Policy Planning, Monitoring, and Evaluation Department
PU	Project Unit
SOE	Statement of Expenditure
SAC	Structural Adjustment Credit
SPAC	Sub Project Approval Committee
TSA	Technical Support Agency
USADEP	Upper Region Agricultural Development Project
VORADEP	Volta River Agricultural Development Project
VRA	Volta River Authority
WB	World Bank

2. Others

B	: Benefit	EIRR	: Economic Internal Rate of Return
C	: Cost	El.	: Elevation above Mean Sea Level
D	: Water Depth	GDP	: Gross Domestic Product
DFL	: Design Flood Level	GNP	: Gross National Product
dia	: Diameter	O&M	: Operation and Maintenance
Eq	: Equation	RD	: Reduced Distance
Fig.	: Figure	Ref.	: Reference

Length

mm	=	Millimetre
cm	=	Centimetre
m	=	Meter
km	=	Kilometre

Time

s	=	Second
min	=	Minute
h	=	Hour
d	=	Day
y	=	Year

Area

cm^2	=	Square centimetre
m^2	=	Square meter
ha	=	Hectare
km^2	=	Square kilometre

Electrical Measures

W	=	Watt
kW	=	Kilowatt
MW	=	Megawatt
kWh	=	Kilowatt hour
V	=	Volt

Volume

cm^3	=	Cubic centimetre
lit	=	Liter
m^3	=	Cubic meter
MCM	=	Million cubic meter

Other Measures

%	=	Percent
°	=	Degree
'	=	Minute
"	=	Second
°C	=	Degrees Celsius

Weight

mg	=	Milligram
g	=	Gram
kg	=	Kilogram
ton	=	Metric ton

Derived Measures

m^3/sec	=	Cubic meter per second
lit/sec	=	Litre per second
lit/s/ha	=	Litre per second per hectare
md	=	Man day
M/M	=	Man Month

Currency and Others

Cedis	=	Ghana's Currency
US$	=	US Dollar
¥	=	Japanese Yen

CONVERSION FACTORS

From Metric System

1 cm	=	0.394 inch
1 m	=	3.28 ft
1 km	=	0.621 mile
1 cm^2	=	0.155 sq.in
1 ha	=	2.471 acres
1 km^2	=	100 ha
1 km^2	=	0.386 sq.mile
1 cm^3	=	0.0610 cu.in
1 m3	=	35.3 cu.ft.
$10^6 m^3$	=	811 acre-ft
1 long ton	=	1,016.05 kg
1 m^3/s	=	35.3 cusec

To Metric System

1 inch	=	2.54 cm
1 ft	=	30.48 cm
1 mile	=	1.609 km
1 sq.ft	=	0.0929 m^2
1 acre	=	0.4047 ha
1 ha	=	0.01 km^2
1 sq.mile	=	2.59 km^2
1 cu.ft	=	28.32 lit
1 cu.ft	=	0.0283 m^3
1 acre-ft	=	1,233.5 m^3
1 kg	=	0.000984 long ton
1 cusec	=	0.0283 m^3/s

SUMMARY

SUMMARY

The Republic of Ghana lies on the west coast of Africa between latitudes 4° and 11° north. Its southern boundary is formed by the Gulf of Guinea and to the north, east and west lie the states of Burkina Faso, Togo and Cote d'Ivoire, respectively. Its area covers about 239,460 km^2. The total population of Ghana in 1994 is estimated at 16.5 million, with an assumed population growth rate of 3.0% per annum. Ghana is mainly an agricultural country. Out of 23.9 million ha of total land area, about 22% is cultivated and 7% is under perennial crops such as cocoa, oil palm and rubber. Agriculture is predominantly on a small holder basis. The mean farm size is less than 1.6 ha. About 70% of its working population is engaged in agriculture which includes crops, livestock, fisheries, forestry and cocoa sub-sectors. However, agriculture is not able to keep up with the growing domestic demand for food and part of the demand for food has been met by increased imports.

In the Plan of Public Investment (1988-1990) and Restructuring Plan (1992-1994), the Government puts priority on increasing of agricultural productivity of smallholder farmers and raising living standards of small farmers in rural areas. Besides, in the Medium Term Agricultural Development Programme (MTADP: 1995-2005) launched in recent years, the Government has placed a high priority on agriculture to satisfy the country's food needs, to create rural employment opportunities, to generate foreign exchange through export promotion of agricultural products, to promote balanced regional development, and to improve the existing irrigation projects.

The Ghana Irrigation Development Authority (GIDA) under the Ministry of Food and Agriculture (MOFA) has constructed and been managing small and medium-scale irrigation schemes with a command area ranging from 100 to 2,000 ha at 22 locations over the whole country. The total area already developed is about 6,700 ha. However, most of these schemes are showing low level performance due to a combination of various constraints. The prevailing constraints are represented by low productivity due to deterioration of irrigation facilities, shortage of irrigation water, soil problem, and weakness of support services from the related institutions. The irrigation review report prepared by the World Bank in 1986 proposed to put priority on rehabilitation of existing irrigation systems and strengthening of the operation and maintenance (O&M) systems rather than promotion of new development of large-scale irrigation projects. Then, the Government gives a high priority to rehabilitation of existing irrigation schemes, as an important measure, to achieve the key polices set out in MTADP.

In this background, the Government of Ghana (GOG) requested the Government of Japan

(GOJ) in 1993 the execution of master plan and feasibility studies on the existing irrigation schemes under GIDA's management, for their rehabilitation and for expansion of the irrigation area. In response to a request from GOG, the GOJ decided to conduct the studies, and the Japan International Cooperation Agency (JICA) carried out the studies during the period between 1995 and 1997. As a result, five (5) priority irrigation schemes are selected for feasibility study in the master plan study and the feasibility study concluded that the priority schemes are both technically and economically feasible.

Then, GOG requested GOJ to extend grant aid assistance for implementation of the Project for rehabilitation of the priority irrigation schemes (the Project) as well as the technical assistance for establishment of the agricultural technologies, such as irrigated farming, water management, and activation of farmers' organisation.

In response to the request for project implementation, GOJ decided to conduct a basic design study and JICA sent a basic design study team during the period from November 22 to December 21, 1997. The study team carried out the basic design study on the five (5) priority irrigation schemes at Ashaiman, Aveyime, Kpando-Torkor, Mankessim and Okyereko for rehabilitation/improvement of the irrigation, drainage system, farm road and building facilities of these five schemes, on the basis of the field investigation and discussion with the GIDA staff in Ghana. Then, the team prepared a draft basic design study report which contained the contents of the Project, implementation plan, the scope of works by GOG, etc.

JICA dispatched a mission to explain the draft basic design report to GOG during the period between 11th and 20th of February in 1998. The basic agreement was signed and exchanged after the contents of the Project have been verified and agreed upon by both parties.

The basic concepts of the basic design are summarized as follows :

(1) Irrigation and Drainage Plan

(a) Preparation of plan and design of the facilities will be made, taking into account the handing-over of O&M function to the farmers' organisations at final stage. The facilities should be those for easy and smooth O&M by farmers themselves from both technical and economical viewpoints.

(b) The function of the schemes as a model for further extension of irrigated agriculture over the country should also be taken into account. The realistic and practical plan and design of the facilities should be prepared for the

purpose of promoting the small-scale irrigated agriculture, also taking into consideration the present irrigated agriculture in Ghana and maximum use of the existing facilities for cost-saving.

(c) The plan and design of the project facilities should be prepared for increase of the project productivity as well as for sustainable management of the facilities through elimination or alleviation of the present technical constraints such as water shortage, water leakage along the canals, poor drainage, etc. In addition, consideration should be given to the countermeasures for soil erosion due to steep slope topography in preparation of plan and design of the facilities.

(2) Building Plan

(a) The design should be made, taking into consideration the climate, natural features, lifestyle, architectural standard and other characteristics prevailing at the proposed construction sites of the buildings.

(b) The alignment and structural design of the building facilities for agricultural use such as dry yard, store house, sorter house, etc. should be made for effective post-harvesting activities.

(c) The training programmes of GIDA as well as those by the Japanese experts of the Small-Scale Irrigated Agriculture Promotion Project should be taken into account for preparation of plan and design of the training facilities. The plan and design of dormitories and dining house to be provided in Accra are prepared so that 20 trainees of GIDA's staff per one training cycle and 20 farmers trainees/one cycle can be accommodated.

(3) Procurement Plan

(a) To cope with the present problems in O&M of the irrigation and drainage facilities and sustainable management of the Project after rehabilitation, the necessary equipment will be procured, taking into account the following :

(i) Procurement of equipment which is familiar to and useful for GIDA's staff and farmers

(ii) Procurement of equipment which has simple mechanical structures and for which the preliminary repair can be made at the site

(iii) Procurement of equipment for which after-care services and necessary spare parts are available in Ghana

(b) The main problems seen in the farm management in the irrigated areas are (i) insufficient services for supply of farm inputs, transportation of farm products and marketing, (ii) shortage of equipment necessary for movable and emergency services for extension in the project area, (iii) difficulties in keeping good communication between the site office and GIDA's headquarters and other relevant agencies, and (iv) lack of transportation equipment for training by GIDA. In order to cope with the problems, appropriate equipment will be procured also for effective and sustainable management of the irrigation schemes as well as for farming.

The proposed contents of the Project will be as follows :

(1) Rehabilitation and improvement of irrigation and drainage system covering the following irrigation area :

(a)	Ashaiman scheme	:	56 ha
(b)	Aveyime scheme	:	80 ha
(c)	Kpando-Torkor scheme	:	70 ha
(d)	Mankessim scheme	:	29 ha
(e)	Okyereko scheme	:	81 ha
	Total		316 ha

(2) Building facility

(a)	For five irrigation schemes	: O&M office, storehouse, garage, dry yard, sorter house and related facilities
(b)	Training facility	: Office, lecture hall, laboratories, and related facilities at Ashaiman
(c)	Dormitory/dining house	: Dormitory for training of GIDA's staff, dormitory for farmer trainees, dining house and related facilities

(3) Procurement of equipment : O/M equipment

The Project will be implemented, dividing the construction works into two (2) stages. At the first stage, the construction of two (2) irrigation schemes at Ashaiman and Okyereko and the training facilities in Accra will be executed. The implementation of Aveyime, Mankessim and Kpando-Torkor irrigation schemes will be carried out at the second stage. The implementation of the Project requires about 30 months in total after signing the Exchange of Note (E/N) by GOG and GOJ.

GIDA under MOFA is the executing agency for the Project implementation and the Department of Project Development of GIDA has the direct responsibility for the construction management. There exist two (2) regional offices under this department and site offices at each site of Ashaiman, Aveyime, Kpando-Torkor, Mankessim and Okyereko. These regional and site offices will also be engaged in the construction supervision under the control and instruction from the Department of Project Development.

O/M works will be executed by GIDA, MOFA, and the farmers1 organisation already established at each irrigation scheme. GIDA has a plan to hand over O&M function of the all project facilities to the farmers' organisations in accordance with the strategy of MTADP.

However, the present structure of the farmers1 organisation do not reach the satisfactory level for O/M of the major facilities such as dam and pumping station. Therefore, the farmers' organisations should be strengthened in order to ensure successful O/M works of the major facilities. For strengthening the farmers1 organisation, GIDA planned to set an appropriate period of time as transition period for the handing-over process. The transition period of three (3) years is planned by GIDA. Regards the minor Project facilities, such as canals, roads, pipeline systems, etc., the farmers1 organisations will execute O/M works by themselves just after implementation of the Project under full technical and managerial guidance and assistance from GIDA as well as the government agencies concerned.

It is concluded that the implementation of the Project is suitable and viable for Japan's Grant Aid as a result of the field investigation in Ghana and the analysis in Japan, since the Project will largely contribute to the achievement of key policies stipulated in the Medium Term Agricultural Development Programme (MTADP : 1995 - 2005)

Judging from the circumstances around the five irrigation schemes included in the Project, it is expected that the Project will be implemented smoothly and effectively with due consideration and realization of the following commitments by the concerned parties :

(a) To carry out land acquisition for rehabilitation/improvement of the project facilities and construction of building facilities.
(b) To strengthen the GIDA's organisation for handing-over of O&M function to the farmers' organisations.
(c) To strengthen the farmers1 organisation for taking-over of O&M function from GIDA.
(d) To establish a technical supporting system to the farmers' organisations for effective and sustainable O&M of the Project after handing-over.

BASIC DESIGN STUDY
ON
THE PROJECT FOR REHABILITATION OF IRRIGATION
IN
THE REPUBLIC OF GHANA

BASIC DESIGN STUDY REPORT

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CHAPTER 1
BACKGROUND OF THE PROJECT

CHAPTER 1 BACKGROUND OF THE PROJECT

The Republic of Ghana lies on the west coast of Africa between latitudes 4° 44' and 11° 10' north and altitude 3° 15' west and 1° 11' east. Its southern boundary is formed by the Gulf of Guinea and to the north, east and west lie the states of Burkina Faso, Togo and Cote d'Ivoire, respectively. Its area covers about 239,460 km^2. The total population of Ghana in 1994 is estimated at 16.5 million, with an assumed population growth rate of 3.0% per annum. This gives a population density of 69 per km^2.

Ghana is mainly an agricultural country. Out of 23.9 million ha of total land area, about 22% is cultivated and 7% is under perennial crops such as cocoa, oil palm and rubber. Agriculture is predominantly on a small holder basis. The mean farm size is less than 1.6 ha. About 70% of its working population is engaged in agriculture which includes crops, livestock, fisheries, forestry and cocoa sub-sectors. According to the statistical data of the country, cocoa, forestry, sawmilling and other agriculture outputs made up about 40% of the Gross Domestic Product (GDP) in 1994 and this proportion is declining in recent years. The agricultural sector earns foreign exchange for the country through exports of traditional commodities (US$ 509 million equivalent in 1994). The two agricultural products, cocoa and timber, have provided over 42% of the country's total foreign exchange earned in 1994. However, agriculture is not able to keep up with the growing domestic demand for food and part of the demand for food has been met by increased imports.

In the Plan of Public Investment (1988-1990) and Restructuring Plan (1992-1994), the Government puts priority on increasing of agricultural productivity of smallholder farmers and raising living standards of small farmers in rural areas. Besides, in the Medium Term Agricultural Development Programme (MTADP: 1995-2005) launched in recent years, the Government has placed a high priority on agriculture to satisfy the country's food needs, to create rural employment opportunities, to generate foreign exchange through export promotion of agricultural products, to promote balanced regional development, and to improve the existing irrigation projects.

The Ghana Irrigation Development Authority (GIDA) has constructed and been managing small and medium-scale irrigation schemes with a command area ranging from 100 to 2,000 ha at 22 locations over the whole country. The total area already developed is about 6,700 ha. However, most of these schemes are showing low level performance due to a combination of various constraints. The prevailing constraints are represented by low productivity due to deterioration of irrigation and drainage facilities, shortage of irrigation

water, soil problem, and weakness of support services from the related institutions. The irrigation review report prepared by the World Bank in 1986 proposed to put priority on rehabilitation of existing irrigation systems and strengthening of the operation and maintenance (O&M) systems rather than promotion of new development of large-scale irrigation projects. Then, the Government gives a high priority to rehabilitation of existing irrigation schemes, as an important measure, to achieve the key polices set out in MTADP.

In this background, the Government of Ghana (GOG) requested the Government of Japan (GOJ) in 1993 the execution of master plan and feasibility studies on the existing irrigation schemes under GIDA's management, for their rehabilitation and expansion of the irrigation area. In response to a request from GOG, the GOJ decided to conduct the studies, and the Japan International Cooperation Agency (JICA) carried out the studies during the period between 1995 and 1997. As a result, five (5) priority irrigation schemes are selected for feasibility study in the master plan study and the feasibility study concluded that the priority schemes are both technically and economically feasible. In addition, the Japanese Technical Cooperation for the Small-Scale Irrigated Agriculture Promotion Project has been started from August in 1997 for the purpose of establishing sustainable farming system for small-scale farmers in the irrigated areas under the management of GIDA. This technical cooperation is continued for five (5) years, up to 2002.

Then, GOG requested GOJ to extend a grant aid assistance for implementation of the Project for rehabilitation of the priority schemes (the Project). The major components of the request are as follows :

(a) Rehabilitation of existing project facilities such as irrigation and drainage system, farm roads and buildings for agricultural use covering 472 ha of land in total at Ashaiman, Aveyime, Kpando-Torkor, Mankessim and Okyereko.
(b) Construction of building facilities for training of GIDA's staff as well as farmers related to O&M of the Project.
(c) Supply of equipment necessary for operation and maintenance (O&M) of the rehabilitated irrigation schemes at the above five (5) sites.

In response to this request, GOJ decided to conduct a basic design study. JICA sent a basic design study team during the period from November 22 to December 21, 1997 in order to collect additional data and information, and to have discussions with the officials concerned of GOG as well as GIDA on the scope of works and the organization for operation and maintenance of the Project after implementation under the Japan's Grant Aid.

Based on the field investigation including the discussions with GOG, the basic design study was conducted, taking into consideration a scale of grant aid and operation and maintenance of the Project. The basic design study team prepared the draft basic design study report on the basis of the study. Then , JICA sent the team to Ghana for explanation of the draft report to the Government of Ghana and for further discussion on the Project component, plan, and design of the Project. GOG and the basic design study team mutually agreed on the draft basic design report and confirmed that the following will be included in the Project works.

(a) Rehabilitation/ improvement of irrigation and drainage facilities for 316 ha of irrigation area at Ashaiman, Aveyime, Kpando-Torkor, Mankessim and Okyereko schemes

(b) Construction of building facilities for operation and farming use such as O&M offices, dry yards, sorter houses, store houses, and garages for the above five (5) irrigation schemes

(c) Construction of training building at Ashaiman and training dormitories for GIDA's staff and farmer trainee in Accra, and

(d) Procurement of the O/M equipment

CHAPTER 2
CONTENTS OF THE PROJECT

CHAPTER 2 CONTENTS OF THE PROJECT

2.1 Objectives of the Project

In the Plan of Public Investment (1988-1990) and Restructuring Plan (1992-1994), the Government puts priority on increasing of agricultural productivity of smallholder farmers and raising living standards of small farmers in rural areas. Besides, in the 10-year Medium Term Agricultural Development Programme (MTADP: 1995-2005) launched in recent years, the Government has placed a high priority on agriculture (i) to satisfy the country's food needs, (ii) to create rural employment opportunities, (iii) to generate foreign exchange through export promotion of agricultural products, (iv) to promote balanced regional development, and (v) to improve the existing irrigation projects.

The Government of Ghana has placed the development of irrigated agriculture and extension of irrigation farming techniques in high priority for satisfying the country's food demand and producing much of its industrial raw materials. In the light of this policy, the Government has a plan to rehabilitate and improve the existing small-scale irrigation schemes being operated and managed by the Ghana Irrigation Development Authority (GIDA), in order to recover the agricultural productivity of these irrigation schemes. In addition, the Government puts the emphasis on the achievement of key policies in MTADP such as recovery and stabilization of productivity of the schemes, increase of farm income of the smallholder farmers, improvement of farmers' living standard, etc. through further extension of irrigated agriculture over the country. For this purpose, the Project for Rehabilitation of Irrigation (the Project) will strongly be expected to be a core and pilot scheme for further rehabilitation and development of small to medium-scale irrigation schemes as well as for extension of operation and maintenance of the irrigation schemes by farmers themselves.

2.2 Basic Concept of the Project

2.2.1 Contents of the Project

The formal request of the Government of Ghana for the Project is to rehabilitate the project facilities and expand the irrigation area from the present 290 ha to 473 ha in total of the five (5) irrigation schemes at Ashaiman, Aveyime, Kpando-Torkor, Mankessim and Okyereko. In addition, the construction of training facilities is requested for the training of GIDA's

staff as well as farmers at two (2) sites, Ashaiman and Okyereko. The request also included the procurement of the equipment needed for operation and maintenance (O&M) of the irrigation facilities of all the five (5) schemes.

In the investigation for the basic design of the Project, the further study and evaluation have been made on the appropriateness of implementing the rehabilitation and improvement works at the above five (5) irrigation schemes in terms of O&M of the Project by farmers themselves and the function of the Project as a core and model scheme for further extension of irrigated agriculture over the country. As a result, an expansion block covering 17 ha of upland by sprinkler irrigation system at Aveyime is excluded from the Project because of the lack of experience of farmers in sprinkler irrigation and high costs per hectare for O&M and replacement of such an irrigation system. Similarly, the expansion block covering 85 ha of upland at Kpando-Torkor and the expansion block No.2 covering 57 ha of upland at Mankessim are also excluded from the Project, since the expansion of irrigated land in these two (2) areas is too large as compared with the existing irrigated land, which requires the farmers more experience in sprinkler irrigation, and higher costs for O&M and replacement of the facilities will be a burden on the farmers.

As for the training facilities, GIDA proposed to provide the training center at the site owned by the Ministry of Food and Agriculture (MOFA) in Accra at the time of field investigation for the basic design. Then, additional study on this matter was made on the basis of the field investigation. As a result, it is recommended that the office, lecture hall and laboratories be constructed at Ashaiman, and that the dormitories and the dining house be provided at the site owned by MOFA in Accra. These training facilities are designed so as to accommodate 20 trainees in one training cycle on the basis of the training programmes prepared by GIDA in the formal request, also taking into consideration the frequency of use of the facilities, O&M costs to be born by GIDA and management of the facilities by GIDA.

The equipment will be procured to meet the requirements for smooth and effective O&M of the project facilities.

The proposed contents of the Project will be as follows :

(1) Rehabilitation and improvement of irrigation and drainage system covering the following irrigation area :

(a) Ashaiman scheme	:	56 ha
(b) Aveyime scheme	:	80 ha
(c) Kpando-Torkor scheme	:	70 ha

(d)	Mankessim scheme	:	29 ha
(e)	Okyereko scheme	:	81 ha
	Total		316 ha

(2) Building facility

(a)	For five irrigation schemes	:	O&M office, storehouse, garage, dry yard, sorter house and related facilities
(b)	Training facility	:	Office, lecture hall, laboratories, and related facilities at Ashaiman
(c)	Dormitory/dining house	:	Dormitory for GIDA's staff, dormitory for farmer trainees, dining house and related facilities

(3) Procurement of equipment for O&M of the Project

2.2.2 Basic Concept for Irrigation and Drainage Plan

(1) Basic Design Policy

The design of rehabilitation and improvement of the irrigation and drainage facilities is made on the basis of the following basic policies :

(a) The O&M function of the irrigation and drainage facilities will be handed over from GIDA to the farmers' organisations already established at each irrigation scheme. Therefore, the facilities should be those for easy and smooth O&M by farmers themselves from both technical and economical viewpoints. For this purpose, the appropriate design of the facilities should be made on the basis of the proposed crops and cropping patterns and irrigation methods, also taking into consideration the farmers' experience in irrigated farming and the site conditions in and around the schemes.

(b) The Project will largely be expected as a model for further development of small-scale irrigated agriculture through extension of improved irrigation farming, reactivation of farmers' organisations and effective O&M of the project facilities by farmers themselves. Therefore, the realistic and practical plan and design of the facilities should be prepared for the purpose of promoting the small-scale irrigated agriculture, also taking into

consideration the present irrigated agriculture in Ghana and maximum use of the existing facilities for cost-saving.

(c) The plan and design of the facilities should be prepared for increase of the project productivity as well as for sustainable management of the facilities through elimination or alleviation of the present technical constraints such as water shortage, water leakage along the canals, poor drainage, etc. In addition, consideration should be given to the countermeasures for soil erosion due to steep slope topography in preparation of plan and design of the facilities.

(2) Basic Design Concept for Irrigation and Drainage Facilities

The basic design concept for rehabilitation of the irrigation and drainage facilities at each irrigation scheme is set and briefly explained as follows :

(a) Ashaiman scheme

- The existing irrigation and drainage facilities are rehabilitated for 56 ha of irrigated land on the left bank because of the limited water source for irrigation.
- The irrigation and drainage plan is prepared on the basis of the present gravity type of irrigation and rotational cropping of paddy rice and upland crops.
- The existing main irrigation canal is of earthen type and water leakage is observed at many points along the canal. Although the lateral canals are partly lined with concrete, they are generally deteriorated, which results in low function. Therefore, the existing irrigation network will have to be rehabilitated totally. The main and lateral canals will be of concrete flume type, in order to minimize canal seepage loss and to ensure the structural stability, because these canals are constructed on backfilled foundation.
- The existing drainage facilities such as main and lateral drains do not function properly due to much sedimentation and grasses. The proposed rehabilitation works are therefore to remove sediments and grasses and to finish the canal section as designed.
- Canal-related structures such as turnouts, checks, siphons, drops, culverts, dissipaters, etc. will be all rehabilitated to recover their functions.

Measuring devices which are essential for realizing proper water distribution by effective use of the limited water source, will be provided immediately downstream of turnouts.

- The existing farm road network is generally poor and requires improvement works for proper O&M of the project facilities as well as for transportation of farm products and inputs. A farm road is also constructed along the main drain so as to facilitate the removal of sediments in the drain.

(b) Aveyime scheme

- The plan and design of the facilities are prepared for 80 ha of land in total to be served by gravity irrigation, including 63 ha of existing paddy field and 17 ha of upland to be expanded.
- The existing pump station should be rehabilitated totally, because the existing pump and engine could not be operated since 1995 due to severe deterioration. The design of new pumps is made for 24-hour operation, because the water supply is mainly for paddy rice. The required number of pumps and capacity will be 4 sets (including one stand-by), each can supply 3.0 m^3/min. of water. Because the new pumps will be electrified, a new transmission line of 1.9 km long will be provided for this purpose by the Government side.
- The existing layout of irrigation canals and farm road network have no technical problems. However, part of them which is severely deteriorated will have to be rehabilitated to recover their original functions.
- The delivery pipeline of 130 m in length between the pump station and the main irrigation canal will be newly constructed. The secondary and lateral canals and drains which are of earthen type will have to be rehabilitated totally, because they are deteriorated due to sediments and slope collapse of embankments. The rehabilitation works of these irrigation canals will be made using concrete flume for easy and sustainable O&M by the farmers themselves.
- All of the existing farm roads will be rehabilitated by additional embankment (H= 60 cm) in order to protect the roads from inundation due to the excess water from paddy field.

(c) Kpando-Torkor scheme

- The Block-A covering 70 ha of land is selected for the scheme to be rehabilitated for upland crops cultivation by sprinkler irrigation system. All the project facilities are therefore designed for this purpose.
- The existing pumps and sprinkler system are deteriorated because of long time use over 10 years, and could not supply sufficient water for irrigation use from the Volta lake. Since the water levels in the lake fluctuate from season to season (LWL : 75.6 m and HWL : 84.7 m in elevation), floating type of pumps will be installed at the new pump station to be constructed on the lake shore.
- The required number and capacity of pumps are determined on the basis of 9 hour-operation per day, and 3 sets of pumps (including one stand-by), each with the lifting capacity of 3.7 m^3/min. of water are required to serve 70 ha of upland.
- The proposed sprinkler irrigation system is designed, using the natural gravity due to the steep slope of the land as effectively as possible. The irrigation water is lifted by the main pumps at first to the highest portion of the land, and then supplied to each irrigation block through concrete flume by gravity. The water is again supplied to the sprinkler system through pipelines by small pumps to be installed at the highest portion of each irrigation block. The required number of small pumps will be 6 sets in total, each can supply 0.6 to 2.0 m^3/min. of water with a total head of 40 m.
- The electrification of pumps requires the construction of new transmission line of 8 km long which should be provided by the Government side and will take time for its construction. Therefore, the supply of electricity to the pumps will be made by using diesel generator to be installed newly.
- The small streams which run downward the Volta lake will be used as the main drain. In addition, lateral drains will be constructed within the project area along the farm roads in order to evacuate the excess rain water to the main drain. The slope protection works to minimize soil erosion will be required at the junction of lateral drains and the small streams.
- Since the present farm road network in the scheme is generally poor in number and function, new road network will be constructed so as to serve a farming plot covering about 12 ha of land in terms of easy O&M of the facilities and protection of the land from soil erosion.

- Green belts will also be provided along the contour lines as the countermeasures for soil erosion.

(d) Mankessim scheme

- The design of the project facilities is made so as to serve 29 ha of upland by sprinkler irrigation system.
- Since the existing pumps, pipeline and sprinkler equipment are all deteriorated, the proposed sprinkler system will be constructed newly.
- Because the irrigation area of the scheme is small, the water will be supplied directly to the sprinkler system from the main pump. The required number of pumps will be 3 sets including one stand-by, each can supply 1.6 to 2.0 m^3/min. of water with 45 m of total lifting head.
- The excess rain water from the scheme will be evacuated to adjacent lowland through the lateral drains to be provided along the farm roads. A new road network will be constructed so as to serve a farming plot covering about 12 ha of land in terms of easy O&M of the facilities and protection of the land from soil erosion.

(e) Okyereko scheme

- The proposed rehabilitation plan for Okyereko scheme is prepared to cover 81 ha of land, including 39 ha of existing paddy field and 42 ha of upland to be expanded in connection with the rehabilitation.
- The existing water source for this scheme (reservoir) has high water shortage and can irrigate the existing paddy field on the right bank only. The proposed plan will therefore include the construction of a new pump station and a new intake weir in order to cope with the present water shortage. These facilities will be constructed on the Ayensu river running adjacent to the scheme on the west.
- The additional water diverted by the weir from the Ayensu will be conveyed to the pump station through a headrace and lifted up in order to supply water to the reservoir.
- The hydrological study of the Ayensu river shows that available water which can be supplied to the reservoir is restricted to 1,457,000 m^3 in a year, by operating the pumps for 7 months from June to December. The required number of pumps will be 3 sets (including one standby), each can supply 4.1 m^3/min. with a total lifting head of 23 m.

- Since the existing distribution line of electricity is located about 8 km far from the scheme, the electricity supply to the pumps will be made, using new diesel generator.
- The existing canal network covering 39 ha of paddy field consists of main, secondary and lateral canals, and the main canal is lined with concrete blocks. They have many water leakage portions because of deterioration and poor construction. In addition, canal-related structures are also deteriorated and insufficient in required quantity as well as location. Therefore, they will be all constructed newly. The expansion block located downstream of the existing paddy field could be irrigated by extending the existing canal network. The new upland block on the left bank will require a new irrigation system to command 18 ha of upland. The proposed canals will be of concrete flume type, and the related structures will be designed and constructed in accordance with the design standard applied for Ashaiman and Aveyime schemes.
- Since the existing drainage system including the main and lateral drains is deteriorated due to poor maintenance, they will be rehabilitated by removing sediment and grasses in the drains to recover their functions.
- The rehabilitation of farm road network will be made for easy O&M of the facilities as well as for transportation of farm products and inputs, keeping a close connection between the left and right bank areas.

2.2.3 Basic Concept for Building Plan

(1) Basic Design Policy

The design of building facilities for agricultural use at each irrigation scheme as well as for the training facilities at Ashaiman and Accra is made on the basis of the following basic design policy :

(a) The design should be made, taking into consideration the climate, natural features, lifestyle, architectural standard and other characteristics prevailing at the proposed construction sites of the buildings.

(b) The alignment and structural design of the building facilities for agricultural sue such as dry yard, store house, sorter house, etc. should be made for effective post-harvesting activities which include collective harvest, trans-

portation, stockpiling, processing and marketing of farm products by farmers' groups.

(c) The training programmes of GIDA as well as those by the Japanese experts of the Small-Scale Irrigated Agriculture Promotion Project should be taken into account for preparation of plan and design of the training facilities. The training facilities to be constructed at Ashaiman (office, lecture hall and laboratories) are designed so as to meet the requirements of the above training programmes. The plan and design of dormitories and dining house to be provided in Accra are prepared so that 20 trainees of GIDA's staff per one training cycle and 20 farmers trainees/one cycle can be accommodated, also taking into consideration the expansion of these facilities which may be made by GIDA in the future.

(2) Basic Design Concept for Building Facilities

The basic design concept for the building facilities at each irrigation scheme and the training facilities in Accra is as follows :

(a) Ashaiman scheme

- The proposed building facilities for Ashaiman scheme will include O&M office, post-harvesting facilities and those for training.
- The construction site for building facilities will be the higher land located on the north-east of the existing facilities complex.
- Because the existing office is originally the house for living and has been used for long time, it is not suitable for O&M office. Therefore, it is proposed to construct a new office to meet the requirements for various activities of the scheme as well as those for the Irrigation Development Center (IDC) of GIDA.
- The new office will have two functions for O&M of the scheme and the training, and will be constructed within the existing building complex. The existing office may be used as store house or accommodation for GIDA's staff, depending on GIDA's plan.
- The post-harvesting facilities will include sorter house and garage, because the existing dry yard and store house can still be used for the post-harvesting purpose.

- The garage will be constructed adjacent to the existing repair shop, and its plan and design will be made, taking into account the store of O&M equipment to be procured for the Project. The sorter house will be provided near the dry yard for convenience of processing of farm products.
- The training facilities include the above O&M office, lecture hall and laboratories. These facilities will be constructed within the existing building complex, which should be convenient for the use by GIDA's staff for O&M and training as well as for the Japanese experts for the Small-Scale Irrigated Agriculture Promotion Project.
- All of the buildings to be constructed newly will be of flat type of building with simple design, using natural ventilation and lighting as much as possible.
- Since electricity and domestic water supply are already available in the complex, only requirement is the internal connection to supply to the office and garage as necessary.
- The existing trees in and around the complex should be remained in order to keep the present environment for working and living.

(b) Aveyime scheme

- The building facilities required for this irrigation scheme will consist of O&M office and post-harvesting facilities. The proposed construction site is the site of the existing buildings complex which is located about 2 km west from the scheme site and has about 5 ha of land space.
- Since the existing office is already deteriorated and also poor in floor space, construction of new office is required for O&M of the scheme and activities by farmers' organisation after rehabilitation of the scheme. The new office will be constructed at the site which is faced to the existing main road for easy transportation and communication by vehicles.
- Because the existing dry yards are sufficient in number and working space and still useful even at present, the proposed post-harvesting facilities will include store house, sorter house and garage. The store and sorter houses will be constructed adjacent to the existing dry yards, and the garage will be provided near the new office.
- Similar to Ashaiman, all of the buildings to be constructed newly will be of flat type of building with simple design, using natural ventilation and lighting as much as possible.

- Because domestic water supply facilities are not available in the existing buildings complex, it is proposed to provide such water supply facilities which will include a shallow tubewell, pumps, water tank and distribution pipeline.
- Since there exist the commercial electricity distribution lines near the complex, the electricity to each building can be supplied from the existing lines as necessary, about 40 m-long extension.

(c) Kpando-Torkor scheme

- The proposed building facilities for Kpando-Torkor scheme will include O&M office and post-harvesting facilities. The construction site can be secured in the project area and is located along the road to enter the scheme, which is about 400 m north from Torkor village.
- The existing building is only the office cum store house, which is very poor in floor space and structural design. Therefore, all of the buildings required will be provided newly. The O&M office and garage will be constructed as one group, and store house, dry yard and sorter house will be provided as another group for exclusive use for post-harvesting activities.
- All of the buildings to be constructed newly will be of flat type of building with simple design, using natural ventilation and lighting as much as possible.
- Because domestic water supply facilities are not available in the project area, it is proposed to provide such water supply facilities which will include a shallow tubewell, pumps, water tank and distribution pipeline.
- Because the electricity distribution lines are not available in and around the project area, the electricity required for buildings and domestic water supply will be supplied from a new small-scale diesel generator.

(d) Mankessim scheme

- The proposed building facilities for Mankessim scheme will include O&M office and post-harvesting facilities. The construction site is located on the hill on the right bank, about 300 m south from the Mankessim dam.
- The existing buildings are only the office and dormitory for GIDA's staff, which are very poor in floor space and structural design. Therefore, all of the buildings required will be provided newly. The O&M office and

garage will be constructed as one group, and store house, dry yard and sorter house will be provided as another group for exclusive use for post-harvesting activities.

- All of the buildings to be constructed newly will be of flat type of building with simple design, using natural ventilation and lighting as much as possible.
- Because domestic water supply facilities are not available in the project area, it is proposed to provide such water supply facilities which will include pumps to lift water from the Mankessim reservoir, water purification facilities, water tank and distribution pipeline.
- Because the electricity distribution lines are not available in and around the project area, the electricity required for buildings and domestic water supply will be supplied from a new small-scale diesel generator.

(e) Okyereko scheme

- The proposed building facilities for Okyereko scheme will include O&M office and post-harvesting facilities. The construction site is located on the hill on the right bank, about 250 m east from the Okyereko dam.
- Although there exist an office, a store house and three bungalows for GIDA's staff on the hill at present, they are all severely deteriorated and poor in floor space and structural design. Therefore, the building facilities required will be provided newly.
- The office will be constructed adjacent to the garage, and store house, dry yard and sorter house will be provided as one group.
- All of the buildings to be constructed newly will be of flat type of building with simple design, using natural ventilation and lighting as much as possible.
- Because domestic water supply facilities are not available in the project area, it is proposed to supply water from the Okyereko reservoir, providing new water supply facilities which will include pumps, water purification facilities, water tank and distribution pipeline.
- Because the electricity distribution lines are not available in and around the project area, the electricity required for buildings and domestic water supply will be supplied from a new small-scale diesel generator.

(f) Dormitory and dining house in Accra

- Out of the training facilities, dormitories for GIDA's staff and farmer trainees and dining house will be provided at the site owned by MOFA in Accra. The site is located at the camp, about 7 km north-east of the GIDA headquarters.
- The arrangement of these buildings is determined, taking into consideration the plan and design of the buildings for the GIDA Training Center which may be provided at the same site in the future.
- All of the buildings to be constructed will be of flat type of building with simple design, using natural ventilation and lighting as much as possible.
- The domestic water for the buildings can be supplied from the existing city water supply network in Accra. The electricity supply to the buildings can also be made through extension of the existing commercial distribution network which should be made by GIDA.

2.2.4 Basic Concept for Procurement Plan

(1) Basic Policy

The equipment to be procured under the Project will include the equipment for O&M of the irrigation and drainage facilities and those for farm management, and the procurement will be made on the basis of the following policies :

(a) O&M equipment

a) The present problems in O&M of the irrigation and drainage facilities are (i) sediments in the earthen type of canals, (ii) maintenance of farm road network especially after heavy rains, and (iii) cutting of grasses in and around the farm plots as well as along the canals and drains. To cope with these problems and effective and sustainable management of the Project after rehabilitation, the necessary equipment will be procured, taking into account the following :

(i) Procurement of equipment which is familiar to and useful for GIDA's staff and farmers

(ii) Procurement of equipment which has simple mechanical structures and for which the preliminary repair can be made at the site

(iii) Procurement of equipment for which after-care services and necessary spare parts are available in Ghana

(b) Equipment for farm management

The main problems seen in the farm management in the irrigated areas are (i) insufficient services for supply of farm inputs, transportation of farm products and marketing, (ii) shortage of equipment necessary for movable and emergency services for extension in the project area, (iii) difficulties in keeping good communication between the site office and GIDA's headquarters and other relevant agencies, and (iv) lack of transportation equipment for training by GIDA. In order to cope with these problems, appropriate equipment will be procured also for effective and sustainable management of the irrigation schemes as well as for farming.

(2) Basic Design Concept for Procurement of Equipment

The basic concept for the procurement is as follows :

(a) O&M equipment

- The O&M equipment will be procured mainly for the purpose of maintenance of farm roads, removal of sediments in the canals and clearing of grasses.
- The maintenance works of the farm roads will be periodical grading of road surface for smooth transportation of farm products and inputs. For this purpose, a motor-grader with 2.2 m of blade width will be procured and will be kept at Ashaiman in terms of availability of repair shop.
- A small-scale backhoe with a bucket capacity of 0.3 m^3 will be procured for removal of sediments from the drains, and this equipment will also be kept at Ashaiman.
- A 4-WD type of pick-up truck will be provided for each of the five irrigation schemes for transportation of materials required for repair works and emergency case, 5 tracks in total.
- Three (3) units of grass cutters will be procured for each of the five schemes for clearing of grasses, 15 units in total.

(b) Equipment for farm management

- A tractor (60 Hp) with trailer will be provided for each scheme for transportation of materials necessary for O&M of the project facilities as well as for farm products and inputs, 5 tractors in total.
- Two (2) motor bicycles (100 cc) will be supplied to each scheme for monitoring of O&M activities and extension services to the farmers, 10 units in total.
- For smooth communication with the GIDA's headquarters in Accra and other site offices, a radio communication equipment will be provided for each scheme and the GIDA's headquarters, 6 sets in total.
- A micro-bus to accommodate 25 persons will be procured for transportation of trainees between Ashaiman and Accra.

2.2.5 Basic Concept for Operation and Maintenance Plan

GIDA has a plan to hand over O&M function to the farmers' organisations already established at each irrigation scheme in accordance with the strategy of MTADP, and GIDA has already announced this handing-over to all farmers' organisations through the site offices..

After completion of the Project, all project facilities will be transferred to the Department of Project Operations of GIDA, which will be responsible for the handing-over of O&M functions to the farmers' organisations. The site offices will also have the responsibility for the handing-over at the site under the management and instruction of the Department of Project Operations. However, the present organisational structure and staffing of the Department and the offices do not reach the satisfactory level. In addition, all of the farmers' organisations have no function and staffing for O&M of the project facilities at present. Therefore, the organisation of GIDA related to O&M as well as the farmers' organisations should be strengthened in order to ensure successful implementation of the handing-over through reorganisation and training of GIDA's staff as well as the farmers. In addition, an appropriate period of time should be set as transition period for the handing-over process, and 3 years of period are planned by GIDA. The activities during the transition period are strengthening of the farmers' organisations for six months, discussion, enumerating, sharing of responsibilities and training of farmers for one year, monitoring, evaluation and training of farmers for one year, and handing-over process for six months.

2.2.6 Basic Plan for the Project

The basic plan of the Project formulated based on the basic concept for respective plans mentioned above is to construct the following irrigation and drainage facilities, farm roads, post-harvest facilities for each of the five irrigation schemes, and the training facilities in order to achieve the objectives of the Project.

(1) Construction of Irrigation and Drainage Facilities and Buildings

(a) Ashaiman scheme (Irrigation area : 56 ha)

a)	Irrigation canal	Main canal	:	1.9 km
		Laterals	:	4.8 km
b)	Drain	Main drain	:	3.4 km
		Lateral drain	:	14.4 km
c)	Related canal structures		:	L.S.
d)	Farm road	Main road	:	4.2 km
		Lateral road	:	5.8 km
e)	Training buildings	Lecture hall	:	1 no.
		Laboratory	:	1 no.
f)	Operation Buildings	O&M office	:	1 no.
		Garage	:	1 no.
		Sorter house	:	1 no.

(b) Aveyime scheme (Irrigation area : 80 ha)

a)	Pump station	Pump	:	4 nos.
		Pump station	:	1 no.
		Electric supply facility	:	L.S.
b)	Delivery pipe line			130 m
c)	Irrigation canal	Main canal	:	0.5 km
		Secondary canal	:	4.1km
		Laterals	:	5.7 km
d)	Drain	Main drain	:	2.1 km
		Lateral drain	:	18.2 km
e)	Related canal structures		:	L.S.
f)	Farm road	Main road	:	1.8 km
		Lateral road	:	13.0 km
g)	Land consolidation		:	18.0 ha
h)	Buildings	O&M office	:	1 no.
		Store house	:	1 no.
		Garage	:	1 no.
		Dry yard	:	1 no.
		Sorter house	:	1 no.

(c) Kpando-Torkor scheme (Irrigation area : 70 ha)

a)	Pump station	Headrace	:	0.3 km
		Pump	:	3 nos.

		Diesel generator	:	1 no.
		Pump station	:	1 no.
		Electric supply facility	:	L.S.
		Generator house	:	1 no.
b)	Canal	Flume type	:	1.6 km
c)	Sprinkler system	Small pumps	:	6 nos.
		Pump station	:	3 nos.
		Main pipe	:	0.4 km
		Secondary pipe	:	4.7 km
		Lateral pipe	:	4.0 km
d)	Drain	Lateral drain	:	16.3 km
e)	Related canal structures		:	L.S.
f)	Farm road	Main road	:	2.2 km
		Lateral road	:	10.9 km
g)	Land consolidation		:	70 ha
h)	Buildings	O&M office	:	1 no.
		Store house	:	1 no.
		Garage	:	1 no.
		Dry yard	:	1 no.
		Sorter house	:	1 no.

(d) Mankessim scheme (Irrigation area : 29 ha)

a)	Pump station	Pump	:	3 nos.
		Pump station	:	1 no.
		Electric supply facility		L.S.
b)	Sprinkler system	Main pipe	:	1.7 km
		Lateral pipe	:	1.7 km
c)	Related structures		:	L.S.
d)	Drain	Lateral drain	:	10.0km
e)	Farm road	Lateral road	:	5.7 km
f)	Land consolidation		:	29 ha
g)	Buildings	O&M office	:	1 no.
		Store house	:	1 no.
		Garage	:	1 no.
		Dry yard	:	1 no.
		Sorter house	:	1 no.

(e) Okyereko scheme (Irrigation area : 81 ha)

a)	Pump station	Pump	:	3 nos.
		Diesel generator	:	1 no.
		Pump station	:	1 no.
		Generator house	:	1 no.
		Electric supply facility	:	L.S.
b)	Delivery pipeline		:	0.8 km
c)	Irrigation canal	Main canal	:	2.4 km
		Secondary canal	:	1.3 km
		Lateral canal	:	7.2 km
d)	Drain	Main drain	:	3.1 km
		Secondary drain	:	1.4 km
		Lateral drain	:	14.9 km
e)	Related canal structures		:	L.S.
f)	Farm road	Main road	:	4.5 km
		Lateral road	:	12.9 km
g)	Land consolidation		:	47.0 ha

h)	Buildings	O&M office	:	1 no.
		Store house	:	1 no.
		Garage	:	1 no.
		Dry yard	:	1 no.
		Sorter house	:	1 no.

(f) Training Buildings in Accra

a)	Dormitory for trainees from GIDA	:	1 no.
b)	Dormitory for farmers' trainees	:	1 no.
c)	Dining house	:	1 no.
d)	Guard house	:	1 no.

(2) Procurement of O/M Equipment

(a) Backhoe (0.3 m^3)	Ashaiman	:	1 no.
(b) Motor grader (2.2 m)	Ashaiman	:	1 no.
(c) Tractor (60 Hp, w/trailer)	For each scheme	:	5 nos.
(d) Microbus (25 persons)	Ashaiman	:	1 no.
(e) 4 WD pick-up track	For each scheme	:	5 nos.
(f) Motor bicycle (100 cc)		:	10 nos.
(g) Grass cutter		:	15 nos.
(h) Radio communication set	GIDA's HQ & 5 sites	:	6 sets

2.3 Basic Design

2.3.1 Design Concept

(1) Design Concept for Natural Conditions

Field investigation by borings and cone penetrometer was made at the proposed construction sites of pump stations, headworks, irrigation facilities including related canal structures and buildings to grasp the foundation conditions. The investigation shows that N-value is more than 20 on the foundation layer about 2 to 3 meters deep from the ground surface, and N-value for the foundation of building construction is more than 10 at one to two meters depth from the ground surface. These N-values show that the foundation layers have sufficient bearing capacity to construct the above structures and buildings. Therefore, conventional foundation works will be applied for the construction works without introducing specific foundation treatment such as piling.

(2) Basic Concept for Social Conditions

As already mentioned, O&M function of the Project is finally handed over to the farmers' organisations after 3 years of transition period, in accordance with the key strategy of MTADP. For successful and sustainable O&M of the Project by farmers themselves, therefore, design of the project facilities should be made so that farmers can operate and maintain the facilities easily and effectively with lower O&M costs.

For successful implementation of the handing-over of O&M function to the farmers' organisations, the training center is constructed at Ashaiman, and the dormitories and dining house for the trainees are provided in Accra.

(3) Use of Local Contractors and Materials

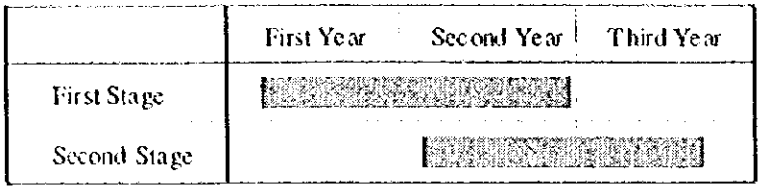
The design of the project facilities is made, using the construction materials for civil and building works available in Ghana such as cement, reinforcement bars, steel products, glasses, concrete pipes, concrete blocks, etc. as much as possible, and also taking into consideration the use of local contractors within technically allowable extent to activate the societies of local contractors and material suppliers in Ghana. In addition, O&M equipment is procured as much as possible from local suppliers who can provide after care services in Ghana, within allowable extent of quality and performance, also taking into account the availability of repair services and spare parts.

(4) Design Concept for Grade of Facilities and Equipment

The construction materials and the equipment for extension services and training will be procured as much as possible from local suppliers who can provide after-care services in Ghana, within technically allowable extent of quality and performance. The materials will have to be selected from those with maintenance-free in order to facilitate O&M works as well as to lower the O&M costs.

(5) Design Concept for Implementation Schedule

The Project implementation would require 29.5 months immediately after the signing of E/N, taking into account the workable days in a year, construction sites, required work volumes and coincidence with the financial system of the Government of Japan, as outlined below.



2.3.2 Basic Design

(1) Irrigation and Drainage Facilities

(a) Design policy

The design of irrigation and drainage facilities will be made on the basis of the following basic design policies :

a) Application of the facilities for their easy operation and maintenance
b) Application of plan and design to expect high efficiency in O&M of the facilities
c) Lowering of the costs for O&M and replacement of the facilities in order to minimize the farmers' burden on such costs
d) Plan and design of the facilities to meet the site conditions in and around the project areas
e) Plan and design of the facilities so as to have sufficient functions as a model for the irrigation and drainage schemes

(b) Design conditions

a) Available water source for irrigation

The water sources available for the five irrigation schemes are as follows :

Project	River Basin	Water Source	Catchment Area (km2)	Tyoe of Intake Facility
Ashaiman	Coastal	Gyorwulu river	82.4	Dam
Aveyime	Volta	Volta river	-	Pump
Kpando-Torkor	Volta	Volta lake	-	Pump
Mankessim	Ochi-Amis	Aprapon river	57.3	Dam
Okyereko	Ayensu	Okyereko river	17.6	Dam
		Ayensu river	1659.0	Weir/Pump*

*: Supplemetal water source for the Okyereko project.

- River runoff study is required to estimate the available amount of water for irrigation through a water balance study for Ashaiman, Mankessim and Okyereko schemes whose water sources are reservoirs. Since the river discharge records related to the schemes were not sufficient in terms of observation period and number of gauging stations, the study was made using the rainfall data.
- The water balance study was carried out under the present Ashaiman project condition, using daily data on rainfall, water level fluctuation in the reservoir, pan evaporation, and amount of water released from the reservoir. This water balance study for the Ashaiman scheme gave useful information for river runoff study for Mankessim and Okyereko schemes for which the tank model method was applied (see Fig.2.1). The model was composed of 4 tanks combined vertically, and each tank had two types of outlets, one for runoff and the other for percolation. At first, rainfall was stored in the upper tank, which was divided into runoff and percolation through each outlet by multiplying with coefficients which vary depending on water depth. Finally, the runoff was estimated as total water volume passing through the runoff outlets of the four tanks.

- The runoff study was made for 10 years from 1986 to 95, using rainfall data at Tema for Ashaiman, Saltpond for Mankessim and Okyereko. The results of the study are summarized as follows:

Project	Station	Rainfall	Runoff	Runoff Coefficient
		(mm/year)	(mm/year)	(%)
Ashaiman	Tema	610.6	26.7	4.4
Mankessim	Saltpond	885.7	49.3	5.6
Okyereko	Okyereko	778.1	36.8	4.7

- The rainfalls at Tema and Saltpond stations observed during the period from 1996 to 97 are shown below, and they are much larger than those obtained from long term observation as shown in the above table.

Station	Annual Rainfall (mm)	
	1996	1997
Tema	954.8	1,216.0 (Jan. to Oct.)
Saltpond	1,130.10	1,248.6 (Jan. to Aug.)

It may be said from these data that the rainfalls during 1996/97 are not usual as compared with those in the normal years and could not be used for additional water balance study. Therefore, the results of the study made on the basis of the rainfall data during the period from 1985 to 1995 are used for the design of the project facilities, as shown in the above table.

- The water released from the Akosonbo dam is stored in the Kpong dam once, and then it is released again from the Kpong dam under the supervision of the Volta River Authority (VRA). The water released from the Kpong dam and the inflow from the downstream basins become the water source for Aveyime scheme. The amount of water released from the Kpong dam can be estimated from the relationship between the water level records and the rating curve. The minimum release was estimated at about 100 m^3/sec, which corresponds to the discharge with a 10-year non-exceedence return period. The water available for Aveyime covering 80 ha of irrigated land will be enough for its rehabilitation.

- The water level at the tail side of the Kpong dam is managed by VRA and ranges from 0.77 m (Low Water Level) to 3.77 m (High Water Level) in elevation above sea level. When the water level at the tail side is operated within such a range, the rive water level at Aveyime site fluctuates within a range between 2.0 m (High Water Level) and nearly sea water level from the study of water levels at the downstream of the Kpong dam and the pump site at Aveyime (refer to Fig.2.2).

- The water source of this scheme is the Volta lake. Its capacity is up to 150,000 million cubic meters (MCM). Although the lake water is used for electric power generation, available water in the lake is sufficient for irrigation use in this project area.

- The water level of the lake is controlled by the Volt River Authority (VRA) within the range from 75.59 m to 84.73 m in elevation which is the basis for design of pumps for this scheme.

b) Proposed crops and cropping patterns

For preparation of proposed cropping patterns for the five irrigation schemes, further study is made on the following :

- Consideration is given to the present crops and cropping patterns without making drastic change in the proposed cropping patterns.
- Optimum combination of food crops and cash crops to expect higher returns which will result in the increase in farm income of the farmers.
- Full and effective use of available irrigation water as well as the land.
- Consideration is given to optimum crop rotation system to avoid crop damage due to continuous cropping.
- The selection of crops to be introduced is made, taking into account the soil and topographic conditions at each scheme.

The proposed crops and cropping patterns for each scheme are thus determined, as summarized below :

Irrigation Scheme	Land	Area ha	Crops to be cultivated	
			Dry season	Wet season
Ashaiman	Paddy field	11	Okra (20%)	Paddy rice (20%)
	Upland	45	Tomato (20%) Onion (20%)	Maize (20%)
			Watermelon (40%)	G'nuts/cowpea (40%)
Aveyime	Paddy field	40	Paddy rice (50%)	Paddy rice (50%)
	Upland	40	Tomato/pepper (13%)	Maize (25%)
			Okra (12%), Onion (25%)	G'nuts/cowpea (25%)
Kpando-Torkor	Upland	70	Okra (25%)	Maize (50%)
			Tomato/pepper (25%)	Groundnuts (50%)
			Onion/shallot (50%)	
Mankessim	Upland	29	Watermelon/onion (50%)	Maize (50%)
			Egg plant (25%)	G'nuts/cowpea (25%)
			Okra (25%)	Sweet potato (50%)
Okyereko	Paddy field	39	Paddy rice (48%)	Paddy rice (48%)
	Upland	42	Tomato (13%), okra (13%)	Maize (26%)
			Onion (26%)	G'nuts/cowpea (26%)

The proposed cropping pattern for each irrigation scheme is given in Fig.2.3.

c) Irrigation water requirements

- Net irrigation water requirements were calculated, using evapo-transpiration and crop co-efficient, and evapo-transpiration was estimated by

the following modified Penman method, using meteorological data at the sites.

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

where, ETo : Evapo-transpiration in mm
W : Temperature and altitude dependent weighting factor
Rn : Total net radiation in mm/day
F(u) : Wind function factor
(ea-ed) : Vapour pressure deficit
C : Adjustment factor

- The net irrigation water requirement for paddy rice was calculated as follows :

$$Wf = (ETo \times Cf + Pd + Dp) - ER$$

where, Wf : Net irrigation water requirement in mm
ETo : Evapo-transpiration in mm
Cf : Crop co-efficient
Pd : Puddling water requirement (ranging from 140 mm to 190 mm)
Dp : Deep percolation loss (ranging from 0.8 mm to 2.4 mm/day)
ER : Effective rainfall in mm

- The effective rainfall in paddy field was calculated on the basis of the daily water balance by tank model analysis, using daily rainfall data, irrigation method, evapo-transpiration, and percolation losses, based on the following conditions :

  - Maximum depth of tank : 150 mm
  - Minimum depth of tank : 50 mm (in case that the depth is less than 50 mm, irrigation is required.)
  - The daily rainfall which is less than 5 mm is not effective.

Fig.2.4 shows the relationship between 10 days rainfall and the effective rainfall.

- The effective rainfall in upland was estimated by using the following experimental formula developed by the U.S. Department of Agriculture Soil Conservation Service :

$$ER = 0.20 \times R^{0.95} \times Cu^{0.31}$$

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

- The irrigation water requirements for respective irrigation schemes were thus calculated for 10-day period, using the overall irrigation efficiency which was estimated as follows :

Efficiency	Paddy Field (%)	Upland (%)	
		Furrow Irri.	Sprinkler Irri.
Conveyance	81	81	90
Distribution	75	60	80
Field irrigation	61	49	72
Overall efficiency	60	50	70

- The irrigation water requirements used for design of the pump capacity and intake facility were determined on the basis of the following :

  - Application of peak irrigation water requirements for both paddy field and upland.
  - Irrigation hours are set at 24 hours (peak water requirement x 1) for paddy field, 10 hours (peak water requirement x 24/10) for furrow irrigation in upland, and 9 hours for sprinkler irrigation in upland (24/9), respectively.
  - Calculation of weighted mean peak water requirements on the basis of coverage ratio of paddy field and upland at each irrigation scheme

- The following design water requirements thus calculated were used for the design of pumps and intake facilities :

Irrigation scheme	Design month & 10-day period	Coverage ratio by		Peak requireme		Design water requirement for pumps, intake facilities & (Canals)	
		Paddy	Upland	Paddy	Upland		
		(%)	(%)	(lit./sec/ha)	(lit./sec/ha)		(lit./sec/ha)
Ashaiman	2nd. period /Dec.	0	100	-	1.00	2.40	[2.40]
Aveyime	2nd.period/Nov.	50	50	1.89	0.77	1.87	[1.87]
Kpando-T.	3rd. period/May	0	100	-	0.65	1.57	[1.57]
Mankessim	3rd. period/Feb.	0	100	-	0.75	1.80	[-]
Okyereko	3rd. period/Nov.	48	52	1.44	0.86	1.76	[2.06]

Note : the figures in [ ] show design water requirements for canals and related structures.

Table 2.1 shows the monthly mean rainfall data and Table 2.2 shows the monthly mean meteorological data for estimating the evapo-transpiration. The evapo-transpiration estimated at each irrigation scheme is shown in Table 2.3.

d) Determination of optimum rehabilitation area

- Further study is made for determination of optimum area to be rehabilitated under the Project, taking into consideration the social conditions, the farmers' experience in irrigation farming, etc. The optimum area for Ashaiman and Mankessim schemes whose water source is reservoir is determined as follows, through the water balance study on the basis of available water source, irrigation water requirements, and water losses due to evaporation and deep percolation in the reservoirs.

Irrigation dependability	Irrigation area (ha)	
	Ashaiman	Mankessim
100	29	114
90	39	139
80	53	142
70	56	158

- Basically, 80 % irrigation dependability is applied for determination of irrigation area. In case of Ashaiman, the irrigation area with 80 % irrigation dependability is estimated at 53 ha. Because total existing paddy field on the left bank is 56 ha, which are served by one complete irrigation network, and the difference of irrigation areas between those with 80 % dependability and 70 % one is only 3 ha, the design of all the project facilities is made based on 56 ha of existing irrigated land. The

area proposed for Mankessim scheme is determined at 29 ha mainly in terms of the social conditions in and around the scheme.

- Since available water for irrigation purpose in Aveyime and Kpando-Torkor schemes is sufficient enough from the Volta river and lake, the areas for these schemes are determined at 80 ha and 70 ha, respectively, mainly in terms of social conditions, the present irrigated area, topography, etc.

- The irrigation area proposed for Okyereko scheme under the Project is determined at 81 ha through water balance study which is made on the basis of irrigation water requirements with 80 % dependability, inflow-outflow analysis of the Okyereko reservoir and available water from the Ayensu river (see Table 2.4). In addition, optimum combination of required pumps and possible irrigation area through cost comparison is also made for determination of the optimum area.

e) Drainage requirements

- Drainage requirements were estimated separately for paddy field and upland, using 10-year probable rainfalls. The drainage requirement for paddy field was calculated, using 10-year probable 3-day continuous rainfall and on assumption that the allowable water depth in paddy field is 150 mm at maximum. The following equation was used for the estimate :

$Hu = 50 + (Rd \times t)/3.0 - Qd \times t \times 8.64$ (in case that "t" is < 3 days)
$Hd = 50 + Rd - Qd \times t \times 8.64$ (in case that "t" is > 3 days)

where,
- Hu : Stagnant water depth in paddy field for 3 days in mm
- Hd : Stagnant water depth on 4th day after rain
- Rd : Design rainfall in mm
- Qd : Drainage requirement in lit./sec/ha
- t : Period for drainage in day

- The drainage requirements thus estimated are as follows :

Ashaiman scheme	:	1.0 lit./sec/ha
Aveyime scheme	:	2.0 lit./sec/ha

Okyereko scheme : 3.0 lit./sec/ha

- The drainage requirements for upland were estimated, using the following MacMath equation :

$$Qd = 0.0029 \times C \times i \times S1/5 \times A4/5$$

where, Qd : Drainage requirement in lit../sec/ha
C : Runoff co-efficient
i : Rainfall intensity in mm/hr
S : Difference in elevation in drainage area in m (one meter against 328 m in horizontal)
A : Drainage area in ha

f) Flood discharge

Analysis of flood discharges was made on the Ochi-Amisa river (for Mankessim scheme), the Ayensu river (for Okyereko scheme), and the Gyorwulu river (for Ashaiman scheme), using the unit-hydrograph method. The design flood discharges are determined as follows :

Return period	Flood discharge (m3/sec)		
	Ochi-Amisa	Ayensu	Gyorwulu
2-year	130	145	44
5-year	200	220	57
10-year	230	255	66
25-year	330	370	-
50-year	360	400	-

Fig.2.5 shows the flood hydrograph with 10-year return period analyzed on the basis of 3-day continuous probable rainfall.

(c) Basic design of irrigation and drainage facilities

a) Pump station

Out of five (5) irrigation schemes under the Project, four (4) schemes, except for Ashaiman, will have the pump stations for lifting water from the water sources and operation of sprinkler irrigation system. The design concept for each of the proposed pump stations is as follows :

(I) Main Pump

The required number and capacity of pumps for Aveyime and Kpando-Torkor schemes are determined on the basis of the irrigation area and design irrigation water requirements, also taking into consideration the lifting capacity, the cost and weight of a pump. In case of Okyereko scheme, the required pump capacity is determined, based on the following :

- Inflow-outflow analysis of the Okyereko reservoir
- Estimate of annual requirement of supplemental water to the Okyereko reservoir
- Pump operation period a year is set for 7 months from June to December the basis of river discharge of the Ayensu with 10-year return period on condition that the daily operation of pumps is set for 14 hours.

Each pump station will have one set of stand-by pump. The proposed pumps for Aveyime, Kpando-Torkor and Okyereko schemes will be as follows :

Irrigation scheme	Required number	Design capacity (m3/min.)	Total head (m)	Type of pump
Aveyime	4 nos.	8.98 in total (each : 3.0)	16	Horizontal type of 2-stage centrifugal pumps with single suction
Kpando-Torkor	3 nos.	7.31 in total (each : 3.7)	32	Horizontal type of centrifugal pumps with single suction
Okyereko	3 nos.	8.1 1 in total (each :	23	Horizontal type of centrifugal pumps with single suction

(ii) Pump for operation of sprinkler system

Small-scale pumps are required for operation of sprinkler irrigation system in Kpando-Torkor and Mankessim schemes. The service area of a small-scale pump will basically be 10 to 15 ha, and the total required head for a pump is estimated on the basis of water pressure for operation of sprinkler nozzle (30 m in water head), friction losses of pipeline and the difference in elevation between the pump site and irrigation area. The required supply capacity of these small pumps

is determined on the basis of irrigation requirement per one irrigation time, irrigation interval and irrigation efficiency.

Basic conditions :

- Effective depth of soil layer : 30 cm
- Soil moisture extraction pattern : Standard type (4 layers, each 75 mm depth)
- Available soil moisture : 20 %
- Total readily available moisture : 28 mm
- Irrigation interval : 6 days
- Water distribution efficiency : 80 %
- Water conveyance efficiency : 90 %

Design conditions of sprinkler

- Irrigation hours per one time : 4.5 hours
- Interval of sprinkler set : 15 x 12 m
- Design intensity of irrigation : 7.8 mm
- Delivery amount of a sprinkler : 23.4 lit./min.
- Number of sprinkler head per one lateral supply pipe : 8 nos.

The required capacity and specification of small-scale pumps are thus determined as follows :

Irrigation scheme	Required number	Service area (ha)	Design capacity (m3/min.)	Total head (m)	Type of pump
Mankessim	1 no.	12.8	1.54	45	Horizontal type of centrifugal pump
	2 nos.	16.2	1.96	45	Horizontal type of centrifugal pump
Kpando-T	1 no.	13.0	1.56	40	Horizontal type of centrifugal pump
	1 no.	15.6	1.87	40	Horizontal type of centrifugal pump
	1 no.	4.8	0.58	40	Horizontal type of centrifugal pump
	1 no.	10.1	1.21	40	Horizontal type of centrifugal pump
	1 no.	10.2	1.23	40	Horizontal type of centrifugal pump
	1 no.	16.3	1.96	40	Horizontal type of centrifugal pump

(iii) Pipeline

The delivery pipelines which connect the main pumps and open canals will be required for Aveyime, Kpando-Torkor and Okyereko schemes. The pipelines will be steel pipes and buried in the ground. In order to minimize the friction losses in the pipe due to bending and

curvature, the pipeline is designed as follows, shortening the pipe length by making the pipeline as straight as possible.

Irrigation scheme	Lenth of pipeline (m)	Diameter of pipe (mm)	Design discharge (lit./sec)	Design velocity in pipe (m/sec)
Aveyime	130	300	150	2.14
Kpando-T.	395	350	120	1.25
Okyereko	804	400	140	1.11

b) Intake weir

The intake weir is constructed on the Ayensu river in order to supply supplemental water to the Okyereko reservoir and is designed, taking into account the following technical requirements :

Construction site

The proposed construction site is selected on the stable river bed with minimum flow of sediments. The site is located at the downstream of the portion where the river turns its direction towards the right angle. Since the main river flow is on the left side where the intake structure will be provided, it is expected that the sediments on the front base of the intake structure will be small in quantity. Fig.2.6 shows the proposed construction site of the weir.

Analysis of flood

The construction site is located at about 350 m downstream from the junction of the river with the Accra-Sekondi national road. The sandwiched area between the junction and the intake site is presently inundated during the wet season. Inundation condition after the construction of the weir is therefore studied through non-uniform calculation, based on the design flood with 10-year return period (255 m^3/sec) and the top elevation of the existing embankment on the right bank, 8.5 m. As a result, the back water level at the junction is estimated at 8.72 m in elevation, which is 1.14 m lower than the top elevation of the national road, 9.86 m. This means that there will be no hydrological impact on the national road.

Structural stability

According to the field investigation by boring, the construction site has sufficient bearing capacity with N-value of more than 40, and the design of weir is made so as to secure the sufficient length of seepage line of the weir in order to have the hydrological stability against water piping, etc.

Operation and maintenance

The intake weir will be of concrete type with one scouring sluice gate, 1.0 m wide x 1.1 m high, and the sediments on the front base of intake structure after floods are flushed out by operating this gate.

The outline of the Okyereko intake weir is summarized as follows :

Intake weir :

Crest elevation	:	EL. 4.30 m
Height of weir	:	2.5 m above the cut-off bed, and 1.0 m above the surface of downstream apron
Crest length	:	11.8 m
Scouring sluice gate	:	1 no., 1.1 m x 1.0 m
Energy dissipater	:	6 m-long
Length of riprap	:	Gabion, 3 m in upstream and 13 m in downstream

Intake structure :

Intake capacity	:	0.137 m^3/sec
Intake water level	:	EL. 4.3 m
Intake gate	:	1 no., 0.7 m x 0.7 m
Intake pipe	:	Concrete pipe, dia. 600 mm, 15 m long
Headrace	:	Concrete flume, H x B = 0.4 x 0.3 m

c) Irrigation canals

(i) Layout of irrigation network

The irrigation network will consist of the main, secondary, lateral canals and canal-related structures, and will be provided completely separated from the drainage system for effective O&M of the facilities. The irrigation canals in Ashaiman, Aveyime and Okyereko schemes will be of open-channel type of canals, and those in Kpando-Torkor scheme will be provided so as to connect each of the irrigation blocks. The lateral canals are branched off from the main and secondary canals and serve 2.4 ha of land in Aveyime and Okyereko, and 4.3 ha of land in Ashaiman on an average, respectively, depending on the topography of irrigated land. The turnouts with discharge measuring device will be provided for proper water distribution at diversion point of water from the main or the secondary canals to laterals . The service area of a lateral canal (irrigation unit) will be as follows :

Irrigation scheme	No. of irri. unit	Max. & min. area of a unit (ha)
Ashaiman	13	8.1/2.8
Aveyime	33	10.1/0.5
Okyereko	34	8.4/0.3

(ii) Canal

All of the irrigation canals will be of concrete flume type in terms of easy construction and O&M as well as for effective use of water with a minimum loss due to leakage. The proposed canals will be as follows :

- Maximum design discharge : 0.135 m^3/sec for Ashaiman
  : 0.15 m^3/sec for Aveyime
  : 0.037 m^3/sec for left main canal, and 0.13 m^3/sec for right main canal in Okyereko
- Allowable maximum velocity : 1.0 m/sec for main canal
  : 0.7 m/sec for secondary/ laterals
- Allowable minimum velocity : 0.2 m/sec
- Design roughness co-efficient : 0.015
- Height of free board : 0.2 m
- Canal section of flume : H= 0.4 to 0.7 m, B= 0.3 to 0.6 m for main /secondary
  H= 0.3 & B= 0.3 m for lateral
- Concrete thickness of flume : 0.08 to 0.15 m for main & secondary canals
  0.08 m for laterals

The design of the irrigation canal network for each irrigation scheme will be summarized as follows :

Ashaiman scheme

Type of canal	Required no. of canal	Length of canal	Design discharge	Width of canal bottom	Height of canal
		(m)	(m3/sec)	(m)	(m)
Main	-	1,872	0.135-0.016	0.6-0.3	0.7-0.4
Secondary	1	43	0.026	0.3	0.3
Lateral	15	4,829	0.02-0.007	0.3	0.3

Aveyime scheme

Type of canal	Required no. of canal	Length of canal	Design discharge	Width of canal bottom	Height of canal
		(m)	(m3/sec)	(m)	(m)
Main	-	879	0.15-0.034	0.6-0.3	0.7-0.4
Secondary	7	4,054	0.037-0.006	0.3	0.3
Lateral	33	5,735	0.019-0.001	0.3	0.3

Okyereko scheme

Type of canal	Required no. of canal	Length of canal	Design discharge	Width of canal bottom	Height of canal
		(m)	(m3/sec)	(m)	(m)
Main	2	3,086	0.134-0.007	0.6-0.3	0.7-0.4
Secondary	3	1,336	0.031-0.007	0.3	0.3
Lateral	33	7,160	0.018-0.001	0.3	0.3

Kpando-Torlor scheme

Type of canal	Required no. of canal	Length of canal	Design discharge	Width of canal bottom	Height of canal
		(m)	(m3/sec)	(m)	(m)
Conveyance		1,567	0.073-0.046	0.5,0.3	0.6,0.4

d) Sprinkler system

(i) Pipeline network

The sprinkler irrigation system is required for Kpando-Torkor schemes. Basically, pipeline network for sprinkler irrigation will consist of the main pipe connected to the main pumps, secondary and lateral pipelines which supply irrigation water to the sprinkler sets. The secondary pipelines will be connected to the small-scale pumps for operation of sprinkler sets in Kpando-Torkor scheme, and directly to the main pumps in case of Mankessim scheme. These pipelines will be of fixed type buried in the ground. The lateral pipelines with hydrants are those to supply irrigation water to movable sprinkler irrigation sets, which will also be of fixed type buried in the ground. The supply pipes of sprinkler irrigation sets will be of movable type by manpower, and a pipe with 90 m long will have 12 nos. of raisers (1.5 m height) which will be provided at 12 m interval on the pipe. Each raiser is equipped with a sprinkler nozzle. The secondary and

lateral pipes will be PVC pipes for cost-saving which are available in Ghana. However, steel pipes will be used for the supply pipes of sprinkler sets.

(ii) Pipe

The secondary/lateral and supply pipes for a standard sprinkler irrigation block (200 x 160 m) are designed as shown below :

Lateral pipe (PVC pipe)

- Pipe diameter : 77.2 mm
- Maximum discharge : 380 lit./min.
- Minimum discharge : 190 lit./min.
- Maximum velocity in pipe : 1.35 m/sec
- Minimum velocity in pipe : 0.68 m/sec
- Pipe interval : 15 m
- Loss of pressure in a pipe : 0.11 - 0.25 m

Supply pipe (steel pipes)

- Pipe diameter : 48.7 mm
- Maximum discharge : 190 lit./min.
- Minimum discharge : 23.75 lit./min.
- Maximum velocity in pipe : 1.7 m/sec
- Minimum velocity in pipe : 0.2 m/sec
- Pipe interval : 12 m
- Loss of pressure in a pipe : 0.02 - 0.53 m

Secondary pipe in Mankessim scheme

- Pipe diameter : 250 - 100 mm
- Maximum discharge : 1,960 lit./min.
- Minimum discharge : 380 lit./min.
- Maximum velocity in pipe : 1.08 m/sec
- Minimum velocity in pipe : 0.81 m/sec
- Pipe interval : 80 - 280 m
- Loss of pressure in a pipe : 1.94 - 0.23 m

Secondary pipe in Kpando-Torkor scheme

- Pipe diameter : 250 - 75 mm
- Maximum discharge : 1,960 lit./min.
- Minimum discharge : 190 lit./min.
- Maximum velocity in pipe : 1.14 m/sec
- Minimum velocity in pipe : 0.72 m/sec
- Pipe interval : 80 - 280 m
- Loss of pressure in a pipe : 2.29 - 0.33 m

The pipeline network in each irrigation scheme will be as follows :

Irrigation scheme	Secondary pipeline (m)	Lateral pipeline (m)	Supply pipeline (set)
Kpando-T.	4,648	4,000	42
Mankessim	1,690	1,665	18

(iii) Sprinkler nozzle

The proposed sprinkler nozzle will have the following specifications :

Classification	Water pressure (Kgf/cm2)	Nozzle discharge (lit./min.)	Diameter of sprinkling (m)
M1	3	23.4	15

(iv) Auxiliary equipment

For supply pipe :
- Joint coupler for hydrant : 1 no.
- End plug : 1 no.
- Raiser pipe (1.5 m height) : 8 nos.

For lateral pipe :
- Hydrant
- Valve for hydrant
- Raiser pipe for hydrant
- Sluice valve

e) Drainage system

(i) Drainage network

The drainage system consists of drains to evacuate the excess water from the irrigated land and collector drains to flow out the rain water from outside the project area. The drains are classified into lateral drain which is provided along the farm road to drain the excess water from the irrigation block, secondary drain to collect the excess water from the lateral drains or to evacuate the rain water directly to the natural streams, the main drain and the collector drains. The proposed drainage network for each of the irrigation schemes will be as follows

Irrigation scheme	Total length of main drain	Total length of secondary drain	No. of lateral drain	Total length of lateral drain	Total length of collector drain
	(m)	(m)		(m)	(m)
Ashaiman	3,390	-	43	10,910	3,484
Aveyime	2,076	-	90	18,205	-
Kpando-T.	-	-	83	14,145	2,150
Mankessim	-	-	54	10,015	-
Okyereko	3,095	1,430	56	12,470	2,380

(ii) Drain

All of the drains will be of earthen type with trapezoidal flow section, and the design conditions are as follows :

- Allowable maximum velocity : 0.6 m/sec
- Allowable minimum velocity : 0.2 m/sec
- Roughness co-efficient : 0.003
- Bottom width : 12.0 - 3.0 m for main, secondary and collector drains, and 0.3 m for lateral drain
- Height of drain : 2.0 - 1.0 m for main, secondary & collector drains
  0.3 m for lateral drain
- Slope of canal section : 1 : 1.5 for main, secondary & collector drains
  1 :1 for lateral drain

f) Farm road

(i) Road network

The farm road is required for the purpose of O&M of the irrigation and drainage facilities, transportation and marketing of farm products and inputs, and to connect the irrigation schemes with the public transportation network. The proposed farm roads are divided into two types in terms of their design, the main and lateral roads. The main road has the function of connecting the O&M office with the intake facilities such as pump stations and intake weir, and for O&M of the main irrigation canal and access road to the public road network. The lateral roads are mainly used for transportation of farm products and inputs, and are aligned so as to enclose a unit farming block covering about 12 ha of land. The following table shows the outline of the proposed road network :

Irrigation scheme	Total length of main road	Total length of lateral road
	(m)	(m)
Ashaiman	4,237	5,795
Aveyime	1,784	12,970
Kpando-T.	2,167	10,925
Mankessim	-	5,700
Okyereko	4,526	12,861

(ii) Design of road

The design standard for the proposed roads is as follows :

- Road width main road : 5.0 m
  lateral road : 3.0 m
- Effective width main road : 3.0 m
  lateral road : 3.0 m
- Pavement Laterite pavement for both main & lateral
- Thickness of pavement : 20 cm
- Minimum height of embankment :
  main road : 60 cm above the ground
  lateral road : 60 cm along paddy field
  lateral road : 20 cm along upland
- Embankment slope : 1 : 1.5

g) Canal related structures

(i) Canal crossing structures

The canal crossing structures will be provided at the sites where the main and lateral roads across the canals and drains, and will be of pipe culvert type of structures. The culvert will consist of concrete pipe and wing wall portions on both the upstream and downstream of the concrete pipe culvert. The pipe culvert on the drains is protected by gabions to be provided on both the upstream and downstream portions. The embankment on the concrete pipe portion will be 60 cm in height at minimum.

(ii) River crossing structures

The river crossing structures will be constructed at the sites where the canals across the natural streams or drains. The structures will be siphon or aqueduct, depending on the topography of the crossing sites and the size of cross section of the streams or drains. The siphon will have the inlet and outlet boxes and concrete pipe portion.

The aqueduct will consist of concrete flume as superstructure and piers. The embankment on the concrete pipe will be more than 1.0 m in height.

(iii) Turnout

The proposed turnout will have an inlet box, slide gate for water division and measuring device which is broad crested weir on the downstream of the turnout. The turnout from which the water is supplied to the farm crossing the road will have concrete pipe culvert portion, of which diameter will be 150 mm. A number of division boxes will be provided on the lateral irrigation canals to supply irrigation water to the farm plots, which will have small-scale stop logs on its downstream for regulation of water distribution and as check structure.

(iv) Drop

Drop will be provided to adjust the canal gradient, aiming to ensure the proper flow velocity in the canal. The proposed drop will be of vertical type and will consist of upstream and downstream transitions, sill and energy dissipater portion. The small-scale drop to be provided on the lateral drains will have a sill by precast-concrete plate and will be protected its downstream portion with wet stone masonry. A chute is required to supply additional water from the outlet structure of delivery pipe of the pump station to the Okyereko reservoir. The chute will consist of outlet box at the end of delivery pipe, transition, chute by concrete flume and protection work by gabion at the end of chute.

(v) Protection work by gabion will be constructed at junction of drains with the natural streams or rivers.

(vi) Causeway

A causeway will be provided on the downstream portion of the existing spillway of the Ashaiman dam in order to secure the transportation crossing the spillway. When no water is spilled from

the reservoir or the discharge of spilled water is very small, the transportation can be secured on the pipe culvert portion through which the spilled water flows to the downstream. When the flood water is spilled out, on the other hand, such a flood water flows over the culvert portion. This causeway will have approach portions on both right and left sides, pipe culvert and protection works on the downstream.

(vii) Green belt work

In order to protect the farmland from soil erosion due to steep-sloped topography, green belt works will be required for Kpando-Torkor and Mankessim schemes. The green belt with 2.5 m of width will be provided along the contour lines, and small-scale collector drains will be constructed along the green belt in order to evacuate the excess rain water to the lateral drains. The average density of green belt zones will be about 55 m per hectare.

(viii) Land preparation works

Land preparation works will be required to open new upland under the Project and for the existing uplands which are left fallow for long time. The works will include land clearing, removal of small tree roots and the preliminary land leveling, and the size of a farming plot will cover 1.5 ha of land in gross.

The proposed canal related structures for each of the irrigation schemes will be as follows :

Structure	Ashaiman	Aveyime	Kpando-T.	Mankessim	Okyereko
Culvert on canal	15	23	-	-	18
Culvert on drain	12	15	28	18	12
Culvert on stream	-	-	1	-	-
Siphon	-	4	-	-	1
Aqueduct	-	-	-	-	1
Turnout	11	25	-	-	29
Division box	168	128	-	-	172
Drop	3	-	-	-	3
Shute	1	-	-	-	1
Protection work	-	-	19	7	-
Causeway	1	-	-	-	-
Green belt	-	-	3,150 m	1,305 m	-
Land preparation	-	18 ha	70 ha	29 ha	47 ha

h) Basic design drawing

The basic design drawings for the irrigation and drainage facilities, and farm roads are shown in Table 2.5.

(2) Building Facilities

(a) Basic policy

The design of building facilities will be made on the basis of the following basic design policies :

a) The arrangement of buildings should be made, taking into account the location of existing buildings and roads in and around the building complex, convenience in use of buildings and structural harmonization with the existing ones.
b) The design should be made, taking into consideration the climate, natural features, lifestyle, architectural standard and other characteristics prevailing at the proposed construction sites of the buildings.
c) The O&M costs will be minimized, using natural ventilation, natural lighting and sunlight effectively.
d) The design of buildings should be made for easy and economical construction, taking into account the level of construction engineering and labours' skill in Ghana.

(b) Site selection and building arrangement

a) Ashaiman scheme

The site for building facilities is dispersed among the existing facilities complex for IDC (Irrigation Development Center) of GIDA. The existing buildings are located on both sides of the main road running between the complex and paddy field. The existing buildings such as (i) dry yards, (ii) repair shop/store house and (iii) offices/bungalows are arranged in sequence from the paddy field. The buildings to be constructed under the Project will follow the these block arrangement, namely sorter house in dry yard block, garage in repair/store house block and office/lecture hall/ laboratories in office/bungalow block.

b) Aveyime scheme

All of the buildings will be constructed at the site which has 5 ha of land. The office and garage will be provided along the main road which is connected with the highway to Accra, for easy transportation of vehicles and to minimize the noise and dusts which may come from the dry yards. The store house and sorter house will be constructed adjacent to the dry yards for effective post-harvesting activities.

c) Kpando-Torkor scheme

The required building facilities are all constructed at the new site within the project area, taking into consideration the connection with the existing public roads and effective O&M of the project facilities. The arrangement of building facilities for agricultural use will be similar to Aveyime scheme.

d) Mankessim scheme

The dry yard, sorter house and store house will be constructed on gentle sloping land which is faced toward the south. The office and garage will be provided at the highest portion of the hill, in order to minimize the noise and dusts which may come from the dry yards. In addition, the office will be along the existing road which connects the scheme with the main public road.

e) Okyereko scheme

The new building facilities will be constructed at the new site adjacent to the existing buildings complex, and the office will be provided along the existing road which is connected with the highway. The arrangement of building facilities for agricultural use will be similar to Aveyime scheme.

f) Training facilities in Accra

The arrangement of dormitories and dining house for trainees from GIDA as well as the farmers from the five (5) irrigation schemes is determined, taking into consideration the plan of the buildings for the GIDA Training Center which may be constructed at the same site in the future, and the convenience in use of these buildings and also so as to minimize the noises and smell from the cooking room.

(c) Plan of building facility

The plan of building facilities such as offices, lecture hall, laboratories, dormitories and dining house is prepared on the basis of the Japanese architectural standards, and the plan of buildings for agricultural use is made, taking into consideration the purpose of their use and post-harvesting works, as shown below :

a) Office for Aveyime, Kpando-Torkor, Mankessim and Okyereko
   - Room for Project Manager, 30 m^2x 1 : 30 m^2
   - Auditor's room, 4 persons x 7.3 m^2/person : 30 m^2
   - Room for extension workers, 2 persons x 13.5 m^2/person : 27 m^2
   - Rest room for each : 15 m^2

b) Office for Ashaiman
   - Room for Project Manager, 35 m^2 x 1 : 35 m^2
   - 6-room for experts, 20.5 m^2 x 1.2 x 6 : 150 m^2
   - Working room, 5 persons x 6.1 m/person x 1.2 : 35 m^2
   - Conference room, 25 persons x 2 m^2/person : 50 m^2
   - Passage, rest room, etc. : 85 m^2

c) Lecture hall and laboratories
   - Laboratories for cultivation, water management, extension, farm machines and training : 180 m^2 in total
   - Large lecture hall, 20 persons x 1.6 m^2/person

	plus 12 m^2 for lecturer	:	50 m^2
-	small lecture hall, 10 persons x 1.6 m^2/person plus 8 m^2 for lecturer	:	25 m^2
-	small lecture hall, 15 persons x 1.6 m^2/person plus 12 m^2 for lecturer	:	36 m^2
-	Passage, rest room, etc.	:	102 m^2

d) Dormitory for GIDA's staff

-	10-bed room, 2 persons x 8.5 m^2/person	:	170 m^2
-	Community room, 20 persons x 2.5 m^2/person	:	50 m^2
-	Shower & rest room, 5.5 m x 7 m x 2	:	77 m^2
-	Open Corridor	:	100 m^2

e) Dormitory for trainees

-	10-bed room, 2 persons x 7 m^2/person	:	140 m^2
-	Community room, 20 persons x 1 m^2/person	:	20 m^2
-	Shower & rest room, 5.5 m x 7 m x 2	:	77 m^2
-	Open Corridor	:	80 m^2

(f) Dining room & cooking room

-	Dining room, 40 persons x 2 m^2/person	:	80 m^2
-	Cooking room,	:	30 m^2
-	Room for management, 8 persons x 3 m^2/person:		24 m^2
-	Rest room	:	6 m^2
-	Open Corridor	:	154 m^2

(g) Guard House

-	2 persons x 3.5 m^2/person	:	7 m^2

(h) Store house

The crops to be stored will be paddy rice and onion. The required floor space of a store house for paddy and onion is determined on condition that 1.44 tons of paddy and 0.5 ton of onion can be stored on one square meter of floor space, respectively. The anticipated production of these crops at each irrigation scheme will be as follows (refer to cropping patterns):

Ashaiman scheme

- Paddy rice 56 ha x 20 % x 6 tons/ha = 67.2 tons
- Onion 56 ha x 20 % x 3 tons/ha = 33.6 tons

The required floor space to store these crop production is estimated at 117 m^2. Since the existing store house has 150 m^2 of floor space, on the other hand, new store house will not be required for Ashaiman.

Aveyime scheme

- Paddy rice 80 ha x 50 % x 6 tons/ha = 240 tons
- Onion 80 ha x 25 % x 3 tons/ha = 60 tons

The required floor space is estimated at 290 m^2, and a new store house with a floor space of 200 m^2 will be provided, also using part of the existing old store house.

Okyereko scheme

- Paddy rice 81 ha x 48 % x 6 tons/ha = 233 tons
- Onion 81 ha x 26 % x 3 tons/ha = 63 tons

The required floor space is estimated at 294 m^2, and a new store house with a floor space of 200 m^2 will be provided, also using part of the existing old store house.

Mankessim scheme

- Onion 29 ha x 25 % x 3 tons/ha = 22 tons

The required floor space is estimated at 45 m^2, and new store house will not be provided, because the existing building can be used for the purpose.

Kpando-Torkor scheme

- Onion 70 ha x 50 % x 3 tons/ha = 105 tons

The required floor space is estimated at 219 m^2, and a new store house with a floor space of 200 m^2 will be provided.

h) Sorter house

A sorter house will be provided for each irrigation scheme in order to classify the farm products such as tomato, egg plant, watermelon, etc. for profitable marketing and to pack for transportation of them to the markets. The required floor space of a sorter house depends on the cropping area, anticipated production, classification work, packing, etc. of the cash crops to be marketed. The following two cases are considered to determine the required floor space of a house :

Item	Case 1	Case 2
Work volume of post-harvest/day	4 tons	2.5 tons
Floor space for one ton of product	(10 m2)	(10 m2)
Floor space for products to be classified	40 m2	25 m2
Working floor space, (4 m2/person)	80 m2 in total	50 m2 in total
Floor space for one ton of classified products	(6 m2)	(6 m2)
Floor space for classified products	24 m2 in total	15 m2 in total
Required floor space	150 m2	100 m2

The maximum cropping area of the cash crops at each irrigation scheme is as follows :

- Ashaiman : 39.2 ha
- Aveyime : 24.8 ha
- Kpando-Torkor : 21.0 ha
- Mankessim : 21.8 ha
- Okyereko : 40.0 ha

The design conditions in Case-1 will be applied for Ashaiman and Okyereko schemes, and those in Case-2 for Aveyime, Kpando-Torkor and Mankessim schemes.

i) Dry yard

The dry yard is required for treatment of paddy, cowpea, pepper, groundnuts, etc. for storage and marketing. A dry yard with concrete floor will be provided for Kpando-Torkor, Mankessim and Okyereko schemes, except for Ashaiman and Aveyime where the existing dry yards are still sufficient in number and floor space. The proposed design conditions of dry yard will be as follows :

Irrigation scheme	Crop	Cropping area	Anticipated production	Work volume per day
		(ha)	(tons)	(ton/day)
Kpando-T.	Groundnuts	35	70	2.33
Mankessim	Groundnuts	7.3	15	0.5
Okyereko	Paddy	40	240	8

Since the floor space required for drying of one ton of groundnuts is 70 m^2, total floor space for Kpando-Torkor and Mankessim schemes is estimated at 82 m^2 and 17 m^2, respectively, on condition that the drying is made twice a day. In case of paddy, the required floor space is estimated at 148 m^2 on condition that the volume of paddy to be dried per day is 10 m^3 and that drying is made for two days. The proposed floor space for Kpando-Torkor, Mankessim and Okyereko schemes will be as follows :

- Kpando-Torkor : 90 m^2
- Mankessim : 20 m^2
- Okyereko : 150 m^2

j) Garage

Except for Ashaiman, new garages with a small-scale store house will be provided for the remaining four irrigation schemes in order to keep the projects' vehicles, and to store O&M equipment, some materials, spare parts, etc., as shown below :

Irrigation scheme	Bay-1	Bay-2	Bay-3	Bay-4	Bay-5	Bay-6
Ashaiman	Libricants Spare parts	Backhoe	Motor grader	Pick-up track Motor bicycle	Farm machines Grass cutter Tractor	Micro-bus
Aveyime	Libricants Spare parts	Pick-up track Motor bicycle	Tractor	Farm machine Grass cutter		
Kpando-T.	Libricants Spare parts	Pick-up track Motor bicycle	Tractor	Farm machine Grass cutter		
Mankessim	Libricants Spare parts	Pick-up track Motor bicycle	Tractor	Farm machine Grass cutter		
Okyereko	Libricants Spare parts	Pick-up track Motor bicycle	Tractor	Farm machine Grass cutter		

All of the building facilities to be provided by the Project are shown in Table 2.6.

(d) Design of building

The design of the building facilities will be made, taking into consideration the construction costs, architectural standards for public buildings in Ghana, easy O&M and social conditions in rural areas. The basic design conditions will be as follows :

a) Basically, the walls of the buildings will be constructed, using reinforced concrete blocks, and supplemental concrete columns will be provided to reinforce the building structure as necessary.
b) The roof structure will be wooden truss, and galvanized-corrugated iron sheets will be used for roofing.
c) The natural ventilation will fully be used for office and other buildings, providing the ventilation window with louver on the walls, except the

laboratories and working rooms at Ashaiman which will be air-conditioned.

d) The buildings will be designed so as to use the natural lighting as much as possible.

e) The height to the ceiling will be designed to be more than 2.8 m for the offices, laboratories, dormitories, etc., and more than 3.0 m for lecture halls.

f) The superstructure of store house will be designed so as to keep 2-m clearance, and the height to the lower beam of the wooden truss from the floor should be 3.8 m.

(e) Finishing works

The following specifications for finishing works of both the outside and inside of the buildings will be applied in terms of the construction costs, prevailing finishing works for the public buildings in Ghana and easy O&M.

a) For the outside

- Roof	:	Galvanized-corrugated iron sheets
- Outside of wall	:	Plastering by cement mortar on concrete block wall

b) For the inside

- Floor	:	Plastering by cement mortar
- Wall	:	Plastering by cement mortar and painting

c) For ceiling

- Living room	:	Plywood ceiling with painting
- Others	:	Exposed rafter

(f) Structural design

Basically, the structural design will be made in accordance with the Japanese architectural standards.

a) Since the bearing capacity of the foundation layers at the construction sites is enough to support the building facilities, the foundation works for all buildings will be of flat reinforced concrete type. The floor slab will be earth slab with qualified soils, after removing 20 to 30 cm of surface soil layers which may contain grasses, small tree roots, etc. The allowable bearing capacity is set at fe = 10.0 tons/m^2 for laterite layers.

b) The following design seismic co-efficient is applied for the structural design :

- Reinforced concrete frame structures : C = 0.026
- Wooden structures : C = 0.036

c) The wind load is estimated, using 25 m/sec of wind velocity.

(g) Electricity supply system

The electricity to the building facilities in Accra and Aveyime scheme will be supplied from the existing distribution lines. In cases of Okyereko, Mankessim, and Kpando-Torkor schemes, the electricity for the buildings will be supplied from the small-scale diesel generators to be newly installed, because the required transmission line from the existing network to the project site will become long. Since the electricity supply network is already available in the building complex at Ashaiman, the electricity required can be supplied by extending the existing network.

- Distribution of electricity : Single phase, 220 V, 50 Hz
- Lighting : Fluorescent lighting
- Cabling and plug sockets: Fitting as necessary

(h) Domestic water supply system

The domestic water required for the building facilities at Aveyime, Okyereko, Mankessim and Kpando-Torkor schemes will be supplied from the new supply sources (shallow tubewells) to the water tank at first and then distributed to each building by gravity. In case of Ashaiman, the domestic water can be supplied from the existing supply network in the building complex. The building facilities in Accra can use the city water service by extending the existing supply network.

- Water supply to : shower rooms, rest rooms, cooking rooms, laboratories, outside supply cocks (Accra)
- Requirements for
  Buildings in Accra : 45 persons x 250 lit./man-day = 11,250 litres/day
  Tank capacity : 4.5 m3 with 4 m height
  Office buildings : 15 persons x 50 lit/man-day = 750 litres/day
  Tubewell with 100 mm dia. and 40 m deep, with submergible pump
  Laboratories : 1,200 litres/day in total

(i) Others

- The sewage pipelines will be provided in order to evacuate the domestic waste water and excess rainwater.
- The equipment for air-conditioning will be provided in the laboratories at Ashaiman.
- The lightning arrester will be installed for each building.
- The extinguishers will be provided in the offices, laboratories and the building facilities for training, as necessary.

(j) Basic design drawing

The basic design drawings of all the building facilities are given in Table 2.5.

(3) Procurement of Equipment

The procurement of the equipment for the Project will be made on the basis of the basic concept mentioned in sub-chapter 2.2.4, and the equipment, required number, specification and the source of procurement are as follows :

Equipment	Required nos.	Specification	Procurement source
Backhoe	1 no.	Bucket capacity : 0.3 m3	Ghana
Motor grader	1 no.	Blade width : 2.2 m	Ghana
Tractor w/trailer	5 nos.	60 Hp, trailer capacity : 2 tons	Ghana
Micro-bus	1 no.	Diesel engine, for 25 person	Ghana
4WD-pick-up track	5 nos.	2,000 cc, single cabin	Ghana
Motor bicycle	10 nos.	100 cc	Ghana
Grass cutting	15 nos.	Nap-sack type with engine & disk type	
Radio communication set	6 sets	Communication range, 300 km	Ghana

2.4 Basic Concept for Project Implementation

2.4.1 Organisation

GIDA under MOFA is the executing agency for the Project implementation , and GIDA consists of three Departments, one Office and Irrigation Development Center (IDC) at present. The Department of Project Development of GIDA has the direct responsibility for the construction management. Under this Department, two regional offices which are related to the Project exist in Ho and Cape Coast cities. At each site of Ashaiman,

Aveyime, Kpando-Torkor, Mankessim and Okyereko, in addition, there exist the site offices. These regional and site offices will also be engaged in the construction supervision under the control and instruction from the Department of Project Development. The main tasks of GIDA headquarters and these offices are as follows :

GIDA Headquarters

(a) Management of all the activities for the Project implementation
(b) Selection of consultant and contracting
(c) Selection of contractor and contracting
(d) Financial arrangement needed for the engineering and construction works of the Project to be executed by the Government side
(e) Co-ordination between the government agencies concerned with the implementation of the Project

Department of Project Development

(a) Supervision of design of all the construction works
(b) Arrangement of the land required for the Project implementation
(c) Execution of the construction works by the Government side
(d) Co-ordination of all the activities by the regional and district organisations related to the Project implementation
(e) Issue of the commencement order of the construction
(f) Progress and quality control of the construction works
(g) Inspection of the completed works

Regional and Site Offices

(a) Arrangement of all the activities for the construction at the site level under the control of the Department of Project Development

2.4.2 Budget of GIDA

The budget of GIDA in 1997, and that being requested for 1997 and 1998 is as follows :

Item	1997 Request	1997 Actual	1998 Request
For Operation			
Personnel Cost	1,046.9	954.0	1,078.1
Transportation	283.2	40.2	303.6
General Expense	204.8	35.0	194.4
Maintenance/Repair	69.7	69.7	56.8
Others	54.0	54.0	74.1
Sub-total	1,658.6	1,152.9	1,707.0
For Development			
Construction	135.0	55.0	100.0
Equipment	305.0	50.0	570.0
Irrigation Schemes	1,490.0	475.0	2,465.0
Sub-total	1,930.0	580.0	3,135.0
Total	3,588.6	1,732.9	4,842.0
(Actual/Request)		(48.0 %)	

2.4.3 Staffing

At present, several development projects are on-going under the management of the Department of Project Development of GIDA which include detailed design, international tendering, selection of consultants as well as the contractors and construction supervision. It may be said from these activities that the staffing and their engineering capability are acceptable and sufficient for the Project implementation. In addition, it is confirmed with GIDA that appropriate number of staff could be assigned for this Project in the GIDA's headquarters as well as for the site offices.