DEPARTMENT OF IRRIGATION
MINISTRY OF IRRIGATION AND WATER DEVELOPMENT
THE REPUBLIC OF MALAWI

BASIC DESIGN STUDY REPORT ON THE PROJECT FOR BWANJE VALLEY SMALLHOLDER IRRIGATION DEVELOPMENT IN THE REPUBLIC OF MALAWI

MARCH 1997

JAPAN INTERNATIONAL COOPERATION AGENCY
NIPPON KOEI CO., LTD.

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PREFACE

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

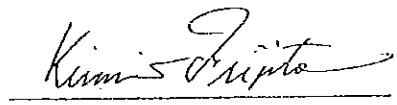
JICA sent to Malawi a study team from September 8 to October 12, 1996.

The team held discussions with the officials concerned of the Government of Malawi, 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 Malawi 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 Malawi for their close cooperation extended to the teams.

March, 1997



Kimio Fujita
President
Japan International Cooperation Agency

March, 1997

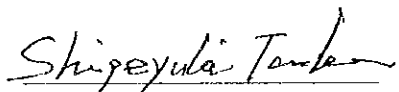
Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for Bwanje Valley Smallholder Irrigation Development in the Republic of Malawi.

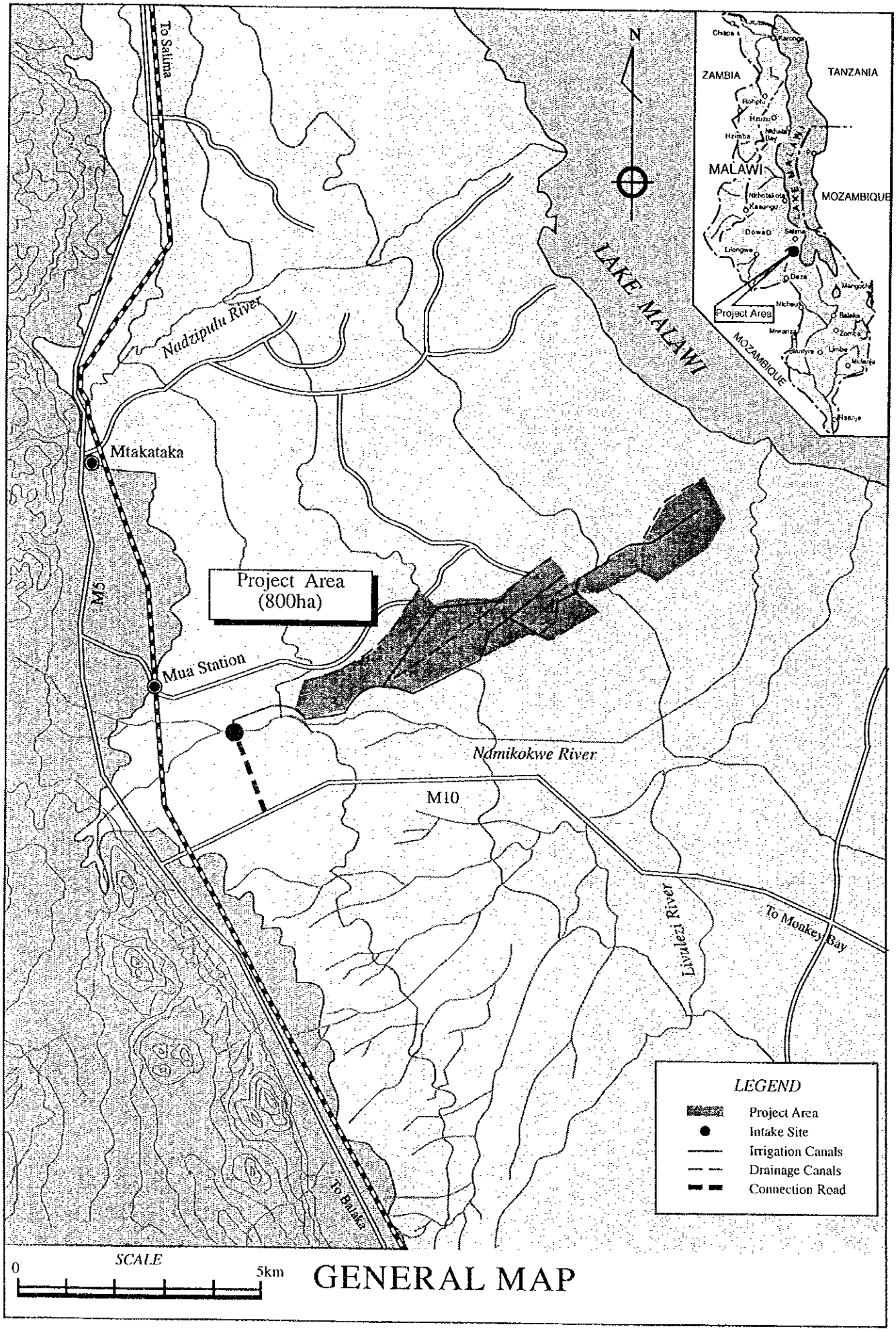
This study was conducted by Nippon Koei Co. Ltd., under a contract to JICA, during the period from September 2, 1996 to March 10, 1997. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Malawi and formulated the most 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,

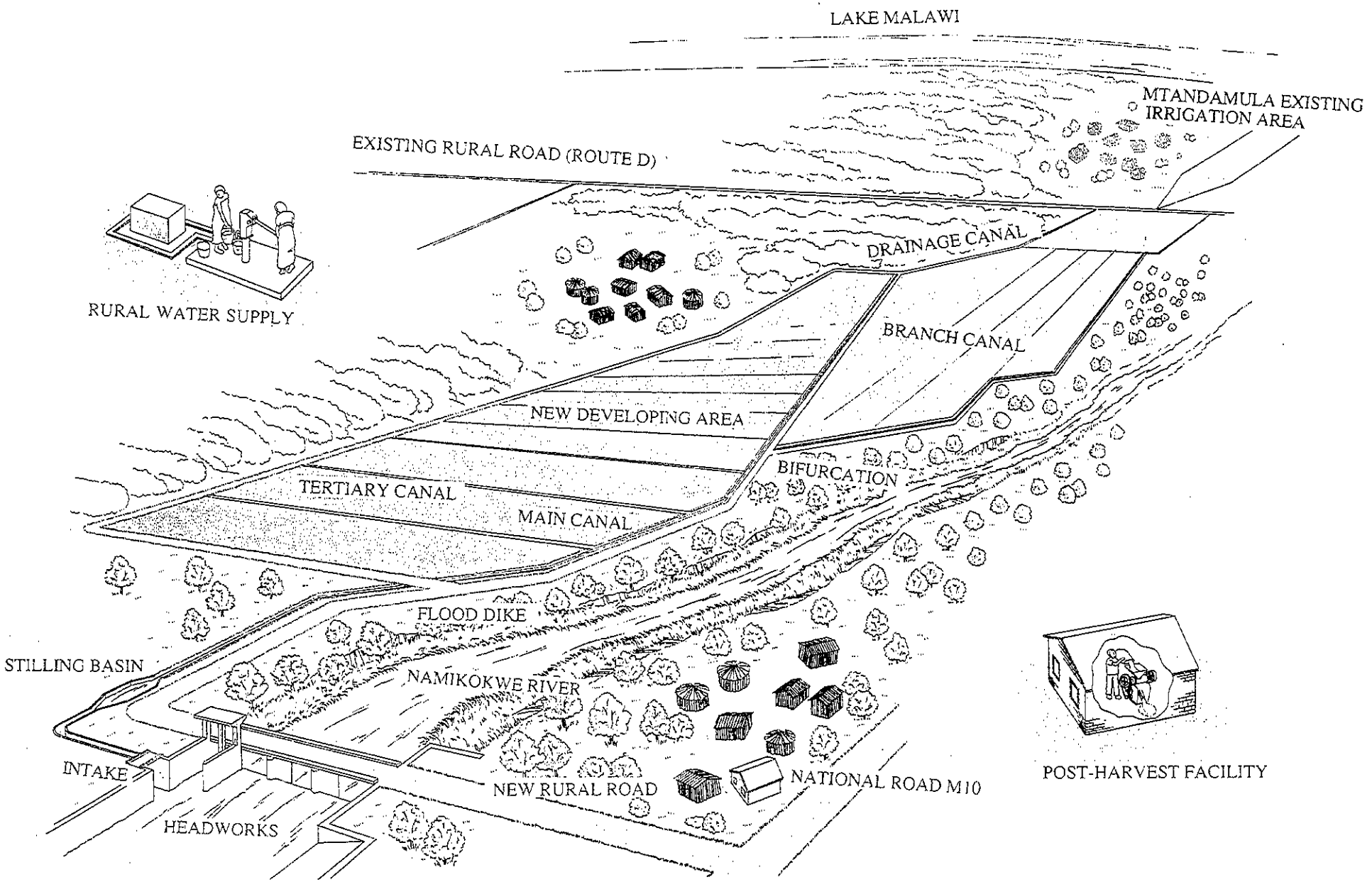


Shigeyuki Tanaka
Project manager,
Basic design study team on
the Project for Bwanje Valley
Smallholder Irrigation Development
Nippon Koei Co., Ltd.


To Salima
N
LAKE MALAWI
Nadzipulu River
Mtakataka
M5
Project Area
(800ha)
Mua Station
Namikokwe River
M10
Livulezi River
To Monkey Bay
To Balaka
ZAMBIA
TANZANIA
MALAWI
MOZAMBIQUE
Project Area
LEGEND
Project Area
Intake Site
Irrigation Canals
Drainage Canals
Connection Road
0
SCALE
5km

GENERAL MAP

BIRD'S-EYE VIEW



ABBREVIATIONS

ACLCO	Land Resources and Conservation Branch
ADB	African Development Bank
ADD	Agricultural Development Division
ADF	African Development Fund
ADMARC	Agricultural Development and Marketing Corporation
ARNC	Adaptive Research National Coordinator
ARO	Adaptive Research Officer
CAARO	Department of Agricultural Research
CAETO	Department of Agricultural Extension and Training
CAM	Chainease Agricultural Mission
CAN	Calcium Ammonium Nitrate
CAS-NRDP	Controller of agricultural services
CAS-I	Controller of agricultural services
CDC	Common Wealth Devilment Corporation
CEC	Cation Exchange Capacity
CIF	Cost, Insurance and Freight
CONGOMA	Council for Non-Government Organizations in Malawi
DANIDA	Danish International Development Agency
DAP	Di-Ammonium Phosphate
DAR	Department of Agricultural Research
DET	Department of Agricultural Extension and Training
DO	Development Office
DOI	Department of Irrigation
EC	European Community
EC	Electric Conductivity
E/N	Exchange of Notes
EPA	Extension Project Areas
EPD	Economic Planning and Development
ESCOM	Electricity Supply Commission of Malawi
ETo	Evapotranspiration
EXST	Estate Extension Services Trust
FA	Field Assistant
FAO	Food and Agricultural Organization of the United Nations
FES	Farming Equipment and Engineering Services
FHA	Farm Home Assistants

FHH	Female Headed Households
GDP	Gross Domestic Product
HESP	Health Education and Sanitation Promotion Programme
IFAD	International Fund for Agriculture Development
IMF	International Manetary Fund
JICA	Japan International Cooperation Agency
Kc	Crop coefficient
KW	Malawi Kwacha
MIWD	Ministry of Irrigation and Water Development
MALD	Ministry of Agriculture and Livestock Development
MOF	Ministry of Finance
MOH	Ministry of Health
MOWS	Ministry of Works and Supplies
MRL	Malawi Railways Ltd.
NEWS	National Early Warning System
NGO	Non-governmental Organization
NOIL	National Oil Industries
NRC	National Research Coordinators
NSCM	National Seed Company of Malawi
NVRC	National Variety Release Committee
O&M	Operation and Maintenance
OPC	Office of the President and Cabinet
PFNO	Food and Nutrition Unit
PHA	Private Hospital Association
PM	Programme Manager
PO	Project Officer
RDP	Regional Development Project
SA	Sulphate of Ammonium
SACA	Smallholder Agricultural Credit Association
SADCC	Southern African Development Coordination Conference
SCF	Save the Children Fund
SFFRFM	Smallholder Farmers' Fertilizer Revolving Fund of Malawi
SFHA	Senior Farm Home Assistants
SLADD	Salima Agricultural Development Division
SMO	Seed Multiplication Officer
SMS	Subject Matter Specialists
STWPC	Seed Technology Working Party Committee
SUCOMA	Sugar Company of Malawi

TA	Traditional Authority
UNDP	United Nations Development Program
UT (M)	United Transport of Malawi
WFP	World Food Program

STANDARD ABBREVIATIONS

m^3	Cubic metre
m^3/sec	Cubic metre per second
d	Day
hr	Hour
°C	Degrees Celsius
El.	Elevation above mean sea-level
ha	Hectare
kg	Kilogram
km	Kilometre
lit	Litre
lit/min	Liter per minute
lit/sec	Litre per second
km	Kilometer
m	Metre
cm	Centimeter
mm	Millimetre
km^2	Square kilometre
m^2	Square metre
ton	Tonne

SUMMARY

SUMMARY

Malawi is landlocked country located between latitudes 9°22' and 17°03' S and longitudes 33°40' and 35°55' E with a total territory of 119,140 km^2 of which 21% are the Malawi lake. The national population was about 9,730,000 in 1994 and the annual growth rate was 3.2% in the period from 1980 to 1992. In 1989, Mozambican refugees of nearly 10% of the national population escaped to Malawi, and this has depressed Malawi's economy, especially in regard to the food security. Maize which is staple food in Malawi was imported 13 % of the demand in 1995.

The structural adjustment programmes with World Bank and International Monetary Fund (IMF) since 1981 made it possible to postpone payment of her debt and invest financial development funds in the estate sectors. The GOM encouraged the export of the estate-oriented crops such as tobacco, tea and sugar. As a result, the economy of Malawi has considerably recovered. However, such government efforts adversely affected the smallholder sector. Namely, the lending conditions of agricultural credit become more severe for the smallholder and the smallholders government subsidy for fertilizer supply was abolished. Under such conditions, smallholders' food production could not meet the increasing domestic demand and it remained at a crucial level in regard to the food balance. Facing serious drought in the mid-1980s, food security became a concern.

The GOM launched the Statement of Development Policies 1987-1996, in which the highest priority is given to agricultural development, paying particular attention to food production by smallholders. The Statement emphasizes the improvement and development of irrigation facilities, agricultural research, marketing, livestock, and agro-industry.

In this situations, the GOM requested a feasibility study (F/S) on the Smallholder Irrigation Project in the Bwanje Valley where is one of the most economically depressed areas in Malawi. In response to a request from GOM, the Government of Japan (GOJ) decided to conduct the F/S for the Project. Japan International Cooperation Agency (JICA) carried out the F/S during the period between 1992 and 1994. The F/S report concluded that the Project is both economically and technically feasible. The GOM requested the GOJ to extend a grant aid for implementation of the Project.

In response to a request from GOM, the GOJ decided to conduct a preliminary study for the Project. The preliminary study was carried out during the period between May 23 and June 5, 1996, aiming at establishing practical and realistic development scheme, and formulated an implementation program for the optimum development scheme. As the result, the GOJ decided to conduct a basic design study for the Project.

JICA dispatched a basic design study team to Malawi during the period between September 8 and October 12, 1996. The study team discussed with GOM officials regarding the contents of the Project and scope of works to be implemented under Japanese Grant Aid Program, and carried out the field survey including site investigation, inventory of existing facilities and so on. A basic agreement was then signed and exchanged.

After returning to Japan, based on the results of the field surveys, the study team carried out the basic design study including the headworks, canal and road design, rural water supply system and post-harvest facility, and prepared a draft basic design report containing contents of the Project, implementation program, scope of works by GOM and so on.

JICA dispatched a mission to explain the draft basic design report to GOM during the period between November 25 and December 7, 1996. A basic agreement was signed and exchanged after the contents of the draft basic report were verified and agreed upon by both parties.

The basic concept of the basic design are summarized as follows;

(1) Irrigation and Drainage Plan

Since the Project is regarded as a farmers participation and self-management type, the management, operation and maintenance of the Project shall be carried out by the farmers organization. In order to simplify the water management activities by the farmers organization, an intake weir will be constructed on the Namikokwe river which will lead to ensuring of stable water supply, and water distribution will be made for crop field through main canal, branch canals and tertiary canals in turn. Main and branch canals will be provided with concrete lining, taking into consideration effective use of water source, that is, less canal conveyance loss.

Land leveling works for total area of 47.8 ha will be carried out for presenting sample construction works of land leveling. Since land leveling work is expected to be gradually carried out by the farmers through the farming practices and also considering the scale of Japan's Grant Aid.

Drainage canal will be constructed in and around the project area to protect the project facilities from heavy rainfall and to increase land productivity. An inspection road of 5 m in total width will be provided along main and branch canals for the purpose of operation and maintenance of headworks, main and branch canals.

(2) Rural Infrastructure Plan

The road plan is made based on the basic concept that 2 routes from national roads to the project area shall be ensured not to isolate the project area. New road from headworks to national road M10 will be provided as one access, and the existing rural road (D route) will be used as another access.

Thirteen boreholes will be provided for domestic use as well as to mitigate the women's works and to reduce the infection with bilharzia.

(3) Post-harvest Facility Plan

Four ricemill will be provided at respective village groups for the purpose of home consumption as there is no ricemill in and around the project area. These mills will be reduce the woman's work load. But the maizemill will not be installed since four private maizemill are existing in and around the project area having enough capacity.

The scope of work determined in the basic design study is summarized as follows:

(a) Irrigation and drainage facilities

Irrigable area	Existing Mtandamula area	230 ha		
	Newly developed area	570 ha	:	800 ha
Headworks			:	1 no.
Irrigation canal	Main canal		:	6.8 km
	Branch canal		:	14.8 km
	Tertiary canal		:	60.8 km
Land leveling works (sample area)			:	47.8 ha
Drainage canal			:	17.3 km
Inspection road			:	13.7 km
Flood dike/road			:	7.8 km
Related structures	Main canal		:	23 nos.
	Branch canal		:	98 nos.
	Tertiary canal		:	2,070 nos.
	Drainage canal		:	54 nos.

(b) Rural infrastructures

Road from headworks to M10		:	2.3 km
Related structures		:	5 nos.
Water Supply	Borehole and hand pump	:	13 nos.

(c) Post-harvest facility

Ricemill including diesel engine, 100 - 120 kg/hr.	:	4 nos.

For the implementation of the Project under the Japanese Grant Aid Program, the detailed design and the construction will be commenced after the respective Exchange of Notes between the GOJ and the GOM. The periods of the detailed design and construction were estimated at 4.5 months and 25 months respectively.

The Project aims to elevate the agricultural production and living standard of smallholder through development of agriculture and social infrastructures centering irrigation facilities thereby intensifying regional economic activities, and will improve the basic human need in the areas.

With the implementation of the Project the paddy production and gross income will increase greatly as shown below ;

With Project				Present Condition			
Production (ton)			Gross Income (KW x1,000)	Production (ton)			Gross Income (KW x1,000)
Paddy	Maize	Vegetables	-	Paddy	Maize	Vegetable	-
3,600	372	600	46,960	980	150	-	5,471

Agriculture plays a dominant role in Malawi's economy as a whole, contributing 87 % of the total employment. The crop production of the smallholder farmers, holding a large majority of the total crop production, is still vulnerable to varying climatic conditions since most of the crop fields are rainfed. Therefore, the income of the farmers is quite low and it frequent occurs a lack of maize, staple crop, for home consumption in the drought year.

Various direct and indirect benefits are expected to accrue from the implementation of the Project. The Major direct benefits will be the substantial increase of rice production and the consequent increase of farmer's incomes and improvement of living standard of farmers. The indirect benefit will be the enhancement of socio-economic activities of inhabitants, stable supply of foodstuffs, increase of employment opportunities and so on.

As the Project scale is in the largest class in Malawi and the construction period would require 25 months, GOM is requested to provide active cooperation for the successful completion of construction works. In order to execute construction supervision effectively, it is indispensable to establish a construction office and to arrange the required manpower and budget accordingly. In particular, some works shall be executed by farmers themselves under the farmers participation program, and these farmers' works will also be controlled by the construction office. The farmers organization shall execute operation and maintenance of the completed facilities in line with the GOM policy. However, it is unlikely that the farmers organization could provide satisfactory management, operation and maintenance activities immediately after completion of construction work because the present farmers organization is not familiar with such activities. Certain transition period is therefore required. During the transition period, GOM is requested to execute the training work to farmers as well as operation and maintenance works.

As mentioned above the implementation of the Project was suitable and viable for Japan's Grant Aid as a result of field survey in Malawi and analyses in Japan, because the Project will significantly contribute to stable food production and stabilizing of public welfare in Malawi as well as improvement of economic status of smallholder farmers in line with the national development policies as already described.

The land in the Project areas is under the jurisdiction of the Traditional Authority (TA) in conformity to the conventional land tenure system, and land acquisition and land allocation will be handled by TA. Although the written commitments on land acquisition and allocation were obtained from the TA, it is recommended that DOI will give full attention and guidance to TA for smooth implementation of the Project.

Judging from the circumstances around the Project, it is expected that the Project will be implemented smoothly and effectively with due consideration to and realization of following commitment by the concerned parties.

(a) To carry out land acquisition for the construction office, temporary stockyard, quarry sites for pavement material, borrow pits as well as land allocation in line with the implementation schedule,

(b) To establish the efficient organization together with budgetary arrangement during the implementing period of the works and the transition period for handing over the completed facilities to farmers organization,

(c) To carry out the construction works under the farmers participation under the technical guidance of GOM in conformity with the implantation schedule of the Project,

(d) To provide training works as well as operation and maintenance works efficiently to the farmers organization during the implementing period and transition period, and

(e) To establish a technical supporting system to the farmers organization after handing-over the completed facilities.

BASIC DESIGN STUDY REPORT
ON
THE PROJECT
FOR
BWANJE VALLEY SMALLHOLDER
IRRIGATION DEVELOPMENT
IN
THE REPUBLIC OF MALAWI

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CHAPTER 1
BACKGROUND OF THE PROJECT

CHAPTER 1 BACKGROUND OF THE PROJECT

Malawi is landlocked country located between latitudes 9°22' and 17°03' S and longitudes 33°40' and 35°55' E with a total territory of 119,140 km^2 of which 21% are the Malawi lake. The national population was about 9,730,000 in 1994 and the annual growth rate was 3.2% in the period from 1980 to 1992. In 1989, Mozambican refugees of nearly 10% of the national population escaped to Malawi, and this has depressed Malawi's economy, especially in regard to the food security. Maize which is staple food in Malawi was imported 13 % of the demand in 1995.

The economy of Malawi had declined in the first half of the 1980s in spite of the steady growth till the end of the 1970s. In this situation, the Government of Malawi (GOM) had performed a series of structural adjustment programmes with World Bank and International Monetary Fund (IMF) since 1981, and the Gross Domestic Product (GDP) had shown a real growth rate of 3.6% in the second half of the 1980s. By 1990 the GDP growth rate had increased and reached 4.8 %. However, the GDP growth rate had decreased in minus 7.9 % and 11.6 % in 1992 and 1994 respectively due to severe drought, which shows an insecure economy of Malawi. The GDP of Malawi is US $ 200 per capita in 1993.

Agriculture plays a dominant role in Malawi's economy as a whole, contributing 36.8 % of GDP in 1995 and 87 % of the total employment in 1992. The exports of Malawi are largely derived from the agriculture sector. In 1995, the total export value was KW 6,077 million, of which 86 % was derived from the agriculture sector.

Agricultural activities occupy 20,143 km^2 or 21.4% of land, of which 13,833 km^2 or 69 % are cultivated by smallholder farmers and 6,310 km^2 are managed by estate farmers which are producing the crops for the export. Staple crops are produced by smallholder farmers, these account for 70 % to 80 % of the total crop production. They are mostly planted by traditional methods under rainfed conditions. Therefore, the crop production levels of Malawi have largely fluctuated.

The structural adjustment programmes mentioned above made it possible to postpone payment of her debt and invest financial development funds in the estate sectors. The GOM encouraged the export of the estate-oriented crops such as tobacco, tea and sugar. As a result, the economy of Malawi has considerably recovered. However, such government efforts adversely affected the smallholder sector. Namely, the lending conditions of agricultural credit become more severe for the smallholder and the smallholders government subsidy for fertilizer supply was abolished. Under such

conditions, smallholders' food production could not meet the increasing domestic demand and it remained at a crucial level in regard to the food balance. Facing serious drought in the mid-1980s, food security became a concern.

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Major components of the request are as follows;

- Construction of irrigation, drainage and inspection road for irrigable area of 800 ha
- Land reclamation and leveling (800 ha)
- Road rehabilitation and new construction (21 km)
- Construction of ricemill (capacity 1 ton/hr, 5 nos)
- Construction of borehole equipped with a hand pump (1 no per 1 village, 29 nos)
- Construction of development center and supply of equipment

In response to this request, the GOJ decided to conduct a basic design study. JICA sent a preliminary study team and a basic design study team as follows;

(1) Preliminary Study May - June 1996

The requested works were considered too large in scale to implement under a grant aid To clarify operation and maintenance organization of the Project after the implementation, discussion were made with the concerned officials of the GOM on the possible reduction of the scope of the works and the necessary organization for the operation of the Project.

(2) Basic Design Study

Based on the preliminary study, the basic design study was carried out taking into consideration a scale of grant aid and operation and maintenance of the Project, and following major components were decided.

- Construction of irrigation, drainage and inspection road for irrigable area of 800 ha
- Land reclamation (47.8 ha)
- Construction of new road (2.3 km)
- Construction of ricemill (capacity 100-120 kg/hr, 4 nos)
- Construction of borehole equipped with hand pump (13 nos)

CHAPTER 2
CONTENTS OF THE PROJECT

CHAPTER 2 CONTENTS OF THE PROJECT

2.1 Objectives of the Project

The food security in Malawi was a serious problem due to low agricultural production by smallholders which had not obtained satisfactory support from the Government of Malawi (GOM), and recurrent droughts in the first half of 1980s. In order to improve such situation, GOM established the Statement of Development Policies 1986 - 1996, in which the highest priority is given to agricultural development, paying particular attention to food production by the smallholders. Concurrently, GOM hammered out the following basic policies in the national irrigation development plan :

(a) Irrigated agriculture is considered a supplement to rain fed agriculture and its overall objective is social and economic development that is sustainable over time.

(b) One of the key concepts of the Policy Framework is "participation". This concept involves members of society in the decision making process for irrigation development. This participatory approach emphasizes the importance of the linkage between research, extension, technology and the farmers.

(c) The policy and development strategy assumes the Government will restore and maintain macroeconomic stability through prudent fiscal and monetary policies.

(d) The aim of this policy and development strategy is to create an atmosphere which encourages the private sector; smallholder farms, estates and commercial farmer to invest in irrigation development and manage their own operations. The Government has the role of a facilitator in this development process.

(e) It is also an aim of the irrigation policy to improve the economic status of smallholder farmers, but where market access cannot be achieved, the first step will be improvement of subsistence farming until market conditions improve.

The Bwanje Valley Smallholder Irrigation Development Project (the Project) was taken up from the Bwanje Valley area where development situation is at the lowest level in Malawi in accordance with the basic policies in the national irrigation development plan in the framework of the Statement of Development Policies. The objective of the Project is to elevate the agricultural production and living standard of smallholders through development of agriculture and social infrastructures centering irrigation facilities under the concept of farmers participation and management irrigation project.

2.2 Basic Concept of the Project

(1) Basic Concept for Irrigation and Drainage Plan

Since the Project is regarded as a farmers participation and self-management type, the management, operation and maintenance of the Project shall be carried out by the farmers organization. Therefore, in the implementation of the Project, the consideration shall be given to introduction of farmers participation and self-management of the Project. In particular, water management which is the most important activity in operation shall also be executed by the farmers organization.

In order to simplify the water management activity, an intake weir will be constructed on the Namikokwe river which will lead to ensuring of stable water supply, and water distribution will be made for crop fields through main canal, branch canals and tertiary canals in turn. Main and branch canals will be provided with lining, taking into consideration effective use of water source, that is, less canal conveyance loss. This lining will bring about ease in operation and maintenance of canals which will result in reduction of farmers' load, and will make proper water distribution in addition to the above merits.

A study was made for the participation of the farmers in the construction of tertiary canals. As a result, it was concluded that the construction of tertiary canal system shall be incorporated into the scope of works for the Project, in view of (a) only easy excavation that farmers could do (confirmed through interview with farmers concerned), and (b) difficulty in quality control and schedule control. On the other hand, farmers participation shall be applied for (a) sod-facing work, (b) construction of small drains, and (c) labors participation for the construction works.

Since land leveling work is expected to be gradually carried out by the farmers through the farming practice and also considering the scale of Japan's Grant Aid, the land leveling works are excluded from the scope of works. However, land leveling works for total area of 47.8 ha in three (3) branch canal systems will be carried out for presenting sample construction works of land leveling. As for the demarcation of paddy fields, the field inlet on the tertiary canal will be provided for every 0.4 ha, which can guide farmers for the demarcation of paddy field of 0.4 ha. Furthermore, work load on the land leveling works will be mitigated through further division of one paddy field into a few plots by constructing small field ridge.

An inspection road of 5 m in total width, 3 m in effective width and 0.2 m in weather rock pavement, will be provided along main and branch canals for the purpose of operation and maintenance of headworks, main canal and branch canals. A foot path of one meter width will be provided along tertiary canal for the manual transportation of agricultural products and inputs from field plots. Five drainage canals will be constructed in and around the project area to protect the project facilities from heavy rainfall and to increase land productivity by smooth elimination of flood and/or excess water from the project area.

(2) Basic Concept for Rural Infrastructure Plan

There is a road network plan in the Project, consisting of construction of 3 connection roads to link with the inspection roads, rehabilitation of 2 existing rural roads (C route and D route), and construction of 2 new rural roads. Connection roads are reviewed and studied, but these are excluded from the scope of works for the Project mainly due to low demand and frequency in use. As for rural road plan, there are 4 route plans such as (a) rehabilitation of C route, (b) rehabilitation of D route, (c) construction of new road from headworks to M10, and (d) construction of new road connecting the upper area of the Project with C route. These plans are studied based on the basic concept that 2 routes from the national roads to the project area shall be ensured not to isolate the project area. As a result, D route will be used as one access, but its rehabilitation is not included in the scope of works for the Project, since its maintenance is expected by the Ministry of Works and Supplies. Another access will be ensured by construction of new road from headworks to M10, especially considering access of relevant farmers living at the opposite side of the Namikokwe river for participation in the construction works and subsequent agricultural activities.

In order to mitigate the women's works, 13 boreholes will be dug and hand pumps will be installed for domestic water use, which are determined based on the inventory results of existing borehole and pump conditions scattered in relevant 22 villages.

(3) Basic Concept for Post-Harvest Facility Plan

4 ricemills will be provided at respective village groups for the purpose of home consumption as there is no ricemill in and around the project area. These mills will reduce the women's work load. But the maizemill will not be installed since 4 private

maizemills are presently existing in and around the project area and their total capacity is considered to be enough to cope with the maize production.

(4) Basic Concept for Construction Management Plan

As the Project scale is in the largest class in Malawi and the construction period would require at least 2 years, GOM is requested to provide active cooperation and involovement for the successful completion of construction works. In order to execute construction supervision effectively, it is indispensable to establish a construction office and to arrange the required manpower and budget accordingly. In particular, some works shall be executed by farmers themselves under the farmers participation program, and these farmers' works will also be controlled by the construction office. A construction schedule will be prepared considering the partial completion, and the completed portions will immediately be transferred to GOM. GOM shall execute operation and maintenance for the completed portions in consultation with the consultant.

(5) Basic Concept for Operation and Maintenance Plan

According to the GOM policy, the farmers organization shall execute operation and maintenance of the completed facilities. However, it is unlikely that the farmers organization could provide satisfactory management, operation and maintenance activities immediately after completion of construction work because the present farmers organization is not familiar with such activities. Certain transition period is therefore required. During the transition period, GOM is requested to execute the training work to farmers as well as operation and maintenance works. Such a transition period will be determined based on scale and importance of facilities.

An operation and maintenance office will be provided with a farmers training section, to strengthen the training activity. After expiring transition period, all facilities completed will be transferred to the farmers organization, and the operation and maintenance office will be closed. But, GOM will provide the farmers organization with continuous technical support through Salima ADD.

The farmers organization for the Project shall be established in accordance with the following basic concepts:

(a) The structure of the present farmers organization which is managing the Mtandamula existing irrigation system covering 230 ha, shall be in principle

applied to the 800 ha canal system, with strengthening measures of the O & M activities; and

(b) The main objective of the farmers organization is to operate and maintain the irrigation facilities, although other objectives such as marketing and credit services are also included in order to meet with the farmers' intention.

(6) Basic Plan for the Project

The basic plan for the Project which is formulated based on the basic concepts for respective plans mentioned above, is to construct the following irrigation and drainage facilities, rural infrastructures and post-harvest facilities, aiming to elevate the living standard of about 9,900 smallholders in the Bwanje Valley where development situation is at the lowest level in Malawi, and to contribute to the stable food production in Malawi:

(a) Irrigation and drainage facilities

Irrigable area	Existing Mtandamula area	230 ha		
	Newly developed area	570 ha	:	800 ha
Headworks			:	1 no.
Irrigation canal	Main canal		:	6.8 km
	Branch canal		:	14.8 km
	Tertiary canal		:	60.8 km
Land leveling works (sample area)			:	47.8 ha
Drainage canal			:	17.3 km
Inspection road			:	13.7 km
Flood dike/road			:	7.8 km
Related structures	Main canal		:	23 nos.
	Branch canal		:	98 nos.
	Tertiary canal		:	2,070 nos.
	Drainage canal		:	54 nos.

(b) Rural infrastructures

Road from headworks to M10		:	2.3 km
Related structures		:	5 nos.
Water Supply	Borehole and hand pump	:	13 nos.

(c) Post-harvest facility

Ricemill including diesel engine, 100 - 120 kg/hr.	:	4 nos.

2.3 Basic Design

2.3.1 Design Concept

(1) Design Concept for the Natural Conditions

(a) Proposed construction site of headworks

Two borings were executed at the proposed construction site of headworks, to grasp the foundation condition. According to the results of borings, it was clarified that the N-value would be between 0 to 10 for the ground surface to 12 or 13 m in depth, and more than 23 for 15 to 20 m in depth which was observed as the sandy or silty clay layers. The expected firm foundation for the headworks would therefore be 15 to 20 m below the ground surface. The foundation treatment of the headworks against such weak foundation condition in the Basic Design will be executed in line with the following guidelines:

- The weak foundation showing N-value of 0 shall be replaced with sand, to heighten the workability for the temporary works and construction of headworks.
- The pile foundation shall be applied for structural stability of headworks.
- The sheetpiles shall be provided under both upstream and downstream aprons of headworks to prevent the piping phenomenon.
- The crossing points of original river course crossing with the proposed dike at the upstream and downstream of the headworks, shall be filled with sands, to avoid settlement of dike.

(b) Irrigation canals

Consideration shall be given for the creation of stable foundation at the crossing points of irrigation canal with the original river course. The crossing points of the canals with the original river course shall be provided with sand replacement and piling.

The village houses and the woods with 20 to 30 cm in diameter are scattered in the newly developed area of 570 ha. The canal route shall be worked out to avoid the shifting of the houses and cutting of woods as far as possible.

(2) Design Concept for the Social Conditions

The river crossing structure is required for the farmers living at the opposite side since these farmers will frequently come to the project area for participation in the farmers' construction works and subsequent agricultural activities. At present, woods are put on the river for crossing purpose, which are usually flushed away by floods. In order to improve such a poor situation and ensure an access from M10 for the operation and maintenance of irrigation and drainage facilities, a concrete bridge shall be constructed on the weir.

In order to minimize a possibility of infection with bilharzia, a canal crossing structure shall be provided at 500 m interval on the main and branch canals as one of prevention measures against bilharzia infection.

In connection with installation of pumps, a fence shall be provided at the drainage box by GOM, as a countermeasure to avoid the germs intrusion.

A ricemill facility shall be provided at village group, and its location shall be determined in consideration of its noise.

(3) Maximum Usage of Local Contractor and Available Materials in Malawi

The facilities shall be designed using the construction materials available in Malawi such as cement, steel bar, steel gate, etc., and taking into consideration the application of local contractors within technically allowable extent to activate the societies of the local contractors and the construction materials suppliers.

(4) Design Concept for Grade of Facilities and Construction Materials

As mentioned in the basic concepts for the Project, the main and branch canals shall be provided with lining aiming at effective use of limited water resource, ease of maintenance and ensuring of proper water distribution. The canal lining will also help in the reduction of burden to the farmers organization about operation and maintenance activities.

The inspection road along the main and branch canals shall be paved with the weathered rocks which are available near the project site, in view of the role and importance in the project area, frequency in use and ease of maintenance.

The type of hand pump will be selected same as those which are widely prevailing in Malawi considering the maintenance works by the beneficial village people.

The ricemill and diesel engine to be equipped shall be the same or the similar type with those being presently used near the project area as far as possible, from viewpoint of easy maintenance.

(5) Design Concept for Construction Schedule

The construction of the Project requires 25 months, taking into account the workable days in a year, the required work volume, and coincidence with the financial system of Government of Japan. The construction schedule will be worked out based on the required period of 25 months and the application of partial completion.

2.3.2 Basic Design

(1) Irrigation and Drainage Facilities

(a) Design Policy

The following concept are considered for the formulation of the irrigation and drainage development plan.

i) Maximum use of the limited water resources
ii) Assurance of stable water intake though proper selection of headworks site
iii) Introduction of rotational irrigation for simplifying water management
iv) Establishment of facility plan for equitable water distribution
v) Protection of the project area by construction of flood dike with dual function of inspection road
vi) Assurance of smooth drainage from the Project site
vii) Appropriate plan and design of inspection road in conjunction with rural road plan
viii) Proper facility plan and design in due consideration of construction technique and method, and working condition in Malawi
ix) Maximum utilization of construction materials available in Malawi for easy maintenance works in future

(b) Examination of Design Condition

(i) Water Resources

Water resource for the project is the runoff of the Namikokwe river and its tributary the Nadzipokwe river. Both rivers are equipped with the gauging stations, which were established by the government agency in the 1950s. In order to confirm the irrigable area through water balance study, the daily discharge data were supplemented to the those collected in the Feasibility Study, and these data are arranged for the period of 23 years out of 40 year from 1957 to 1996. The flow condition of both river are described as below.

- The Namikokwe river is a perennial stream with a catchment area of 129 km^2 at the gauging station 3.E.2. The mean annual flow discharge at 3.E.2 is observed at 1.47 km^2/sec., but there are large monthly fluctuations.
- The Nadzipokwe river is the main tributary of the Namikokwe. It joins with the Namikokwe about 1.5 km downstream of the railway bridge. It has a catchment area of 30.1 km^2 at the confluence and a mean annual discharge of 0.77 m^3/sec.

The monthly mean discharge of each year is given in Table 2-1, and the summary is presented below.

(unit:m3/sec)

Name of station	N	D	J	F	M	A	M	J	J	A	S	O	Mean
(3E2)	0.27	2.25	3.59	5.04	3.93	2.16	1.02	0.67	0.48	0.33	0.21	0.15	1.47
(3E1)	0.11	1.04	1.71	1.49	2.28	0.93	0.47	0.32	0.24	0.18	0.11	0.07	0.77
Combined	0.36	3.37	5.39	6.61	6.60	3.15	1.51	1.01	0.73	0.52	0.34	0.22	2.25

(ii) Proposed Cropping Pattern

Paddy is selected as the main crops for the Project taking account of 1) plant physiological suitability for local climatic conditions and soil conditions, 2) marketability and profitability of crops, 3) yield response by irrigation water supply, 4) farmer's familiarity for crops, 5) farm labor requirement and availability of workforce in and around the project areas, and easy storing and processing. The selected variety of paddy is Faya with growth period of 150 days, which is prevailing in the Project area at present, and has reasonable

yielding even with little agro-chemical and fertilizer. The selected crops for the dry season are early matured maize and vegetables that have a less than 90 days growth period in consideration of the available water and crop water consumption. Based on the above conditions, the proposed cropping pattern is illustrated in Fig. 2-1. The target yield of crop is 4.5 ton/ha of paddy, 2.0 ton/ha of maize, and 10 ton/ha of vegetable.

(iii) Irrigation Water Requirement

Irrigation water requirements are estimated based on the following concepts using the data collected during the Feasibility Study and during the field survey of the Basic Design Study.

- Evapotranspiration (ETo) at the Monkey Bay meteorological station in "Climatological Tables for Malawi" prepared by the Meteorological Department is used.
- Water requirement for puddling of paddy field is assumed to be 150 mm.
- Percolation losses in paddy field during cultivation period is assumed to be 3 mm/day.
- Effective rainfall is estimated by the daily water balance method using the daily rainfall records. Daily rainfall record of Mua mission station is used in the period from 1957 to 1978, and since the said station was closed in 1978, the rainfall record at Mtakataka airwing station, located about 7 km northern part of the Project area, is used after 1979 for estimation.
- Water requirement for the nursery is neglected due to small amount.
- Computation is done on the 10-day basis.
- Irrigation efficiency is assumed at 72 %, consisting of 90 % of conveyance efficiency, and 80 % of field application efficiency.

Based on the above conditions, unit diversion water requirements on the 10-day basis are estimated for 31 years from 1957 to 1996, when the daily rainfall records are available. The results are shown in Table 2-2, and the average diversion water requirement is summarized below.

(unit: lit/sec/ha)

Month	Rainy Season : Rice		Month	Dry Season : Maize	
	early	0		early	0
Dec.	middle	0	Jun.	middle	0.04
	late	0.69		late	0.10
	early	0.70		early	0.23
Jan.	middle	0.85	Jul.	middle	0.38
	late	0.77		late	0.49
	early	0.67		early	0.78
Feb.	middle	0.64	Aug.	middle	0.86
	late	0.77		late	0.87
	early	0.85		early	0.81
Mar.	middle	0.95	Sep.	middle	0.40
	late	1.08		late	0.09
	early	1.09		early	0
Apr.	middle	1.16	Oct.	middle	0
	late	1.00		late	0
	early	0.53		early	0
May	middle	0.18	Nov.	middle	0
	late	0		late	0

Unit peak diversion water requirements in the rainy season and dry season are shown below.

Rainy season crop	1.42 liter/sec./ha
Dry season crop	0.87 liter/sec./ha

(iv) Water Balance Study

In order to confirm the irrigable area under the natural conditions, a water balance study was carried out by use of 10-day river discharge and diversion water requirement as calculated above based on the following procedures.

- The water balance study was made for the period of 23 years, for which daily discharge record and rainfall records are available.
- The same calculation method mentioned in the Feasibility Study was applied for this study. The irrigable area was calculated in comparison with 10-day river discharge and diversion water requirement.
- The irrigable area with probability was estimated by use of normal distribution method with the minimum irrigable area of each year. In addition, the minimum irrigable areas are plotted on lognormal probability paper by applying the Hazen plot.

According to the results of the water balance study carried out through the above procedures as shown in Table 2-3 and Fig. 2-2, the irrigable area with a dependability of 80 %, namely that a drought year occurs once in five (5) years, is 850 ha for the rainy season crop, and 145 ha for the dry season crop. Consequently, the proposed irrigation area of 800 ha is confirmed with a 80 % dependability.

(v) Water Right

Necessary action to secure the water right for the Project will be taken by the implementation agency based on the diversion water requirement for the Project. According to the diversion water requirement and irrigable area as calculated above, the required volume of water for irrigation is given below.

Crop Season	Peak Diversion Water Requirement (liter/sec./ha)	Irrigation Area (ha)	Required Volume of Water for Irrigation (m3/sec.)
Rainy season crop	1.42	800	1.14
Dry season crop	0.87	145	0.13

(vi) Flood Discharge Analysis

The flood analysis was carried out by applying Drayton's equation, which is most popular for the estimation of the design flood peak discharge, and used for many facilities like dam and bridge in Malawi.

$$Q = MAF \times (-1.92 + 2.58 \times (T - 0.5)^{0.17})$$

$$MAF = 2.89 \times Area^{0.55} \times STMFRQ^{0.36}$$

Where,

Q	:	Flood Discharge (m^3/sec.)
MAF	:	Arithmetic Mean of Annual Floods (m^3/sec.)
T	:	Probable Year
Area	:	Catchment area (km^2)
STMFRQ	:	Steam Frequency Variable (2.63)

Based on the above equation, the peak flood discharge was estimated for the catchment area of 159.1 km^2 with combination of Namikokwe river and Nadzipokwe river as follows.

Name of River	Peak flood discharge(m3/scc) Return Period(year)				
	5	10	25	30	50
Namikokwe river	93.9	123.9	167.9	177.3	205.4

Based on the daily discharge record of the Namikokwe river, the annual maximum flood discharge is checked as shown in Table 2-4, and the probable flood discharge analysis was made by applying Hazen plot method. The result is shown in Fig. 2-3, and flood discharge of probable year more than 10 years are similar with the above figures. The flood discharges of 50 years and 25 years to be applied for design of headworks and flood dike are confirmed with the actual flood discharge data.

(vii) Drainage Water Requirements

The calculation method of drainage water requirements is based on the same manner of Feasibility Study. The drainage water requirement is estimated for paddy field and upland field respectively in accordance with the 5 year return period. The maximum duration of surface drainage in paddy fields and upland fields were planned within 24 hours and 4 hours, respectively. For determination of the design rainfall for drainage plan, the maximum rainfall with five year return period was estimated to be 94.2 mm/day by using daily rainfall at Mua mission station on the basis of normal distribution method. The unit drainage water requirements was estimated with the rational formula as shown below.

$$Qp=1/3.6 \cdot re \cdot A$$

where :

Qp : design flood discharge (m^3/sec)

re : average rainfall intensity (mm/hr) within the time of flood concentration

A : drainage area (km^2)

$$re=rt \cdot fp$$

where :

fp : runoff coefficient paddy field 0.7
upland field 0.6
rt : rainfall intensity (mm/hr) within the time of flood concentration

The unit drainage water requirement is as follows.

Paddy Field	:	7.64 liter/sec./ha
Upland Field	:	16.01 liter/sec./ha

(c) Basic Design

(i) Headworks

For the preliminary design of headworks, following technical points are considered:

1) Selection of site

To select the headworks site, conditions considered are (a) stability of river course for water intake, (b) less sediment inflow during water intake, and (c) less effect on water level due to weir construction on upstream and downstream. The layout of newly driving channel is designed in almost straight line, and averaged river gradient is set at 1/500, and velocity of river during intake of irrigation water is estimated within the range of 0.2 to 0.3 m/sec. The river bed will be maintained stably against flood flow, judging from the designed river gradient and velocity during flood time. The hydraulic calculation during the flood time is made to determine the elevation of crest of flood dike. The water intake through the proposed headworks is considered stable judging from location of scouring sluice gate (left side) and estimated river course during intake of irrigation water.

2) Design flood discharge

The designated criteria regarding the flood of respective rivers are not available in Malawi, therefore, the design flood discharge of proposed headworks site is applied to 50 years return period calculated from hydrological data of existing river, and the design flood discharge is determined to be Q=205 m^3/sec.

3) Stability of structure

Foundation:

The geological condition of proposed site is judged " not suitable without foundation treatment " due to existence of very soft layer composed of sandy silt having N value less than 5. The estimated acting pressure from headworks structure is about 15 tf/m^2 to 20 tf/m^2. The concrete pile foundation method is employed taking into consideration of acting pressure, availability of construction materials and construction equipment in Malawi, and total work quantity required. In addition to the concrete pile foundation, steel sheet piles having 6 and 12 m length are provided at underneath of foundation to avoid the piping and requirement of seepage length.

Measure for scouring against river bed:

The riprap protections at upstream apron and downstream portion of stilling basin are provided to avoid the scouring of river bed due to super critical flow during flood time. The material of protection will be gabion mattress.

4) Operation and maintenance of gate

2 scouring sluice gates and other steel gates are provided to control sediment that will deposit in front of the weir and to control intake water. The gates will be steel structure with spindle, hoist and gate leaf and will be operated by man-power. The hoist will be provided with reduction gear for easy operation by man-power.

5) Measures against flood during construction

The proposed headworks is located at the right bank side of existing river, and the elevation of construction site is about El. 522 m to El. 523 m , which is found higher than flood water level El.521.72. Therefore, no specific coffering works during construction period will be required. However, the groundwater level is found and existed near the ground surface, and dewatering and surface drainage will be required during foundation excavation and slab concrete placing of headworks.

The general features of proposed headworks are as follows:

Intake Weir

Catchment area	:	159.1 km²
Design flood discharge	:	205 m³/sec.
Type	:	Fixed weir with pile foundation
Crest elevation	:	El 519.40 m
Design food level	:	El 521.72 m
Height of weir	:	4.50 m
Length of weir	:	50.0 m
Sluice gate	:	Steel sluice gate, 1.5m(W)x1.4m(H), 2 sets
Downstream apron	:	Stilling basin type, l=15.0 m
Riprap	:	Gabion mattress, l=19.0 m

Intake

Intake discharge	:	1.42 m³/sec.
Intake water level	:	El. 519.30 m
Intake gate	:	Steel sluice gate, 1.2m(W)x1.2m(H), 1 set

Settling Basin

Length x width	:	72.0 m x 8.0 m
Spillway	:	l= 48.0m with, steel sluice gate, 1.0 x 1.0(m),1set
Measuring device	:	Broad crest weir type

Inspection Bridge

Type	:	Concrete slab bridge
Width x length		2.50 m(effective) x 50.0 m

Control House

Area	:	15 m²
Type	:	Brick construction

(ii) Irrigation System

Irrigation system is composed of a main canal, branch canals, tertiary canals and their related structures. The main canal will start from the left side of headworks, and align down along the Namikokwe river, and branch off three (3) branch canals. All the tertiary canals will be diverted from the branch canals, but not from the main canal. Based on such canal hierarchy, three (3) independent areas commanded by each branch canal can be delineated, which will take advantage of independent water distribution and management within

the branch canal system Tertiary canal is designed with dual function of water distribution and field drainage in consideration of effective use of return flow. The scale of irrigation canals are determined on the basis of 24 hours continuous water supply for the main and branch canals and 4-day rotational water supply for tertiary canals.

The irrigation flow diagram is shown in the Drawing (No. ID-01), and the following table shows the length and the net command of each canal.

Irrigation Canal	Total Length (km)	Net Command Area (ha)	No. of Tertiary Canals (No.)
Main Canal	6.79	800	0
Branch Canal			
BC-1	4.92	278.4	43
BC-2	4.33	246.4	41
BC-2-1	0.73	(15.0)	5
BC-3	4.80	275.2	43
Tertiary Canals	60.8	1.9 - 12.2	-

(iii) Irrigation Canal

The main and branch canals are lined with in-situ concrete so as to minimize the canal conveyance loss, which takes another advantage of easy operation and maintenance of canals. The tertiary canals, supplying irrigation water to the fields, are of unlined earth canals with another function of field drainage to evacuate the excess water from the field.

The design condition for the irrigation canals are as follows.

1) Lining Canal (Main and Branch canals)

Design discharge	:	1.42 liter/sec./ha
Maximum velocity		
Main canal	:	1.5 m/sec.
Branch canal	:	1.0 m/sec.
Minimum velocity	:	0.3 m/sec.
Roughness coefficient	:	0.015
Minimum freeboard	:	0.2 m for lining
		0.3 m for embankment
Canal base width	:	1.0 m to 0.6 m

Canal inside slope	:	1 : 1.0
Lining thickness	:	10 cm

2) Earth Canal (Tertiary canal)

Design discharge	:	1.42 liter/sec./ha
Maximum velocity	:	0.5 m/sec.
Minimum velocity	:	0.2 m/sec.
Roughness coefficient	:	0.030
Minimum freeboard	:	0.2 m
Canal base width	:	0.4 m
Canal inside slope	:	1 : 1.5

General features of the irrigation canals are as follows :

Name of Canal	Design Discharge (m3/sec.)	Hydraulic Gradient	Base Width (m)	Canal Height (m)
Main Canal	1.14 - 0.385	1/220 - 1/2400	1.0 - 0.6	1.0 -0.6
Branch Canal				
BC-1	0.395	1/600	0.6	0.6
BC-2/BC-2-1	0.350	1/600	0.6	0.6
BC-3	0.385	1/600	0.6	0.6
Tertiary Canal	0.01 - 0.07	1/200 - 1/1200	0.4	0.5

(iv) Irrigation Canal Related Structures

1) Bifurcation

Bifurcation will be provided for the diversion of irrigation water from the main canal to the branch canal as well as from branch canal to sub-branch canal. Distribution rate of irrigation water proportional to irrigation area will be fixed based on the opening width. Steel slide gate will be provided for the maintenance works of irrigation canals and for the emergency case.

2) Turnout

Turnout will be provided for the distribution of irrigation water from the branch canal to tertiary canal. The structure is mainly composed of check structure and inlet structure to the tertiary canals. Check structure will be provided with a steel slide gate to control upstream water level. Inlet structure

will have an opening width proportional to the irrigation area, and broad crest weir will be equipped for measuring discharge.

3) Culvert

Box culvert and pipe culvert will be provided for crossing inspection road, and foot path bridge will be provided for the people and draft animals to cross the irrigation canals.

4) Drop

Drops will be provided in case the canal velocity exceeds the maximum allowable velocity, or where high embankment is needed. Vertical drops will be applied in this project.

5) Cross Drain

Cross drains will be provided where the irrigation canal crosses the drainage canal.

6) Field Inlet

Field inlet will be provided on the tertiary canal at every field plot (0.4 ha), and are planned to be constructed by using pre-cast concrete with PVC pipe of 150 mm. Check structure will be provided just downstream of field inlet for regulating irrigation water level.

General features of irrigation canal related structures are as follows.

(Unit : nos.)

Name of Structure	Main Canal	Branch Canal				Tertiary Canal
		No.1	No.2	No.2-1	No.3	
Bifurcation	2	0	1	0	0	0
Turnout	0	30	27	5	29	0
Culvert	15	1	1	0	2	0
Drop	6	0	0	0	0	0
Cross Drain	0	0	0	0	2	0
Field Inlet	0	0	0	0	0	2,070

(v) Drainage System

The drainage canal system collects surplus water in the field, and connects to the natural stream to drain out to the outside area. The excess water in the field is collected by the tertiary canals, and flows into drainage canals.

Drainage canal is of unlined earth canal. Drainage flow diagram is shown in Figure ID-02, and general features of drainage canal system are summarized below.

Canal Name	Canal Length (km)	Drainage Area (ha)	No. of Tertiary Canal(nos.)
DC-1	4.17	176.6	15
DC-2	4.35	181.2	20
DC-2-1	1.58	(50.4)	7
DC-3	4.15	267.1	47
DC-4	3.05	636.5	22

Note : Drainage canal of 10.9 km in total will be constructed through farmers participation.

(vi) Drainage Canal

The drainage canal is trapezoidal earth canal, and design condition is as follows.

Maximum allowable velocity	:	0.75 m/sec.
Minimum allowable velocity	:	0.3 m/sec.
Roughness coefficient	:	0.030
Designed water lever	:	0.20 m below from ground line
Base width	:	0.60 m to 3.3 m
Canal inside slope	:	1 : 1.5

General features of drainage canals are as follow.

Drainage Canal	Design Discharge (m3/sec.)	Hydraulic Gradient	Base Width (m)
DC-1	0.38 - 2.20	1/300 - 1/950	0.6 - 1.4
DC-2	0.31 - 1.38	1/260 - 1/2000	0.6 - 1.2
DC-2-1	0.39	1/300 - 1/2000	0.6
DC-3	0.51 - 2.0	1/360 - 1/900	0.8 - 1.2
DC-4	0.35 - 8.6	1/300 - 1/2400	0.6 - 3.3

(vii) Drainage Canal Related Structures

1) Drop

Drainage drops will be provided in the drainage canal to adjust the canal gradient the same as irrigation drops. The drop structure will be constructed with gabion mattress, which is a popular material in construction of the river protection works at upstream and downstream of bridge near the project site.

2) Culvert

Pipe-type culverts and box-type culverts will be provided for crossing the inspection road.

General features of drainage canal related structures are as follow.

(Unit : nos.)

Drainage	Drop	Culvert
DC-1	11	0
DC-2	10	1
DC-2-1	2	0
DC-3	15	1
DC-4	14	0

(viii) Inspection Road and Flood Dike

Inspection road will be provided along the main canal and each branch canal for the operation and maintenance of canals as well as transportation of farm product and inputs. Flood dike will be provided along the Namikokwe river to protect the project area from the flood of the Namikokwe river, which also has function of inspection road for the main canal. Design condition is as follows.

- Total width and pavement width are 5.0 m and 3.0 m respectively.
- Pavement material is of crushed weathered stone, whose quarry is near the project site.
- Minimum embankment is 60 cm from the ground surface.
- Height of flood dike is designed on the basis of the flood discharge at a 25-year return period, and a freeboard is set at 0.60 m. The flood water level is determined by non-uniform flow analysis with cross sectional survey result.
- Slope of embankment is set at 1: 1.5.

General features of inspection road and flood dike are as follows.

Item	Total Length (km)
Flood dike	7.84
Inspection road	
IR-1	0.9
IR-2	2.3
IR-3	2.7
IR-4	3.5
IR-5	1.0
IR-6	3.3

(x) Land Leveling Works

An area of 1 paddy field is to be 0.4 ha in net with width of 30 m and length of 150 m in the light of existing paddy field in Mtandamula irrigation system. In order to mitigate the work load in farming practice due to high dependency on manual work, one paddy field will be further divided into a few fields by constructing field band. The land leveling works will be carried out as a sample farm plot in two (2) tertiary blocks in every branch canal system. The tertiary blocks for land leveling works to be executed are as follows.

Branch Canal	Tertiary Block	Irrigation Area (ha)
BC-1	BC-1-1L	9.6
	BC-1-2L	8.7
BC-2	BC-2-8L	7.3
	BC-2-9L	7.3
BC-3	BC-3-4R	7.2
	BC-3-5R	7.7
Total		47.8

The tolerance of finished surface of paddy field will be generally plus-minus 5 cm.

(2) Rural Infrastructure

(a) Design Policy

Improvement of rural infrastructure is proposed under the Project for 22 villages unified in 4 village groups, which are located in or near the irrigation development area of the Project. These villages have been suffering from poor conditions of

existing roads and/or shortage of borehole water supply, both leading the stagnancy of social and economic activities of villagers. The rural infrastructures to be improved under the Project are as follows;

i) Improvement of rural road between the Project area and national road M10.
ii) Provision of borehole equipped with a hand pump for 13 villages, which have neither existing borehole, nor can replace damaged or outdated boreholes.

(b) Examination on Design Condition

(i) Rural Road

To secure smooth access between the national road M10 and the Project development area, the following rural road will be constructed under the Project. The road will be operated and maintained by the Dedza District Office of the Ministry of Works and Supply .

	Present Condition		
Location	length	Width	Road Conditions
Headworks - M10	2.3 km	3.0m	Jeepable in 0.8 km from M10
		Foot path	Jeepable in dry season

(ii) Rural Water Supply

According to the result of field survey for existing boreholes in 22 villages as shown in Table 2-5, 13 villages have been suffering from a serious shortage of borehole water. To solve this problem, 13 villages will be provided with borehole and hand pump under the Project as shown below. The operation and maintenance of the borehole will be made by the Borehole Committee to be organized by the beneficiaries.

Name of Village Group	Name of Village	Present Condition
Mthembanji	Dziko	No borehole and hand pump
	Mkondorire	-do-
	Chatewa	-do-

	Mthembanji	Existing one has serious damages
	Mbangali	No borehole and hand pump
	Bwannamakowa	-do-
	Mwasinja	-do-
Kafulama	Maluza	-do-
Bwanari	Msolo	-do-
Mchanja	Mdulambale	-do-
	Khoswe	-do-
	Mchembo	Existing one has been too old
	Ndongwe	No borehole and hand pump

The design concepts for the rural water supply facilities are as follows;

(a) The facilities will be of the similar types to those constructed and being operated by the Department of Water (Ref. Table 2-6).
(b) In designing of the borehole as well as related structure, maximum use of locally available materials will be considered for easy maintenance works after the implementation.
(c) Design capacity of the facilities will be based on a standard applied to those in neighboring areas.
(d) Since the water quality of existing boreholes is acceptable in accordance with the Malawi standard as shown in Table 2-7, no measures are taken.

(c) Basic Design

(i) Rural Road

Construction of rural road will be made by filling and providing crushed weathered stone pavement. The proposed dimensions of road are as follows;

Name of Road	Length (km)	Embankment height (m)	Total width (m)	Effective width (m)	Pavement thickness (m)
Rural Road-1	2.3	0.6 min.	5.0	3.0	0.2

(ii) Rural Water Supply

Considering the existing boreholes, the construction of rural water supply will be made in the following design;

(a) Total 13 numbers of boreholes in total equipped with a hand pump are to be constructed in the respective villages as mentioned above.

(b) Design of borehole will be as follows;

- Depth of borehole : 50 m
- Diameter of borehole : 250 mm
- Diameter of casing and screen pipe : 150 mm
- Expected length of screen : 20m

(c) Afridev pump will be installed.

(d) Discharge will be expected at 60 to 80 m^3/min.

(e) Related structures such as washing place, drainage pit, etc. will be constructed following the standards of Malawi.

Fencing work for the drainage pit (wooden made, 3.60m x 3.60m) should be constructed by the beneficiaries to protect the pit from animals.

(3) Post-harvest Facility

(a) Design Policy

The ricemill facility, of which capacity is to be designed for the home consumption, will be installed as the post-harvest facility mainly aiming at the reduction of the women's work load. The basic design conditions for the construction of the post-harvest facility are as follows;

(i) Climate, natural features, lifestyle, architectural style and other peculiarities prevailing in the Project area will be carefully considered and adopted for the basic design.

(ii) The O & M cost will be minimized by using natural ventilation, natural lighting and sunlight effectively.

(iii) Considering the level of constructing engineering, construction method and laborers' skill in the Malawi, the facility will be of easy and economical construction.

(iv) For easy equipment of the facility, locally available construction materials will be used as much as possible.

(v) Design of ricemill machine and diesel engine will be done by referring to the existing ones in and around the Project area.

(b) Examination on Design Condition

The structures of the existing maizemills in the Project area are cheap made by brick or wooden to protect the machine and engine from rain. The combined structure of ricemill and maizemill in Salima is made of rigid type by brick. The existing ricemills, maizemills and diesel engines in and around the Project area are from the same manufacturers', which are very commonly used in Malawi.

The capacity of ricemill will be designed enough for processing of the home consumption.

The operation and maintenance of ricemill will be done by the Ricemill Committee to be organized by the beneficiaries.

(c) Basic Design

(i) Plan of Ricemill

On the basis of the consumption rate of paddy by farmers in the Project area (Table 2-8), the capacity of the ricemill to be operated by diesel engine will be determined as follows (Table 2-9). The ricemill will be installed in four (4) village groups considering the transportation distance of beneficiaries and ease of O & M works.

Name of Village Group	Capacity of Mill	No. of Mill
Mthembanji group	100-120 kg/hr.	1
Kafulama group	-do-	1
Bwanari group	-do-	1
Mchanja	-do-	1

(ii) Facility Plan

The arrangement of ricemill and diesel engine will be made in the light of the existing facilities in and around the Project area and the discussion with Salima ADD. The floor space will be determined considering space for mill machine and engine, the spare parts and fuel tank, temporary places of paddy for milling, temporary place of milled rice for shaking the milling heat and working area. The floor space is designed as follows;

Name of Village Group	Floor Area
Mthembanji group	$42m^2$
Kafulama group	$42m^2$
Bwanari group	$42m^2$
Mchanja group	$42m^2$

The wooden slide door (2.00m wide and 1.80m height) will be installed at the entrance, considering the O & M work of the ricemill and diesel engine.

(iii) Structural Plan

The basic design of facility was conducted by referring to the design standard of buildings in Malawi as follows;

Item	Structure
Foundation for floor	Concrete pitching
Foundation for machines	Mass concrete
Wall	Wet brick masonry
Roof	Corrugated cement sheet
Truss	Wooden made

(iv) Site Plan

The post-harvest facility site is selected in four village groups as mentioned above and given in the attached drawing. The respective locations of the facility will be selected by the Ricemill Committee of the village groups after

the implementation of the Project is realized. The site selected tentatively as shown in the attached drawings have suitable foundation for the facility.

(4) Basic Design Drawings

The list of basic design drawing is given in Table 2-10, and those drawings are attached in Appendices-B for the cost estimate and construction planning purpose.

Technical Section 1 shall be responsible for construction supervision for the headworks and the irrigation system covering the upper Namikokwe area. The Technical Section 2 shall be responsible for construction supervision of the irrigation system covering the middle Namikokwe area and the irrigation system covering the lower Namikokwe area. The Guidance Section shall be responsible for providing technical support for farmers' construction works to be executed under the farmers participation policy, for keeping the satisfactory quality of the works and the time schedule. The Administrative Section shall be responsible for operation and maintenance of the Office. The Financial Section shall be responsible for accounting works such as payment of salary to the staff and operation and maintenance costs for the Office. The duties of respective sections of the Office are given in Table 2-11.

(2) Farmers Side

Farmers' participation in construction works is one of important policy for the development of irrigation project in Malawi. The philosophy behind this farmers' participation is to realize the farmers that the project will be developed for them, which would lead them to do satisfactory operation and maintenance of the project. In Malawi, there is another philosophy that such farmers' participation is a key screening factor for land allocation to farmers. Therefore, it is essential to introduce the farmers' participation in the construction of the irrigation and drainage facilities in Malawi. In the light of such philosophy, the farmers' participation will be included in the implementation of the Project. Immediately after determination of the project implementation, the Land Allocation Committee chaired by the Traditional Authority, will inform relevant farmers of implementation of the Project, and register the farmers who intend to cultivate the land. The registered farmers will organize the Farmers Construction Committee through election, which is composed of 10 members. The Farmers Construction Committee will prepare a regulation on participation in construction work, prepare a work schedule, record participation conditions including frequency, control the farmers construction works under technical support by the Guidance Section of the Construction Office and demarcate the field plots together with the Department of Irrigation staff.

2.4.2 Budget

The budgets for the last 3 years for the Department of Irrigation are as follows:

1994/95 (actual)	:	KW 4,879,185
1995/96 (actual)	:	KW 10,163,816
1996/97 (budget)	:	KW 11,797,802

These budgets are revenue budgets including salary of staff, housing allowance, operation and maintenance costs for the offices and the existing government irrigation projects. In addition to this revenue budget, there is a development budget for the development of irrigation project under financial assistance of donor countries. In 1996/97, the development budget is KW 32,704,900 so that the total budget for the Department of Irrigation comes to KW 44,502,702. In the Project, operation and maintenance cost for the Construction Office would be included in this development budget. After handing-over all the completed facilities to the farmers organization, the operation and maintenance cost for technical support would be included in the revenue budget.

2.4.3 Staffing

At present, there are 155 staff in the Department of Irrigation, of which 44 staff are assigned in the head office, and 18 staff in the Irrigation Section of Salima ADD. The present staff number does not reach to the authorized one. Even in the head office and the Salima ADD, 11 staff are less than the authorized one. The Department of Irrigation does not have any plan to increase the staff for the Project, but will increase the staff number up to the authorized one. Therefore, it is possible to assign the required staff to the Project by adjustment of staff within the Department of Irrigation since the required staff is not so many.

In Malawi, the experienced staff and engineers are limited. However, the Department of Irrigation has implemented similar projects in which total irrigable area is about 1,800 ha. In addition, the Department of Irrigation has developed the government project of about 3,600 ha in total since 1968, and is presently executing the development of about 400 ha in total. From such facts, it is considered possible to assign the required experienced staff engineers for the Project .