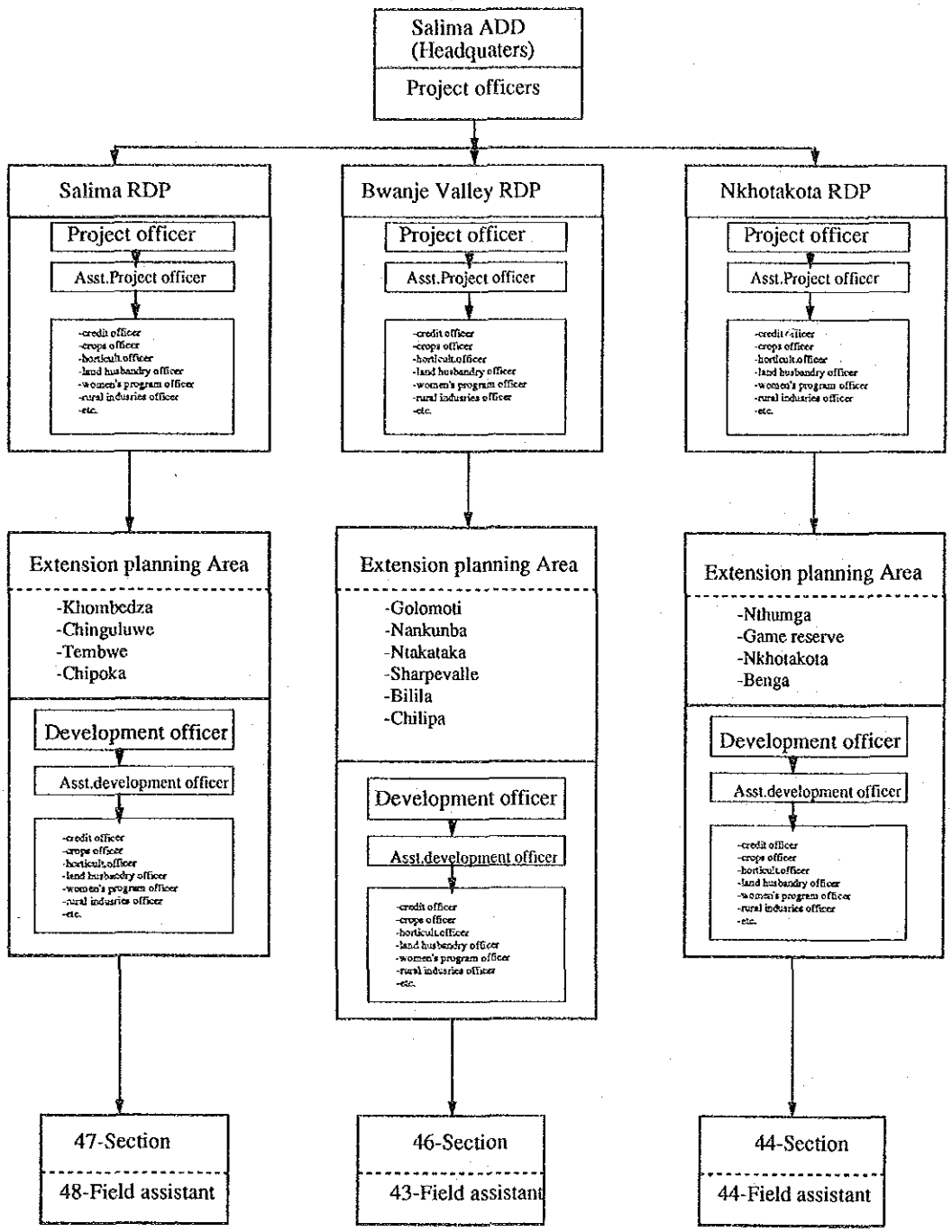

FIG. 3.15. 2 ORGANIZATION CHART OF THE FIELD OFFICES IN THE SALIMA ADD

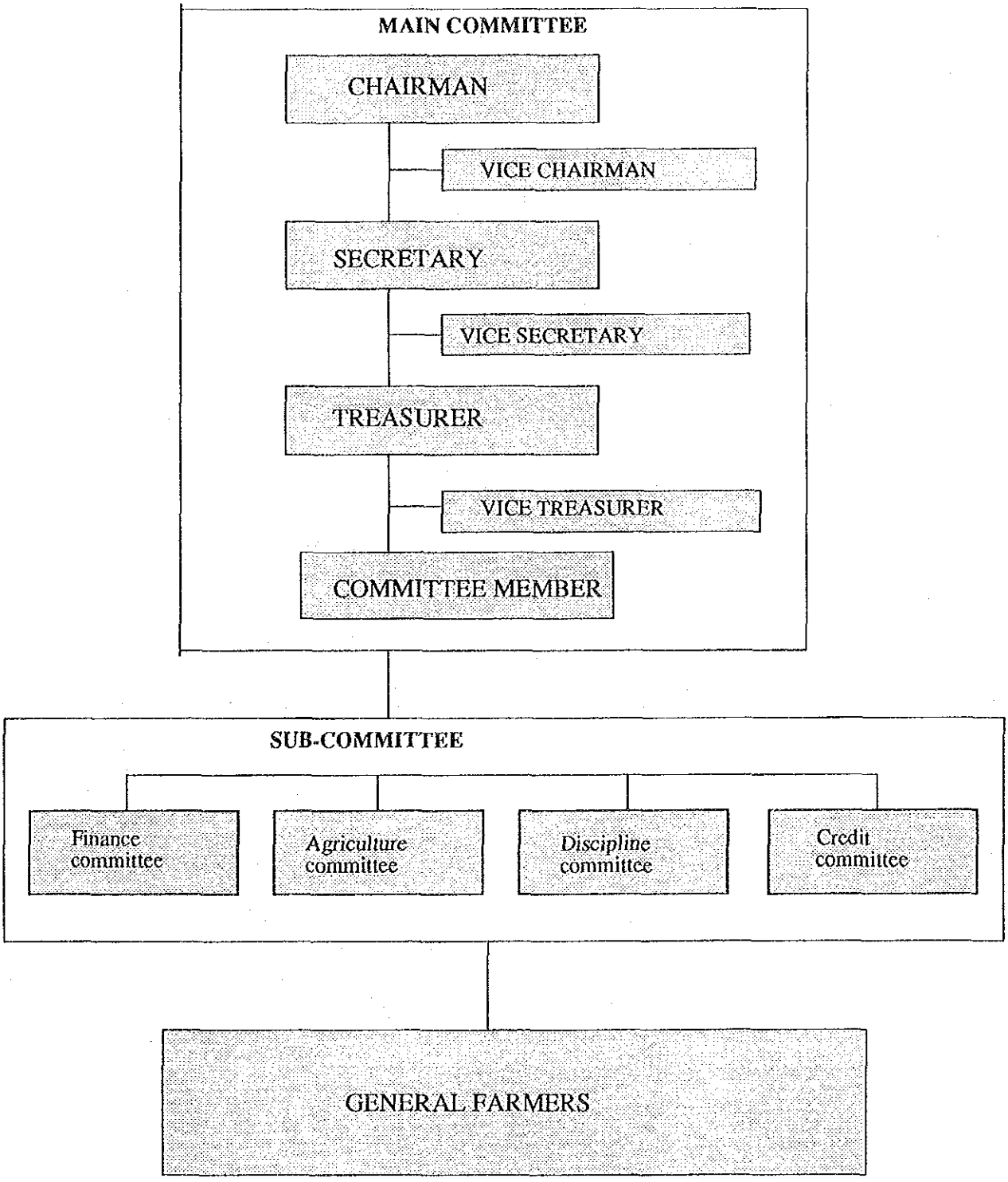

Fig. 3.16.1 ORGANIZATION CHART OF THE TYPICAL FARMER'S CLUB

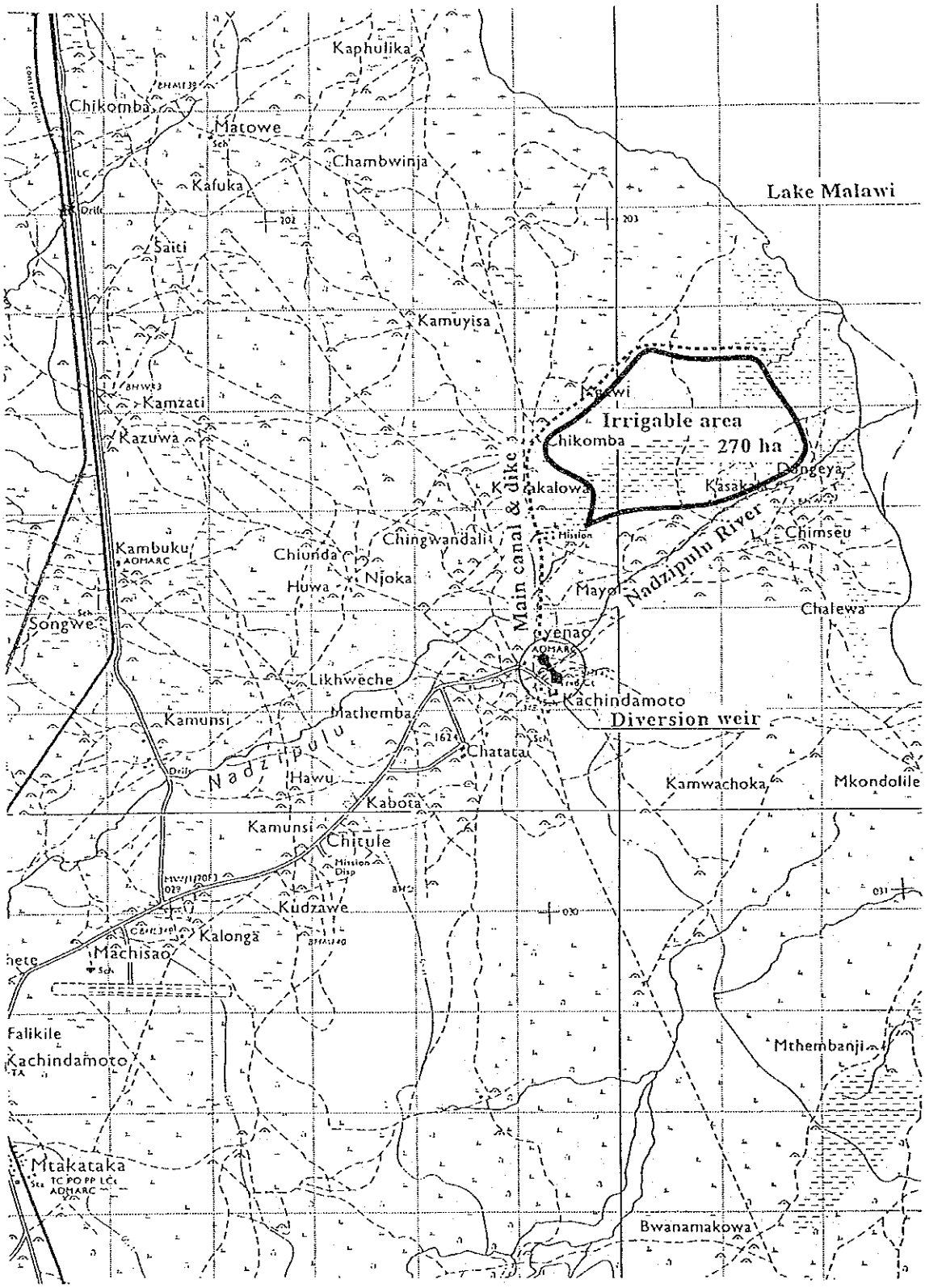

Figure 4.3.1 PRELIMINARY LAYOUT OF IRRIGATION PROJECT (1/2)

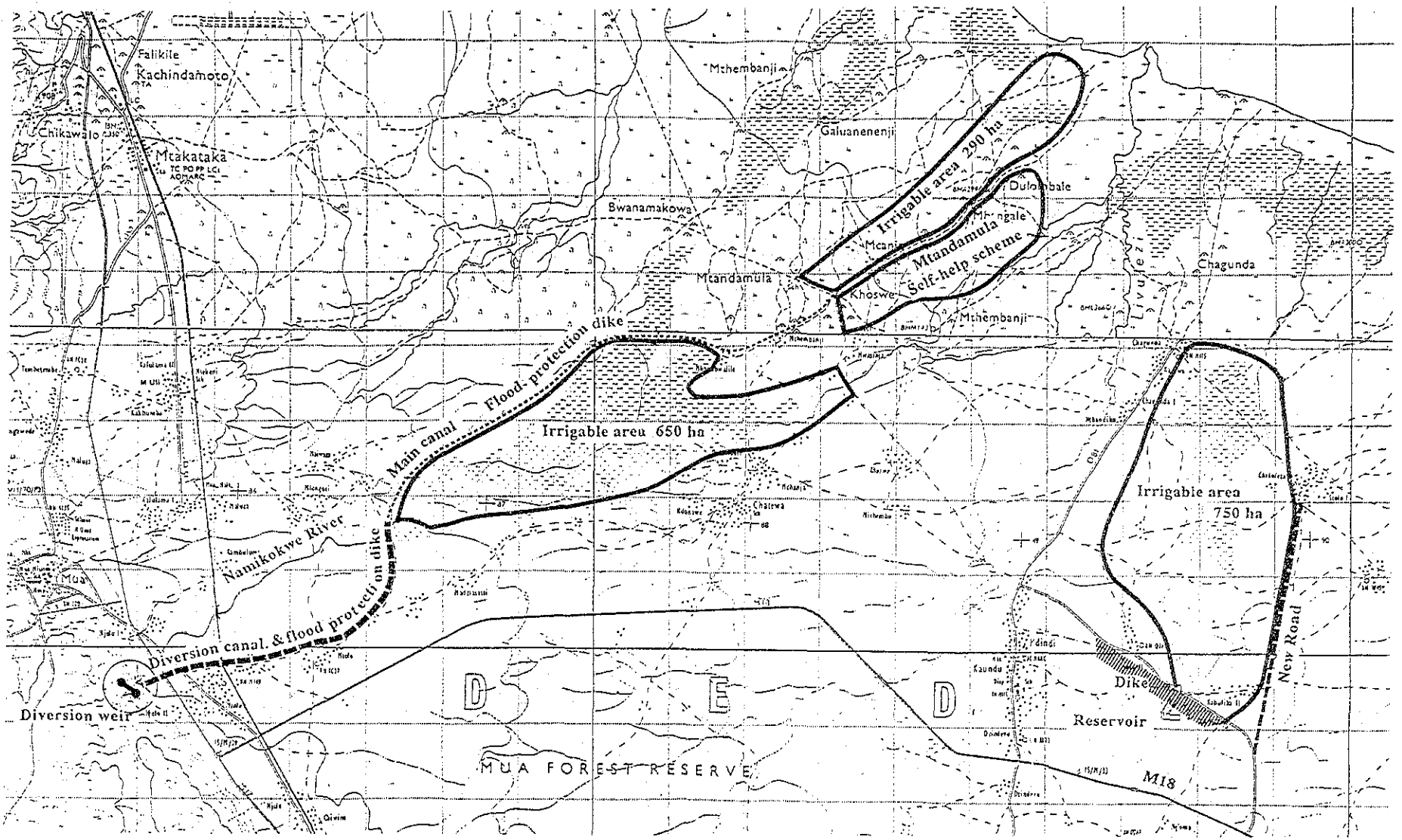

Figure 4.3.1 PRELIMINARY LAYOUT OF IRRIGATION PROJECT (2/2)

ANNEX II

FEASIBILITY STUDY FOR FIVE SELECTED PROJECTS

1. INTRODUCTION

This Annex II deals with the results of the Phase II study, in which the feasibility study was carried out for the project areas selected. The irrigable area amounts to 2,190 ha in total among the potential area of 3,380 ha, which was identified through the detailed water balance study.

Chapter 2 of this Annex II mentions the present conditions of the five project areas in terms of administration and demography, soils and land suitability, climate, hydrology, river conditions, flood discharge, water quality and water right, the existing irrigation schemes in Salima ADD, social infrastructure, land use, land tenure, farmers' economy, agricultural production, farmers' view and expectation. The Study placed focal point of assessment of the existing irrigation schemes aiming at identification of technical and financial constraints against their operation and maintenance. The study results were carefully discussed from the viewpoint of project sustainability and were fully taken into consideration for formulation of the Bwanje Valley Smallholder Irrigation Development Project (the Project) including its O&M system.

Chapter 3 presents the prospective development plan for the Project. Firstly, the development needs and strategies are discussed. Secondly, the project areas are defined on the basis of the detailed topographic, soils and meteo-hydrological information. Thirdly, the prospective development plan with targets was set up. The plan consists of (i) agricultural development plan, (ii) irrigation and drainage plan, (iii) rural infrastructure development plan, (iv) plan for strengthening agricultural supporting activities and (v) operation and maintenance (O&M) plan.

Chapter 4 presents the implementation plan of the Project, which comprises implementation schedule and construction plan.

Chapter 5 describes the details of cost estimate, in which the project cost for the above-mentioned project components and O&M cost.

Chapter 6 presents the study results of the organizational set-up of the Project. The organization and staff structures of the Project is preliminarily proposed for each stage of project execution (construction) and O&M.

The procedure and results of the project evaluation is proceeded out in Chapter 7.

2. THE PRESENT CONDITIONS IN THE DEVELOPMENT AREAS

2.1 ADMINISTRATION AND DEMOGRAPHY

Through the Phase I study, the following five (5) irrigation development areas in the Study area are identified.

(i) Lower Nadzipulu irrigation development area,
(ii) Lower Namikokwe irrigation development area,
(iii) Upper Namikokwe irrigation development area,
(iv) Existing Mtandamula irrigation scheme area, and
(v) Lower Livulezi irrigation development area.

Those areas are located on lowlying land bounded by M-18 national road in south, M-17 national road in west and the Lake Malawi in north and east as shown in General Map.

The areas are under administration of the jurisdiction of Kachindamoto Traditional Authority (TA) of Dedza District, the Central Region. There are 42 villages in and around the project areas. within the administrative structure of the Ministry of Agriculture (MOA), the project areas fall in the Bwanje Valley Regional Development Project (RDP) area of Salima Agricultural Development Division (ADD).

The demographic conditions of the areas are presented in **Table 2.1.1**. The total population of the said 42 villages in and around the project areas is estimated to be 15,800 on the basis of the files owned by Development Officer (DO) of the Extension Planning Area (EPA) under Bwanje Valley RDP. The total number of the households is estimated to be 3,780. The average family size is 4.2 ranging from 2.58 to 6.21. It is estimated that female headed households (FHHs) occupy about 40 % of the total households in the project areas. The sex ratio is 46% for male and 54 % for female.

The village size varies with a wide range from 23 households of Chatha and Njoka villages to 332 households of Ndindi village giving an average size of 90 households. The villages are generally located on slightly elevated flood-free topographic position. Location of each village was confirmed by the JICA Study Team in the field with aid of the latest 1:12,500 aerial photos taken in August 1992 and the existing 1:50,000 topo-map prepared by Department of Surveys in 1973. The survey verified that the location of villages was remarkably changed during the past two decades, in particular, along the lower reaches of the Nadzipulu, Namikokwe and

Livulezi rivers. In these areas, villagers were forced to shift by recurrent floods as well as frequent changes of river courses. Along the lower reaches of the Nadzipulu river, villages sometimes shifted into the other villages and formed "mixed villages".

2.2 SOILS AND LAND SUITABILITY

2.2.1 EXISTING SOIL INFORMATION

The Land Resources Evaluation Project Malawi (LREP, MOA/FAO, 1992), i.e. the latest nationwide soil study, provides an up-to-date and comprehensive information of the agro-climate, soils and physiography, present land use and land suitability of Salima ADD on relevant thematic maps on a scale of 1:250,000. In LREP, the soils and land suitability of the project areas are classified as below.

No.	Project Area	Soil Unit	Land Suitability	
			Wetland Rice	Improved Traditional Management (Maize)
1.	Lower Nadzipulu Area	A1f5	Nm	S3w
2.	Upper Namikokwe Area	A1f5/A1f2	Nm & S1/2n	S3w & Nfw
3.	Mtandamula Area	A1f4/A1f2	S1/2n	Nfw
4.	Lower Namikokwe Area	A1f5/A1f2	Nm & S1/2n	S3w & Nfw
5.	Lower Livulezi Area	A1f2/A1v1 in west	S1/2n & S3x	Nfw
		A1e8 in east	Nm	S2/3mn

The soils are derived from fluvial, colluvial and/or lacustrine sediments deposited on flat to gently undulating terrain of the lower Rift Valley floor. They have juvenile and deep profiles (>200 cm) with various horizons of clay, silt and sand. Land suitability classes are given under without-project conditions in which limitations would not be eliminated and left as they are. The soil limitations are represented by poor drainage and flood hazard.

The soils of A1f5 are classified into Eutric Fluvisols on outwash plains. They are dark brown soils with sandy clay loam over sandy clay loam - clay. The soils are not suitable for wetland rice with a limitation of moisture stress (m) due to low water holding capacity, while they are marginally suitable for maize with a limitation of low oxygen availability in root zones (w) due to poor internal drainage and/or high groundwater table. They are currently used for rainfed farming with maize, pulses, groundnuts, cotton, etc.

The soils of A1f2 are Eutric Fluvisols and Mollic Fluvisols on floodplains. The soil characteristics are more or less same to A1f5 except for more variable texture and colour. The soils of A1f4 are Eutric Fluvisols on depressions. They are dark gray soils with medium to fine texture (sandy clay loam - clay) throughout profiles. Where texture is finer, A1f2 and A1f4 are suitable for wetland rice with a little limitation of low fertility (n). Flood hazard and low oxygen availability in root zones are main limitations to upland crops. They are used for rainfed paddy or left as grassland of flood plains.

The soils of A1v1 are Vertic Cambisols and Eutric Vertisols derived from lacustrine deposits on bottomlands of the Lower Livulezi Area. They are characterized by very deep, poor drainage, black colour, and clayey texture with moderate chemical fertility; pH 7.0 - 8.0 and ECe 2 - 4 mmhos/cm (slightly saline). They are marginally suitable for wetland rice with a little limitation of alkalinity and salinity (x). The limitations to upland crops are flood hazard and low oxygen availability in root zones. They are covered extensively by grasses and partly used for rainfed paddy.

The soils of A1e8 are Haplic Luvisols derived from fluvial and lacustrine deposits in the eastern part of the Lower Livulezi Area. They are characterized by very deep, moderately well to well drained, yellowish brown, coarse to medium (sandy loam to sandy clay loam) over medium (sandy clay loam) texture with moderate chemical fertility; pH 5.5 - 7.0 and ECe 0 - 2 mmhos/cm (non-saline). They are not suitable for wetland rice with a limitation of moisture stress (m) and moderately to marginally suitable for upland crop. They are currently used for upland crops, e.g. maize and cotton.

2.2.2 METHODOLOGY OF SEMI-DETAILED SOIL SURVEY

A semi-detailed soil survey was carried out in order to obtain more detailed soil information of the development areas. At 23 representative sites, the soil profiles of two (2) meter deep were made, described according to the FAO guideline, and sampled for laboratory tests. Auger holes of 1.5 m deep were also made to identify location of soil boundaries. The soil profile descriptions are summarized in **Table 2.2.1**. Throughout the survey, 97 soil samples were collected and analyzed at the field laboratory.

With aid of the 1:12,500 aerial photos taken in August 1992, spatial distribution pattern and extent of each soil unit were analyzed and mapped on a scale of 1:10,000.

Land suitability was assessed according to the modification of the criteria set up for the purposes of LREP. Taking the proposed crop selection into consideration, the land suitability of the project areas was classified for irrigation farming with wetland rice

and maize. The land suitability classes were given under the assumptions, in which such prevailing limitations as flood hazard and poor drainage would be eliminated under the with-project conditions.

2.2.3 SOILS OF THE PROJECT AREA

(1) Lower Nadzipulu Area

The Lower Nadzipulu Area lies on the left bank of the Nadzipulu river which gently slopes to Lake Malawi with a gradient of 1/250. The elevation ranges from El. 495 m at the river-crossing point near Mayola village to El. 474 m on the lakeshore. The soil profiles were observed along the longitudinal cross-section as illustrated in **Figure 2.2.1** in order to verify a coincidence between soil conditions and topographic positions. As presented in **Figure 2.2.2**, the soil profiles show complex horizon sequence with variable soil texture. The soils are classified into Eutric Fluvisols as a whole and further divided into three (3) soil groups according to features of horizon sequences and soil texture as spelled out below.

The uppermost area is covered by recent silty and sandy sediments transported by the Nadzipulu river. The soils, i.e. P7 and P3, show many laminates of various thickness throughout the profiles as an evidence of frequent floods and inundation. They are characterized by coarse texture and friable consistency. Clayey subsoils are not found within 200 cm in depth.

In the transitional area, i.e. P4, P6, P1, P8 and P5, thickness of coarser topsoils change place to place in coincidence with micro-topography, i.e. thicker on concave slopes and thinner on convex slopes. Clayey subsoils are often observed within 50 cm in depth.

The soils at P9 shows the typical profile on outwash plains of the lakeshore. Recurrent rapid flush does not allow to deposition of loose sediments on soil surface. As a result, soils expose smooth, hard and dark clayey topsoils. Weakly developed cracks and slickensides are observed in sub-surface soils. Soil pH and EC values are slightly higher due to salt accumulation through alternation of dry and wet (inundation) conditions as presented in **Table 2.2.1**.

(2) Upper Namikokwe Area

The soil map of the Namikokwe river basin is presented in **Figure 2.2.3**. Soil units identified in the area are Eutric and Mollic Fluvisols, which are further divided into seven (7) sub-units according to (i) physiologic and topographic positions, (ii) soil texture, (iii) soil colour, (iv) drainage class and (v) flood conditions.

The major soils of the Upper Namikokwe Area are alluvial soils on floodplains (F2) lying over the left bank of the Namikokwe river, which functions as seasonal floodways. Mollic Fluvisols are more predominant on higher position (F21) of floodplains. The soils, i.e. M9 and M11, are dark and fine to medium textured throughout profiles. The soils on bottomlands (F22), i.e. N2 and N3, are poorly to imperfectly drained more than soils on F21. They show hydromorphic properties, e.g. grayish colour.

The floodplains of the Upper Namikokwe Area are sandwiched by uplands, which are flood-free or exceptionally flooded in the limited period a year. The unit of southern uplands (U2) is further divided into flat to convex summit (U21) and gentle slopes (U23) on a transitional zone between U21 and F2. They are brown, medium to coarse and excessive to well drained. U22 extends to the right bank of the Namikokwe river immediately adjacent to the river course in Mchanja village. The soils of U22 are classified into Eutric Planosols and Stagnic Luvisols, which specifically occur under Mopane woodland and show a formation of hard pan (fragipan) resulting in imperfect internal drainage. On the other hand, the soils on the north uplands (U3) elongating in and around Mlongoti village are Eutric Fluvisols under well to moderately well drainage conditions. U31, i.e. upper positions of U3, are covered by black clayey soils with gently undulating configuration, while the soils on U32, i.e. lower position of U3, are brown and coarse textured.

(3) Mtandamula Area

The soils of Mtandamula Area are Eutric and Mollic Fluvisols on floodplains (F1) which are currently used for irrigated rice cultivation. The bottomlands (F11) are covered by dark clayey soils with poorly to moderately well drainage. The unit of F12 is the miscellaneous land along the river courses. In the downstream of Mtandamula Area, the lakeshore plains (L) extend. Major soils are coarse sand on minor aeolian deposits and ridges (L1) and flat lacustrine deposits (L2).

(4) Lower Namikokwe Area

The Lower Namikokwe Area lies on upland (U1) consisting of higher flat to convex summit (U11) and lower positions with irregular micro-relies (U12). The soils are classified into Eutric and Mollic Fluvisols. Their topsoils are black to brown in colour and fine to medium in texture overlying brown to black subsoils with various texture. U11 is well to moderately well drained, while U12 is moderately to poorly drained. In the north of the upland (U1), the outwash plains (O) extend towards the lakeshore. The soils are brownish black clay under poor to imperfect drainage conditions.

(5) Lower Livulezi Area

The soils of Lower Livulezi Area are classified into two (2) groups according to their physiographic positions, i.e. bottomlands in the western parts and uplands in the eastern parts. Vertic Cambisols and Eutric Vertisols are major groups on bottomlands. They are very deep black clay under poor drainage conditions. The soils of uplands are Haplic Luvisols characterized by very deep, moderately well to well drained, yellowish brown, coarse to medium texture.

2.2.4 LAND SUITABILITY CLASSIFICATION

The criteria for land suitability classification for irrigation farming is presented in **Table 2.2.2.** For Upper Namikokwe, Mtandamula and Lower Namikokwe Areas, the land suitability maps are prepared as presented in **Figures 2.2.4** and **2.2.5.** The land suitability classes for irrigated rice farming are summarized below.

No.	Project Area	Total Survey Area	Extent of Land Suitability Class (ha)	
			Suitable	Not suitable
1.	Lower Nadzipulu Area	450	300	150
2.	Upper Namikokwe Area	1,150	640	510
3.	Mtandamula Area	420	280	140
4.	Lower Namikokwe Area	450	280	170
5.	Lower Livulezi	850	620	230
	Total	3,320	2,120	1,200

2.2.5 FIELD MEASUREMENT OF PERCOLATION AND CYLINDER INTAKE RATES

The field measurement of percolation and infiltration rates were carried out at the selected sites where the typical profiles of major soil groups were observed. The results at the following test sites are presented in **Figures 2.2.6** and **2.2.7.**

i. Percolation rates - Mchanja (near water hole) on floodplains of Upper Namikokwe (F22)

ii. Infiltration rates - P4 in the centre of the Nadzipulu area
- M3 on upland of lower Namikokwe (U11)

2.3 CLIMATE

Location of the meteorological stations and hydrological stations around the project areas is illustrated in **Figure 2.4.1.** There are four (4) meteorological stations around the project areas, namely (i) Dedza meteorological station, (ii) Ntcheu Bomba station, (iii) Salima station and (iv) Monkey Bay meteorological station. In addition, several rainfall stations are available around the project area.

The stations at Dedza and Ntcheu are located on the highly elevated land with El. 1,615 m and 1,277 m, respectively. Temperature at both stations is considerably lower than that of the project areas. Although temperature at the Salima station must be more applicable because of same altitude as that of the project areas, rainfall at this station is much higher than the project areas. As far as rainfall record is concerned, the data at the Mua mission is the most appropriate. Taking the said conditions of those stations into consideration, the meteorological record at the Monkey Bay station (14° 05'S - 34°55'E, El. 482 m) must be the most suitable for formulation of agricultural and irrigation development plan of the project areas. The climatic data at the Monkey Bay station are summarized in **Table 2.3.1** and illustrated in **Figure 2.3.1.**

The project areas fall in the tropical savannah. The annual average temperature is 25 °C. The highest mean monthly temperature is 28.1 °C in November and the lowest is in June or July, 21.2 °C. Mean monthly maximum temperature is over 31 °C and this occurs in September, October or November and the mean monthly minimum temperature is 16 °C in June or July.

The relative humidity averages about 66 % ranging from 53 % in September and October to 80 % in February. Mean monthly wind speed is 2.4 m/sec ranging from 1.8

m/sec in February to 3.0 m/sec in October. Mean monthly sunshine hours are as long as 8.5 hours/day on an average. The month with the longest sunshine hours are September and October with 9.8 hours/day, while that with the shortest is January with 6.6 hours/day. Annual evaporation is about 2,100 mm giving the daily average of 5.8 mm. Mean monthly evaporation ranges from 240 mm/day in October to 138 mm/day in February. Except for rainfall factor, these climatic conditions in the project areas are favourable for agricultural productions.

2.4 HYDROLOGY

2.4.1 RAINFALL

There are four (4) rainfall stations in and around the project areas, namely (i) Mua mission, (ii) Golomoti agricultural station, (iii) Mtakataka agricultural station and (iv) Mtakataka airport (**Figure 2.4.1**). Except for the Mua mission, which started the observation in 1952, their observation periods are less than 20 years with considerable missing data. As mentioned above, rainfall data recorded at Mua rainfall station for 26 years from 1952/53 to 1977/78 are the most applicable for the Study.

Mean annual rainfall is 976 mm for the said 26 years. There is a considerable variation in annual rainfall, these range from 621 mm in 1952/53 to 1,520 mm in 1977/78. The wet season extends over six (6) months, generally from November to April. Ninety-nine % of the annual rainfall falls in the rainy season. The highest monthly mean rainfall occurs in December, January or February, and these months account for
over 70 % of the annual rainfall.

A probability analysis was made using normal distribution method as shown in **Table 2.4.1**. A rainfall of 1/5 drought year is estimated to be 750 mm in 1969/70. The 10-day rainfall with 1/5 drought year is summarized in **Table 2.4.2**. The maximum daily rainfall with 5-year return period is estimated on the basis of normal distribution method. The design rainfall is 95 mm/day as shown in **Table 2.4.3**.

2.4.2 RIVER DISCHARGE

Water sources of the Project are to be the Nadzipulu, Nakaingawa (a tributary of the Nadzipulu), Namikokwe, Nadzipokwe (a tributary of the Namikokwe) and Livulezi rivers. Their river systems are illustrated in **Figure 2.4.1**. There are six gauging stations in these rivers. Their drainage areas are as follows;

Name of River	Name of Station	Drainage Area (km^2)
Nadzipulu	3.F.3	224.0
Nakaingwa	3.F.2	63.4
Namikokwe	3.E.2	129.0
Namikokwe	3.E.5	44.2
Livulezi	3.E.3	452.0
Nadzipokwe	3.E.1	30.1

The mean monthly discharge of these rivers is shown below;

(unit: m^3/sec)

Name of station	N	D	J	F	M	A	M	J	J	A	S	O	Mean
Nakaingwa(3F2)	0.39	1.05	1.31	2.60	2.35	1.08	0.51	0.31	0.20	0.12	0.08	0.04	0.70
Nadzipulu(3F3)	0.35	3.00	6.04	7.61	7.38	3.82	2.00	1.26	0.89	0.65	0.45	0.29	2.81
Nadzipokwe(3E1)	0.07	0.76	2.14	1.56	2.20	0.79	0.40	0.25	0.18	0.13	0.08	0.05	0.72
Namikokwe(3E2)	0.28	2.43	3.79	5.50	4.58	2.35	1.12	0.74	0.52	0.36	0.23	0.16	1.71
Namikokwe(3E5)	0.14	1.12	1.72	2.12	2.00	0.93	0.51	0.35	0.28	0.20	0.15	0.12	0.79
Livulezi(3E3)	0.66	5.52	8.82	13.9	10.9	4.51	2.00	1.29	0.93	0.67	0.45	0.50	4.18

The daily discharge for the design year, i.e. 1969/70 is presented in **Tables 2.4.4** to **2.4.8.** Two biggest discharge records are omitted from calculation of average 10-day discharge in order to avoid over-estimate of design discharge of those rivers. Run-off pattern indicates that an average duration from peak discharge to base flow takes about two days.

There is a lot of data blank of the daily discharge of 1969/70 at the 3.E.3 station in the Livulezi river, especially in December, January, February, March, April and August. For filling up data blank in those months, a run-off pattern of the Livulezi river is checked upon for the period from 1957 to 1991. The daily discharge in 1965/66 is selected to fill up the blank because a run-off pattern of discharge and discharge is mostly as similar as that of 1969/70.

Water source for the Lower Nadzipulu irrigation development area is the combined river water of the Nadzipulu and the Nakaingwa. Water sources for the Upper Namikokwe irrigation development area, the present Mtandamula scheme and the Lower Namikokwe irrigation development area are the combined river water of the Namikokwe and the Nadzipokwe. Water source for the Lower Livulezi irrigation development area is the Livulezi river. The 10-day discharge at proposed intake sites of the said development areas are presented in **Table 2.4.9.**

2.5 RIVER CONDITIONS

The river conditions were analyzed through interpretation of the latest aerial photo and the field investigation. The river courses are illustrated in **Figures 2.5.1** and **2.5.2.**

(1) Nadzipulu river

The Nadzipulu river has a catchment area of 224 km^2 at the 3.F.3 station with a perennial flow throughout the year. The length of the river course is 32.7 km. The Nakaingwa river, a perennial stream, is the main tributary of the Nadzipulu. It has a catchment area of 63.4 km^2 with a river course of 20 km long. The Nakaingawa river joins the Nadzipulu at one (1) km downstream of the railway bridge. The longitudinal gradient of the river course of the Nadzipulu downstream of the confluence with the Nakaingawa is about 1/420. The river course of the Nadzipulu is relatively straight and stable with a bank height of 4 m up to Mathemba village or about 4 km downstream of the confluence. In the downstream of the confluence, the river channel capacity becomes smaller (bank height is less than 0.5 m) and the riverbed is apt to raise due to sediment.

Through comparison between the existing 1/50,000 topo-maps prepared in 1973 and the latest aerial photos, the river course of Nadzipulu has drastically changed in its downstream of Mathemba village for the last 20 years as shown in **Figure 2.5.1** and villages located in the left bank were washed out by flushing. The new delta with an area of 0.4 km^2 has been formed.

(2) Namikokwe river

The Namikokwe river is a perennial stream with a catchment area of 129 km^2 and a length of 27.8 km at the 3.E.2 station. The Nadzipokwe river, which has a catchment area of 30.1 km^2 and a river course of 12.5 km long, joins the Namikokwe at about 1.5 km downstream of the railway bridge. The river course is stable up to about 1 km downstream of the confluence. The bank height of the river is less than 0.5 m with a width of 2 to 3 m and the channel capacity of the river becomes smaller. The longitudinal gradient of the river course is between about 1/300 and 1/500. As shown in **Figure 2.5.1**, the present river course of the Namikokwe moves rightward and joins with the old river course of the Livulezi in the low flow season. Floods recurrently occur from January to March, spill onto river banks and flows into the dambos, and recede after 2 to 3 days in general. Some flood water is used for irrigating the paddy

fields in the existing Mtandamula self-help irrigation scheme. Most of the flood water is drained out into the old Livulezi river.

(3) Livulezi river

The Livulezi river has a catchment area of 452 km^2 and a length of 50.3 km at the 3.E.3 station. The river course is very stable in the upstream portion where bank height is about 4 m. In the downstream portion of the railway bridge, the bank height becomes lower (about 2.0 - 0.5m). The longitudinal gradient of the river course is about 1/300. The river carries much sediment load since the lands in the upper catchment are cultivated by maize and there is no forest reserve. According to the master plan report on national water resources, the sediment transportation rate is over 0.4 kg/m^3. As shown in **Figure 2.5.2**, the river course has drastically changed ion the past 20 years.

The flow capacity of the Namikokwe and Nadzipule rivers are estimated by means of non-uniform flow analysis. The coefficient of roughness of these river courses of 0.045 is applied in the analysis. **Figure 2.5.3** shows the location of the cross section with 50 m interval of the Namikokwe river courses used in the analysis. The results of the analysis are shown in **Figures 2.5.4 and 2.5.5**. Accordingly, the flow capacity of the Nadzipulu and the Namikokwe at the proposed intake site for the irrigation development areas are estimated at about 180 m^3/sec and 200 m^3/sec, respectively. As for the Livulezi river, no analysis on the flow capacity of the river course is carried out since the intake is proposed to be in the dambos with construction of the flood protection/ intake dikes.

2.6 FLOOD DISCHARGE

2.6.1 RECORDED MAJOR FLOODS

The maximum flood discharge of the rivers in the Study area are shown in **Table 2.6.1**. The recorded maximum flood discharge of each river is listed below:

Name of River	Drainage Area(km^2)	Maximum Discharge(m^3/sec)	Recorded
Nakaingwa river	63.4	109.0	Feb 79
Nadzipule river	224.0	91.7	Jan 68
Nadzipokwe river	30.1	80.5	Feb 82
Namikokwe river	129.0	130.2	Feb 82
Livulezi river	452.0	372.0	Jan 86

Note: The daily recorded flood discharge relating to the Namikokwe river is available since 1981.

The flood discharge, however, is not reliable, because observations at the gauging stations are only made twice a day: in the morning and evening, and a flood data is sometimes missed.

2.6.2 FLOOD DISCHARGE ANALYSIS

The flood peak discharge analysis of the relevant rivers was carried out by using available formulae in Malawi: (i) Pike's coefficients and formula, (ii) Drayton's equation, and (iii) Laisi's equation. The flood peak discharge for each river is estimated as shown in **Tables 2.6.2** to **2.6.4** and summarized in **Table 2.6.5**. For the estimation of the design flood peak discharge, the Drayton's equation is applied. The Drayton's equation is the most popular with estimation of the design flood peak discharge in Malawi and many facilities such as dams and bridges were constructed based on the design flood discharge estimated by using this equation.

The design flood peak discharge of the rivers in the study area are summarized as below:

(Unit: m^3/sec)

Return period	Nadzipulu	Namikokwe	Livulezi
5	121.6	93.9	170.6
10	160.5	123.9	225.1
25	217.5	167.9	305.0
50	266.1	205.4	373.2

2.7 WATER QUALITY AND WATER RIGHT

2.7.1 WATER QUALITY

The water quality analysis for the following three rivers was carried out by the Department of Water :

- Nadzipulu river at Bridge on M17 Road,
- Namikokwe river at bridge on M17 Road, and
- Livulezi river at bridge on M17 Road

The results of water quality analysis as shown in **Table 2.7.1** indicate that the river water are favourable for irrigation.

2.7.2 WATER RIGHT

The existing water right of the rivers concerned are as follows:

Name of River	Grid refer.		Water Right (m^3/day)	Purpose	Remarks
Nakaingwa			200.0	Road Construction	
Nadzipule	634	283	90.9	Domestic Water	Upstream of grid refer
Nadzipule	630	212	568.0	Domestic, Power and Irrigation	
Namikokwe	638	194	200.0	Road Construction	Downstream of grid refer
Livulezi			200.0	Road Construction	

Source : Department of Water
Note : Grid refer No. is co-ordination on map sheet.

2.8 ASSESSMENT OF EXISTING IRRIGATION SCHEMES

2.8.1 OBJECTIVE OF THE ASSESSMENT

The main objective of the study is to clarify the conditions for a successful irrigation project in Malawi paying a particular attention on the project sustainability through the following analyses and considerations.

(i) To verify past and present conditions of the existing irrigation schemes and to identify technical constraints in O&M,
(ii) To induce a O&M system including institutional set-up suitable for the Project,
(iii) To optimize quality of project works taking into account management capability of DOI, Salima ADD and local farmers, and
(iv) To identify supporting system required for the Project during the initial stage to ensure sustainable irrigation farming activities.

2.8.2 INSPECTION OF THE EXISTING IRRIGATION SCHEMES IN SALIMA ADD

Within the framework of the present F/S, the JICA Study Team carried out site inspection of the following nine (9) on-going schemes and two (2) abandoned ones located in the territory of Salima ADD as illustrated in **Figure 2.8.1**. The details of data and information collected during the site inspection are shown in **Table 2.8.1** and the outline of the irrigation schemes inspected are shown below.

Irrigation Scheme	Irrigation Area (ha)	Water Source	Main Crop	Management Status (Donor)	Note
1. Bua	200	Bua River	Rice	G.S. (Taiwan)	
2. Mpamantha	60	Lake Mdila	Rice	G.S. (Taiwan)	
3. Lifuwu	54	Lake Malawi	Rice	G.S. (Germany,EEC)	
4. Kasitu	60	Kasitu River	Rice	S-H (EEC)	
5. Likowa	45	Likowa River	Rice	S-H (EEC)	
6. Lifuliza	50	Dzuma River	Rice	S-H (EEC)	
7. Ngolowindo	15	Groundwater	Vegetables	S-H (EEC)	
8. Mtandamula	230	Namikokwe River	Rice	S-H (EEC)	
9. Mwalawoyera	120	Bwanje River	Rice	S-H (EEC)	
10. Mnema	100	Limpimbi River	Rice	S-H (EEC)	Abandoned
11. Thiwi	250	Lake Cjilingari	Rice	G.S.(U.K.)	Abandoned

Remark: 1). G.S. : Government Supported Scheme
2). S-H : Self-help Scheme

For the discussions on the existing irrigation schemes under Salima ADD, three (3) schemes are selected from the viewpoints of scale of scheme, water source, target crop, and physical constraints on the schemes, of which conditions are similar to those in the Bwanje Valley Smallholder Irrigation Development Project. The selected schemes are the Bua irrigation scheme, the Mtandamula irrigation scheme, and the Mnema irrigation scheme.

2.8.3 MAJOR CONSTRAINTS ON THE EXISTING IRRIGATION SCHEMES

(1) Floods and sedimentation

The rivers passing in Salima ADD are raised within the plateau, incise the Escarpment, and drain through the Rift Valley Floor into the Lake Malawi. Due to loose soil materials and lack of conservation practices in the upper catchment, soils are highly susceptible to erosion hazard. In the wet seasons, rivers transport and deposit huge amounts of sediments to the Rift Valley Floor where irrigated areas are selected. The most critical factors to operation of the schemes are frequent changes and braiding characteristics in lower reaches of the rivers as well as damages by rapid runoff of heavy precipitation in the catchment. Typical constraints on the three (3) selected schemes are caused by such river characteristics as;

(a) siltation at intake structures and in canals,
(b) flood damages on dikes, intake structures, and commanded areas, and
(c) unstable river courses.

A typical pattern of serious effects by floods and sedimentation is shown as the project history of the Mnema irrigation scheme. Sedimentation of more than two (2) m deep on the Limpimbi river course caused the collapse of the flood protection dike, change of the river course, and consequently abandonment of the scheme. Desiltation works at the intake site and in the canals have seriously pressed operation and maintenance expenses in the Bua irrigation scheme. In the Mtandamula, farmers have been forced to clear the intake and the canals three times in a cropping season.

It is noteworthy that no specific structure for preventing the irrigation facilities from flood sedimentation is provided in the said schemes. The flood protection dikes in the Mnema and the Bua were constructed just a side of the main river course without any artificial protection on them, where huge energies of floods would directly attack.

(2) Irrigation efficiency

Irrigation efficiency in the existing irrigation scheme is generally low mainly due to poor maintenance of the irrigation facilities.

Deterioration of the irrigation facilities is salient in the Self-help schemes which were mostly initiated with EEC fund and directly handed over to Scheme Committees. The committee has maintained the scheme by contribution of farm labour force with minimum support by external sources as well as the government. In the Mtandamula irrigation scheme, one of the Self-help schemes in Malawi with an average record of 2,992 kg/ha in paddy production, the unlined main feeder canal has been deteriorated without the original shape in section. Most of the concrete structures on the canal have been partly deteriorated during past five years since initiation. Poorly-maintained facilities have caused loss of water, improper and unfair water distribution, and consequent low irrigation efficiency in the scheme.

In Government Supported schemes which were constructed by the donors and generally transferred to the Governmental bodies, the recurrent costs for operation and maintenance of project facilities are bone by the Government. The irrigation facilities in the Bua irrigation scheme, one of the government support schemes, are well-maintained and properly functioned. To minimize water loss from the canal (conveyance loss) the canals; main canal and lateral canals, are partly lined. Water distribution to farm blocks is properly carried out through gated division structures. With more than 10 years operation no serious deterioration on the structures is observed during the inspection of the scheme.

As regards the operation and maintenance in on-farm level, the deterioration of the field channels and poor on-farm structures as well as the extensive farm operation have caused the application losses of water in the Mtandamula Self-help scheme. Water distribution through farm inlet without any check device is unequalized in water quantity in every farm plot; the upstream plot obtains more water than the lower plot. Consequently, surplus water occurs in the upper plots and flow over into the drain as the serious application loss of water. In the Bua irrigation scheme, well maintained field channels and on-farm structures with strict farm operation have minimized the water application losses.

(3) Extension of irrigation technology

No certain irrigation programme is prepared in the whole Self-help irrigation schemes inspected. For maximum and effective use of limited water, a scheduled irrigation programme, especially for rotation irrigation with proper gate operation, is to be required. Watch-and-open gate operation system has been dominant in the schemes, which might cause unfair water distribution, breaking down the facilities by the farmers, and serious water shortage in the downstream portion in the dry years. Although measurement of intake water discharge, water distributed to the rotation block, and rainfall is to be required for preparation of irrigation programme, no such activity has been carried out.

ADD staffmembers at scheme site, who have a capability for measuring required information and for preparing an irrigation programme, are limited in number. The technical supports in the initial stage of the project are indispensable for successful project operation in terms of extension of irrigation technology. In the government support schemes, technical assistants were carried out as those in the Bua irrigation scheme. Appropriate irrigation activities have been performed in the scheme in conformity with the certain irrigation programme prepared by the engineers of China Agricultural Mission.

(4) Operation and maintenance expense

Maintenance works of irrigation facilities in the Mtandamula irrigation scheme consist of desiltation and clearing the canals and intake, digging a ditch leading water from upper dambo to the intake site, and purchasing small spare parts and grease for intake gate. Most of the works have been carried out by contribution of farm labour force. In accordance with interviews through the inspection, contribution of farm labour force is nine (9) day/year/farmer which can be converted into labour charge of about MK

22,000/year. Expense to the small spare parts and grease for intake gate and others may be negligible small. The converted unit expense for maintenance works amounts about MK 96/ha/year.

In the Bua irrigation scheme, the major maintenance works include desiltation of the intake structure and the canals, construction of the temporary weir, clearing the canals, and rehabilitation of the concrete and steel structures. Actual expense for desilting of the intake and construction of the temporary weir is informed as MK 45,000/year. The labour forces of prisoners have been used for clearing and desilting of the canals without any charge. Some 25 prisoners daily engage such maintenance works, which converted into labour charge of about MK 23,000/year for one cropping season. The converted unit expense for the works amounts MK 115/ha/year.

The operation and maintenance expenses for desilting of the intake and construction of temporary weir are peculiar to the Bua irrigation scheme. The comparison can be made on labour works for maintenance; MK115/ha/cropping season in the Bua and MK 96/ha/cropping season in the Mtandamula.

(5) Poor quality in land levelling

The inspection of the existing irrigation schemes reveals the poor quality in land levelling. Serious micro-relieves are observed in the most of paddy fields in every irrigation schemes; the Government Supported and the Self-help. Generally, the micro-relieves in the farm plots would be hotbeds for pests, diseases, and weeds infestation and impede the uniform crop yield in the plot and over the scheme. In Mtandamula, the farmers have provided sub-levees in the own farm plot of 0.4 ha for preventing the partial or one-sided water distribution caused by the farm surface irregularities. The uneven farm plot surface might cause the varied crop yields in each plot. The recorded unit yields vary widely; between 1 ton/ha and 6 ton/ha.

(6) High and stable productivity

As clarified through the farm interview survey, farmers are most keen to irrigation water supply. As far as farmers are convinced with sufficient and stable water supply, they are motivated to apply crop credit of SACA and other investment. Farmers are always negative with a sense of risk management to apply qualified farm inputs under unreliable water supply conditions.

The paddy yields in the government support schemes, i.e. 4 to 6 ton/ha, are higher and more stable than ones in the Self-help schemes, i.e. 1 to 3 ton/ha. In the demonstration farm of the Bua irrigation scheme, the average paddy yield is over 5 ton/ha by applying 400 kg/ha of DAP as basal dosage and 100 - 200 kg/ha of urea for top-dressing (total nitrogen: 60 - 100 kg/ha), which yield is nearly twice of that in the Mtandamula irrigation scheme. At the time of initiation of the Bua irrigation scheme, CAM supplied a package of farm inputs including certified seeds, fertilizers, and chemicals under the agronomic guidance. This might contribute to the present high yield in the scheme.

2.8.4 FACTORS GOVERNING SUCCESSFUL PROJECT

As a result of the assessment, significant factors for governing the successful project in the study area are identified as follows.

(i) Optimum engineering plan formulation and design against floods and sedimentation,
(ii) Certain quality of the irrigation facilities for maximizing the irrigation efficiencies,
(iii) Urgent extension of irrigation technology for ensuring the appropriate irrigation activities,
(iv) Simplification of operation and maintenance works for minimizing the expense on O & M,
(v) Improving the quality in land leveling of farm plots for obtaining the maximum effect of farm activities, and
(vi) Strengthening the agricultural support services.

For realization of the project with certain sustainability as the Bwanje Valley Smallholder Irrigation Development Project, the following definite measures are to be considered in conformity with the results of assessment on the existing irrigation schemes in Salima ADD.

(1) Optimum engineering plan formulation and design against floods and sedimentation

The alignment and design of the project facilities are to be prepared based on the following planning concepts in terms of protection of floods and sedimentation, as well as the maximum use of available land and water resources.

(i) to minimize effect of floods, sedimentation, and river course meandering in selecting the intake sites,
(ii) not to disturb the present floods activities by the artificial structures; intake structures, flood protection dikes, and flood ways, and
(iii) to provide desilting structures at intakes and in irrigation canals.

(2) *Certain quality of irrigation facilities for maximizing the irrigation efficiency*

For the maximum and effective use of water , the proposed irrigation facilities for the project, such as irrigation canals, water distribution structures, and on-farm division structures, are to be designed with certain quality as those in the Bua irrigation scheme at least. Definite recommendations are;

(i) to line the major irrigation canals with concrete or brick covered by mortal,
(ii) to apply reinforced concrete for the major diversion structures with simple steel gates,
(iii) to provide water measuring devices at intake and diversion points to farm blocks,
(iv) to provide simple division structures on field channels.

(3) Urgent extension of irrigation technology

For carrying out the optimum irrigation with limited water, the well-scheduled irrigation programme shall be prepared. Since the irrigation engineers or other engineers for preparing the irrigation programme for the project are short in number, human development in irrigation planning sector is urgently required. The following definite plans for such a human development are recommendable.

(i) To train the ADD staffs through on-the-job training method by using the technical assistants of the donor countries in the initial stage of the project,
(ii) To establish an irrigation/agriculture training centre and to train ADD staffs and farmers in the centre by long term experts of the donor countries and irrigation engineers in Malawi. The centre shall be managed by the Department of Irrigation, the Ministry of Agriculture.

(4) Simplification of operation and maintenance works for minimizing O & M expense

The major maintenance works in the existing irrigation schemes in Salima ADD are those for desiltation, clearing, and rehabilitation of irrigation structure. The optimum plan formulation and design lead to the simplification of the works and to consequent minimization of the maintenance expense. By providing the desilting structure like settling basin at the certain point, the desilting works can be concentrated at such a structure site. Lining canal well contributes to reduction of the maintenance works in re-shaping, clearing, and rehabilitation of slope collapse.

As regards the maintenance work in tertiary /farm block level, the Self-help system is superior to any other system in terms of the minimization of maintenance expense. After training of farmers in the initial stage of the project, the Self-help system can be employed for the maintenance works in the tertiary/farm block level as well as the operation works.

(5) Improving the quality in land levelling

In the most of the existing irrigation schemes, the land levelling works in farm plot level have been carried out by the farmers themselves without any assistants of the donors or the Government. Consequently, the quality in land levelling is seriously poor and the paddy yields are irregular in the plot and over the scheme.

For increasing the paddy production and uniforming the unit crop yields over the project areas, the land levelling works shall be performed as the project works. The paddy field with an even land surface is the basic element for obtaining the maximum effect of the farm activities.

(6) Strengthening agricultural support services

Applying certified seeds, fertilizers, and chemicals under agronomic guidance is integral for increasing unit crop yield as well as stable supply of irrigation water. The irrigation/agricultural training centre mentioned above will have a function to train agricultural extension workers of ADD and farmers through on-the-job training on an experimental programme in the demonstration farms.

2.9 SOCIAL INFRASTRUCTURES

Inventories of social infrastructures in and around the development areas are shown in **Table 2.9.1** and illustrated on **Figure 2.9.1**.

2.9.1 ROADS

The present road systems in and around the development areas are illustrated in **Figure 2.9.1**. The development areas have a favourable position to link the main national roads of M-17 and M-18 which play an important role in passenger and commodity flow within the inter-regional traffic. The main roads connecting the project areas with the main national roads are all unpaved and jeepable during the dry season. The total length of these roads is estimated to be about 35 km and insufficient as follows;

	Road section	km
(i)	Mtakataka to Chatala	5
(ii)	Chatala to Mtandamula scheme (Mtembanji)	7
(iii)	Mtembanji to Dziko	3
(iii)	Chatala to Chitula (lake Malawi)	5
(iv)	Mlangeni to Dungeya	4
(v)	M-17 to Mwasinja	5
(vi)	M-18 to Ndindi	2
(vi)	Kapili centre to Sitole-I	4
	Total	35

All the roads except between Chatala and the Mtandamula scheme (Mtembanji) are bumpy and are difficult to drive during the wet season. The traffic flow from the south to the north is hindered by the rivers such as the Nadzipulu, the Namikokwe, the Livulezi and their tributaries because of no bridges at any rivers and no roads.

There are a lot of foot paths around the project areas. However, these foot paths often become impassable during the flood season.

2.9.2 MEDICAL SERVICES

The Kaundu Health Centre in Ndindi village is the only one (1) health centre in the villages related to the development areas. In addition, there are four (4) health centres around the development areas as follows:

(i) Mtakataka health centre
(ii) Police college air wing health centre
(iii) Mua hospital and
(iv) Golomoti health centre

Mua hospital is managed by the mission and other trees are under the Ministry of Health. Their location is very far from the relevant villages and distance from the villages are over six Km away at least.

2.9.3 COMMUNICATION

The postal services are under the East Post Division Office's service network. The nearest post office around the development areas is located at Mtakataka. No telecommunication system is available in the development areas. The telecommunication between Mtakataka EPA office and the headquarters of Salima ADD is available.

2.9.4 DRINKING WATER SUPPLY

It is estimated on the basis of the results of the farmers' interview survey that 23 % of the total farmers use shallow wells, 50 % boreholes and 27 % lake or river. There are 17 boreholes and 5 shallow wells in the villages related to the project areas. Among these, 13 boreholes and 4 shallow wells are functional at present. A density of the functional boreholes and wells per 1,000 households becomes 3.4 for boreholes and 1.1 for shallow wells. The conditions of water supply from these wells are not always good and water is often exhausted in the dry season. The existing boreholes are partly rehabilitated by both Kampax with World Bank and the Save the Children Fund (SCF) with ODA/UK at present.

2.9.5 POST-HARVEST AND MARKETING FACILITIES

There are 4 maize mills in the villages of Mwasinja, Mchanja, Kabulika-II and Mkhalira. The basic information about mills are shown in **Table 2.9.2**. The number of mills are few and the distance to the mills is 4 to 8 km away for the farmers who live in the village except the above villages. The milling capacity of those is 360 to 1,100 kg/hour. These mills are operated with good conditions throughout the year. The milling charge is MK 1.5 to MK 2 per 20 kg of maize. There are no rice mills and chemical shops in and around the development areas.

Four ADMARC markets are available in and around the development areas; at Mtakataka, Mtembanji (Mtandamula scheme), Kapiri and Mkalira. The Mtakataka market is the parent market of ADMARC. The Mtembanji and Mkalira markets are the seasonal one to deal with paddy produced in the Mtandamula scheme and with cotton, respectively. The Kapiri market is the unit market operated throughout the year. There are 8 local markets held once a week in general.

There are 22 small stores (Kiosk) in the project areas which function to provide daily commodities to the local farmers.

2.10 LAND USE

The information concerning land use was collected through the semi-detailed soil survey. By applying aerial photo interpretation, the present land use maps of the project areas are prepared as illustrated in **Figures 2.10.1** to **2.10.3**. The distribution of land use categories is presented in **Table 2.10.1**. The land use patterns of the project areas are represented by rainfed farming with the following specific features.

(i) Under the authority of Kachindamoto TA, irresponsible farming activities are controlled in and around the project area. Therefore, farmlands are semi-permanent and shifting (slush and burn) cultivation is not done.

(ii) Perennial crops, e.g. orchards and sugarcane, are not planted in and around the project area except for homestead production.

(iii) Single cropping with maize or paddy is prevailing. Double cropping is practiced only to the limited extent, where groundwater table is favourable for root zones or soil moisture recharged during the wet seasons is retained for a certain period after onset of the dry seasons. Early maturing pulses, e.g. white haricot, are planted there.

(iv) Low vegetation provides grazing sources for cattle and smallstock. As well, plant residues after harvesting season are broadly utilized for grazing purposes. Paddy straw left on farm after threshing is valuable feed for local animals in the Mtandamula scheme.

2.11 LAND TENURE

There are four types of land tenure in Malawi : (i) customary land, (ii) public land, (iii) free hold land and (iv) leasehold land.

All the lands of the project areas are customary lands. The customary lands of the project areas are under the jurisdiction of the Kachindamoto traditional authority and the village headmen. Lands are earmarked to the farmers under permission of the authority based on the farmers' requirement in general. The land allocated to can not be sold and leased. In effect, the lands are leased to the relatives and/or neighbours without the rental charge in the case that the farmers cannot afford to cultivate lands due to some causes such as sickness. In general the right to cultivate the allocated land is traditionally owned and heritaged by wife and children.

The village headman and the Kachindamoto traditional authority have the right to re-allocate part of the land to other families who need it in the case that the family moves out of the village or dies. The land reclamation for the unused lands can be made if the traditional authority permits it.

2.12 FARMERS' ECONOMY AND CHARACTERISTICS OF SOCIAL LIFE

2.12.1 METHOD OF THE FARMERS' SOCIO-ECONOMIC SURVEY

Three kinds of the socio-economic surveys are performed to clarify economic conditions and social life of the farmers in the project areas. These are (i) the farmers' interview survey, (ii) the farm work survey and (iii) the interview survey for the village headmen.

(1) The farmers' interview survey

The purpose of this survey is to identify the present condition of farming practices, socio-economic condition of the farmers and their view expectation for the future rural development.

A list of the farmers of 42 villages related to the project areas was prepared. Among these farmers, 160 sample or 4 % of the total farmers in 42 villages were selected at random. Prior to commencement of the survey, sixteen enumerators were trained with respect to the method of the survey. The interview survey was carried out during period from July 3 to July 12, 1993. The collected data were processed by computer after checking original data.

(2) The farm work survey

This survey aims to clarify (i) an accurate labour requirement necessary for cultivation of rice and maize, (ii) a role of family members in farming activities and (iii) daily expenditures for living.

This survey was conducted for 3 farmers selected from the Mtandamula self-help irrigation scheme for about 220 days from December 16, 1992 to July 22, 1993. The characteristics of these farmers are shown below:

Farmer	Head	Family size(nos)	Lowland (ha)	Upland (ha)	Draft animal
No.1	male	9	3.7	1.0	has
No.2	male	4	0.4	1.0	not have
No.3	female	4	0.4	1.0	has

In this survey, the farmers keep a diary to fill up the questionnaire form which includes (i) daily farming activities of family members and casual labourers on hourly basis, (ii) farm tools used, (iii) amount of seed, fertilizer and chemicals and (iv) daily cash expenditure.

(3) The interview survey for the village headmen

This survey aims to identify the social conditions in the villages. The items surveyed are (i) organizational structure of village, (ii) present administrative and social constraints, (iii) roll of village headman and group village headman, (iv) role of family members, marketing of agricultural products, (v) contribution system to maintain a village society, (vi) prevailing illness and diseases, (vii) facilities of medical services and (viii) farmers' perception to irrigation system management and collection of irrigation fee in the future condition after the implementation of the project.

The interview was undertaken for 8 group village headmen and/or village headmen from July 26 to 30, 1993. This survey is a supplemental study for the farmers' interview survey.

2.12.2 GENERAL FEATURES OF THE FARMERS IN THE PROJECT AREAS

(1) Family size and labour force

According to the results of the farmer' interview survey for 160 sample farmers, an average family size is 4.4 in the project areas. It ranges from a maximum of 4.9 in the lower Livulezi project area to a minimum of 4.1 in the lower Namikokwe and the Mtandamula project areas. A sex ratio in the whole project area is 49 % for male and 51 % for female. The labour force for agriculture is 2.45 persons/family, ranging from 2.1 persons in the upper Namikokwe project area to 2.78 persons in the lower Nadzipulu project area. The labour derived from the female occupies 55 % of the total labour force for agriculture. The labour force is equivalent to about 55 % of the total family members. Details are shown in **Table 2.12.1**.

(2) Farm size

An average farm land per farmer in the whole project area is 1.25 ha, ranging from a maximum of 1.61 ha in the upper Namikokwe and Mtandamula project areas to a minimum of 0.95 ha in the upper Namikokwe project area as shown in **Table 2.12.1.**

(3) Crops

The main crops in the project areas are maize and rice, followed by cotton and beans/pulses. Other crops such as millet/sorghum, groundnuts, sweet potatoes, cassava and tobacco are grown in a small scale. The maize occupies 58 % of the total cultivated land, rice 31 %, cotton 5 % and beans/pulses 4 %. Details are shown in **Table 2.12.1.**

(4) Raising livestock

The main livestock in the project area are chicken, followed by goat and cattle. The average heads/farmer in the whole project area is 4.6 for chicken, 1.9 for goat and 1.3 for cattle. Other livestock such as sheep and pigs are grazing on a small scale. Details are shown in **Table 2.12.1.**

(5) Typical farmer

Based on the results of the farmers' interview for 160 farmers, it may be concluded that the typical farmer in the project areas is the farmer having the following characteristics.

(i) family size: 4 persons
(ii) family labour force for agricultural farming: about 2 persons
(iii) cultivated land: about 1.1 ha consisting of 0.7 ha for maize and 0.4 ha for rice
(iv) the farmer raises some livestock and
(iv) the farmer has no draft animal

As a typical sample farmer having the above characteristics, the No.2-farmer selected in the farm work survey could be identified. The characteristics of the farmer are shown in Section 2.12.1.

2.12.3 FARMERS' ECONOMY

The farmers' economic condition in the projects area is examined by preparation of a farm budget. The farm budget was made for the farmers selected in the farmers' interview survey and the 3 farmers selected in the farm work survey. The farm budgets of the above are shown in **Tables 2.12.2** and **2.12.3**.

The project areas were seriously hit by the drought in 1991/92 and crops were damaged, which considerably affected economic condition of the farmers. To prepare an appropriate farm budget of the farmers, special attention was paid on deleting the effect of such drought to farmers' budget .

For preparation of the farm budget for the farmers' interview survey , agricultural production and farm income in 1990/91 season and expenditures in 1991/92 season are used. Because farm income obtained by the crop harvest in 1991 is used for the expenditures during the period until the crop harvest of 1991/92 season. And a greater part of the expenditures in 1991/92 season fully depend on the farm incomes in 1990/91.

With respect to the farmers in the farm work survey, the daily incomes and expenditures were recorded in the period from December 1992 to July 1993. The incomes and expenditures for the future four months from August to November in 1993 are estimated and the farm budget is made. Though there are some purchase of maize meals and supply of the governmental subsidized maize meals due to the effect of the drought, such effect seems not significant.

In case of the farmers of the interview survey, the total annual income of the farmers averages MK 705, comprising MK 395 (or 56 % of the total income) from crops, MK 126 (18 %) from livestock and MK 184 (26 %) from non-farm income. The main source of crop income are dependent on sale of rice and maize. The main source of livestock is from sale of cattle, goat and poultry. Non-farm incomes are derived from mainly fishing, mat making, tin smith, collection of grass for roof and casual labour.

The average total annual outgo is MK 746, consisting of MK 40 (5 % of the total outgo) of production costs, MK 29 (4 %) of non-farm costs and MK 677 (91 %) of the living expenditures. As a result, the balance becomes the red and minus MK 23 annually. A living expenditure per head is estimated to be about MK 160/annum or MK 13/month.

In case of the 3 farmers in the farm work survey, the No-1 farmer is one of the leading and aggressive farmers in the Mtandamula self-help scheme. It seems that the No-1 farmer is the largest scale on cultivation and earns the highest farm income in the scheme. The total annual incomes account for MK 13,939 consisting of MK 11,790 of rice and MK 2,149 of livestock. The total annual outgo are MK 8,566, being MK 5,325 for production costs and MK 3,241 for the living expenditures. The annual balance is the black and MK 5,373.

On the other hand, the total annual incomes of the No-2 and No-3 farmers accounts for about MK 2,300, all of which are derived from the farm income. The total annual outgo is MK 1,979 for the No-2 farmer and MK 1,581 for the No-3 farmer. The balance is plus MK 302 for the No-2 and MK 754 for the No-3, respectively. A living expenditure per head is MK 421 for the No-2 farmer and MK 373 for the No-3 farmer. Among the expenditures, the expenditures of foodstuff are the largest and occupies about 60 to 80 % of the total living expenditures. The expenditures of foodstuff are about 50 % of the total income. Followed by foodstuff, clothing and footwear are the main expenditures.

As a whole, it may be concluded that the farmers in the project areas eke out a living and remain in the subsistence level of living.

2.12.4 SOCIOLOGICAL CHARACTERISTICS IN THE SOCIAL LIFE

Sociological characteristics in the social life of the villagers related to the project areas are identified through the interview survey to group village headmen and village headmen. The results are summarized in **Table 2.12.4.**

(1) Social life and women's role

Matrilineal society: *Eighty five to ninety of the present societies in the project* areas are matrilineal with matrilocal marriages. Husband lives in the wife's home village. Property is owned by the matrilineage and descendance, and inheritance are traced and passed through the female lineage in general. In case of divorce, there are two cases: (i) husband and wife share 50 % of property and (ii) wife inherits all property. With respect to the farm lands, their inheritance is traced by wife and children in the customary lands. In the public lands, however, inheritance of the land is shared with 50 % by wife and 50 % by husband.

Administrative and social constraints: The main social constraints encountered in the project areas are a shortage of the social infrastructures such as drinking water boreholes, school, hospital, market, good roads and bridge, maize mill and post office. In addition damages by floods and hippos are also the constraints in the project areas. Among these constraints, a shortage of water boreholes for drinking water and hospital is crucial for the farmers' daily life in the project areas.

Marketing of agricultural products: The farmers sale about 60 to 70 % of the total produced paddy in general. The farmers in the Mtandamula scheme sale over 95 % of the total produced paddy. The main channel is ADMARC to which about 90 % of the marketed amount above are sold at the price of one Kwacha per one kg. The second channel is private trades mainly in Salima, Lilongwe and Blantyre, occupying 10 %.

The marketed maize is estimated to be about 10 % of the total produced amount. 90 to 95 % of the marketed maize is outlet to ADMARC at the price of MK 0.43/Kg. The remainder are local markets.

Illness and medical services: There are many kinds of diseases in the project areas. Among them, the most serious diseases prevailing to the project areas are malaria, cholera, blood diarrhoea, whooping cough, tuberculosis, measles and pneumonia. Last year blood diarrhoea broke out in the villages around the Mtandamula scheme and a lot of people died.

There are only one hospital in the project areas, i.e. the hospital at Ndindi, and there are four (4) health centres around the project areas. The farmers have to rely on the hospital of which location is very far from the villages around the project areas, often more than 10 km. The farmers have to walk to the hospitals due to lack of transport.

Women's role: The women in the project areas undertake the majority of all daily activities and have a very heavy work load.

The role of women for farming activities is analyzed through the farm work diary of the 3 farmers in the farm work survey. The results of the farm working hours in each farmer are summarized in **Table 2.12.5.** The total farm working hours contributed by housewife are about 1,000 hour for one rice cropping season. All housewives work longer than any members of their family.

In addition, housewives have to perform traditionally many kinds of daily work, among which the important work are cooking, fetching drinking water and fire wood,

milling rice and maize, and house keeping, and children care. Fetching drinking water work levies a heavy work load to women because of shortage of boreholes and wells in and around the villages in the project areas. The condition of the drinking water is summarized in **Table 2.12.6**. Each woman in the family fetches water of about 20 litters/head (or 1.1 buckets) daily. The average distance to boreholes, wells or lake is about one km per one way for this work. In case of 4 persons in family size, a fetching water work is done four times/day in total. It takes about two hours/day for the one family supposed that fetching water per one way needs 15 minutes.

Most of the farmers in the project areas bring maize to the maize mills which operate by private millers. Maize is milled twice a month and about 40 kg are milled one time. There are only four maize mills around the project areas and the distance to the millers are very far. The conditions of the maize milling are shown in **Table 2.12.7**. The distance ranges from 4 to 8 km, where no mill is available near the village. Since there are no rice mills in and around the project areas, this work is performed by woman and it takes 0.5 to one hour/day/woman.

In the project areas, number of the female headed households (FHHs) is estimated to be about 40 % of the total farm households. Though the number of FHHs having no husband is not clear, such situations of daily work makes very crucial problems especially to the housewife having no husband. It turns out that in such FHHs a scale of the cultivated land is forced to be small due to shortage of labour force and the farm income becomes smaller.

The above fact indicates that the women's role in the project areas is vast and levies a heavy work load to the women. It is considered that an alleviation of the women's work in daily work activities, especially fetching water and milling should be essential for betterment of female's living as well as increasing farm incomes by an enlargement of cultivated land.

(2) Mutual assistance system

The mutual assistance system in the rural society in the project areas can be divided into four categories: (i) obligations to maintain the social conditions of the villages, (ii) labour contribution services to maintain the public agricultural facilities such as irrigation system, (iii) obligation to traditional festivals and religious ceremonies and (iv) mutual personal aids of villagers. **Table 2.12.4** presents the conditions of the mutual assistance system in the project areas.

Obligations to maintain the social conditions of the villages: The society in the project areas makes it a rule to contribute villager's labour services to the public works such as cleaning and repairing the village roads, construction of bus shelter and school, cleaning grave yard and borehole and so forth. The total man-days for these services are 4 to 14 days per family per annum. The penalty is levied to the farmers who do not contribute labour services without being sick. An charge of the penalty is one chicken per day.

Labour contribution services in the Mtandamula self-help scheme: Maintenance of the irrigation system in the Mtandamula scheme is made by the farmers themselves. Each farmer annually contributes labour services of about 10 man-days per household for maintenance as follows; (i) 2 days for cleaning protection dike, (ii) 2 days for cleaning the main canal, (iii) four (4) days (December to March) for cleaning the secondary canal and (iv) one day for repairing box culverts. The penalty against absence is applied as same as the above.

Obligation to traditional festivals: It is common that the farmers donate in kind such as maize flour, firewood, water and chicken to the traditional festivals.

Mutual personal aids: A mutual personal assistance is not common in the project areas except ceremonial occasions such as wedding and funeral. The mode of aids is to provide labour services and some money as gift. A mutual assistance among the relatives and the neighbours is likely made to small extent with respect to money, commodity and labour services.

(3) Leadership in the rural area and in family

Organization of village: Local people in the project areas are controlled throughout the traditional authorities system that has a hierarchy of traditional authority (TA), group village headman and village headman. TA and both headmen are hereditary and lifelong. The village headman is selected formally through an electoral process in the traditional village committee, " Kabungwe" when a village headman dies or retires.

Responsibilities and duties of the village headman are (i) to encourage villagers to pay tax, (ii) to organize villagers for the self-help development work, (iii) to arbitrate disputes and conflicts among villagers, (iv) to allocate land and (v) to attend the official meetings.

Administration of the village has only a village headman and messengers comprising one or two called as "Nyakwawa". There is no budget of the village and no salaries for these staff are not paid.

Allocation of lands: In the customary lands, land ownership to the farmers is not permitted in the project areas. The right to cultivate land is inherited. When a cultivator goes away from his/her village, the right to cultivate land is inherited by his/her relatives in reality. In the case that farmers can not afford to cultivate land owing to shortage of labour, such farmers rent lands to another farmers by making an annual mutual trust between farmers without fee and need not to inform the trust to his/her village headman.

In the Mtandamula scheme, the "Land Allocation Committee" has a right to allocate vacant land, if occurred, to the farmers who want to cultivate by an assessment of farmers' capability for farming. In case of renting lands, the farmers should report an annual mutual trust to the land allocation committee and get its approval.

Leadership in family: In matrilineal societies, it is common that the farm income is managed by both wife and husband. An uncle is the overall supervisor of every fundamental matters concerned his nephews and nieces such as their marriage.

(4) Employment of labourer and mode of payment

The farmers in the project areas sometimes employ casual labourers for the farming of maize and rice. The supply of casual labourers is made within the project areas. A seasonal labourer supply from the hill sides is seldom.

The farmers employed casual labourers in the period of land preparation, weeding and harvesting for rice cultivation, and ploughing and weeding for maize. A peak labour requirement occurs in the period of January and February when labour supply is tight and wage of casual labourers soars.

There are three mode of payment to casual labourers in the project areas: (i) monthly based payment, (ii) daily based payment and (iii) piece work based payment. Among them, case of (iii) is common in the project areas. Payment is different depending on kind of crops and kind of farming activities as follows; There is no difference of fee on casual labourer between male and female.

Maize: MK 0.01/one meter for all farming activities

Paddy:

for land preparation, planting and weeding:

monthly base :	MK 4.94/day
daily base:	about MK 5/day
piece work:	MK one/125 m^2

for harvest:

daily base:	MK 3.5/day
maize in kind:	equivalent to MK 3.5/day

for bird control: MK 10 to 20/month

With regard to rent of draft animals, fee is MK 33 to MK 50/0.4 ha

2.13 AGRICULTURAL PRODUCTION

2.13.1 METHOD OF THE AGRICULTURAL SURVEY

The agricultural surveys are performed to identify the present conditions of (i) kinds of crops cultivated, the cropping patterns, farming practices, farm inputs including labour requirement and yield of crops. These surveys are (i) the farmers' interview survey, (ii) rice yield survey in the Mtandamula scheme area conducted by the rice crop cutting in the field and (iii) the rice yield interview survey in the Mtandamula scheme area.

The farmers' interview survey is performed by the same method that is conducted in the socio-economic survey as mentioned in Section 2.12.1. The rice crop cutting survey is conducted for 20 samples for the rice field plots in the Mtandamula scheme area. The samples are taken and analyzed in the laboratory of Lifuwu Rice Research Station. The yield components are analyzed. Also the farming conditions in the 20 plots are interviewed to the farmers. Besides, the rice yield interview survey in the Mtandamula scheme is conducted for 80 farmers selected at random from the 472-farmers of the total number of farmers.

2.13.2 CROPS AND CROPPING PATTERNS

According to the results of the farmers' interview survey, the crops and their cropping areas in the project areas are as shown in **Table 2.12.1**. The main crops are maize and rice. Those two crops occupy about 90 % of the total cultivated lands. Other

crops such as cotton, beans/pulses, millet/sorghum, groundnuts, cassava and tobacco are cultivated to small extent.

Most of the crops are planted at the onset of the wet season. The maize is planted from the beginning of November to the beginning of December and harvested at May and June. There are two kinds of planting method for paddy: one is direct sowing in the rainfed lands and the other is transplanting in the irrigated land. A direct seeding starts at the beginning of November and sowing for transplanting method commences at the beginning of December. Harvesting is performed from the middle of May to the end of June. The staggering period of the planting is about one month in the project areas. In the direct sowing fields, supplementary transplanting is done at 1 to 2 months after sowing for the unestablished places of seedlings.

Though a single cropping of maize or paddy per year prevails in the project areas as a whole, beans and pulses are cultivated in the upper Namikokwe and the lower Nadzipulu project areas to a small extent after harvest of maize and paddy.

2.13.3 FARMING PRACTICES AND LABOUR REQUIREMENT

(1) Farming practices of paddy

The main varieties used in the project areas are Faya which about 75 % of the farmers in the project areas use, followed by Kalonga (14 %), Nkhotakota (8 %), Zuriya (2 %) and Bonnet (one %). Faya variety used has been created by the pure selection of Faya 14-M-69 variety. It is photosensitive and its heading period is March to June. The growth period is about 150 to 155 days. The dosage of seed per ha is estimated to be 60 to 70 kg. About 40 % of seeds are purchased from ADMARC and donated. Fertilization and application of chemicals are not done.

Farming from land preparation to harvest is carried out mostly by the man power. Prior to sowing, ploughing is done in September and October. About 2 % of the farmers perform land preparation by draft animals. Direct seeding is common in the project areas. Transplanting method is found only in the Mtandamula self-help irrigation scheme. Due to low germination and seedling establishment in case of direct seeding, farmers prepare for seedling in the part of the paddy field and transplant seedlings after one month to the paddy field having a low density of seedlings. Nursery is raised in October and November. Seedlings of about one month old are transplanted. Weeding is generally done one or two times. Harvest is carried out by sickle. Hills slashed are kept on the paddy field for one to two weeks for drying. Grains are threshed on mats in the

paddy field and bagged after winnowing. The harvested paddy is stored in the on-farm storage.

(2) Farming practices of maize

The main varieties used in the project areas are local varieties and hybrid varieties such as NSCM-41 and MH-16. The composite maize is not grown. According to the results of the farmers' interview survey, about 60% of the farmers use local varieties, 16 % hybrid varieties and 24% both local/hybrid varieties. The growth period of maize is about 4 to 4.5 months. The dosage of seeds per ha is estimated to be about 60 kg for local varieties and about 50 kg for hybrid varieties. Fertilizers and chemicals is not applied to local varieties. About 24% of the farmers used hybrid varieties or 10% of the total farmers are estimated to apply fertilizers. The dosage of fertilizer per ha is estimated to be about 200 kg. The fertilizers such as urea, CAN and 23:21:0 compound fertilizer are common. Agricultural chemicals are not used.

Farming from land preparation to harvest is also carried out by the man power. Cleaning and ridging work is carried out in September and October. Seeding is conducted in November and December. Fertilization is done for the hybrid varieties during the period between the middle of December and the end of January. Weeding is done during the period between the middle of December and the end of January. Wild animals control such as monkey, cow and hippos is carried out during the period between the middle of January and the end of March. The harvest is carried out by axes, hatchets and/or sickle in May and June.

(3) Labour requirement

Labour requirement for the maize and rice cultivation in the project areas was made clear by the hearing survey carried out for 160 farmers in the project areas, 120 farmers in the Bwanje area, 20 farmers in the Mtandamula irrigation scheme and the farm work survey for 3 farmers in the Mtandamula irrigation scheme.

According to the hearing survey of the 160 farmers in the project area, the maize cultivation needed a labour requirement of about 300 man·day/ha, of which 30% for weeding, 25.8 % for land preparation, 21.8 % for disease and pest control, 12.1 % for harvesting, 5.9 % for sowing and 4.4 % for fertilizer application (**Table 2.12.5**). These labours were mostly covered by the family labours.

The labour requirement for the rice cultivation is 923 man.day/ha for the direct sowing culture and 1,079 man.day/ha for the transplanting culture. The disease and pest control required the highest labour requirement in both the direct sowing and the transplanting culture, which is 332 man.day/ha or 36 % of the total requirement for the direct sowing and 36 % for the transplanting culture. Around 10 % of the total labour requirement depended on the employed labours. In the irrigated transplanting culture in the Mtandamula, a considerably large amount of labour (127 man.day/ha) was required for the transplanting practice as compared with that of the rain fed cultivation. Land preparation by draft animal drastically reduced the labour requirement to be one fifth (21 %) of that by man-power, which freed female labours from the heavy farm works.

The farm work survey for the 3 farmers in the Mtandamula irrigation scheme was carried out for the detailed labour requirement. In general, the farmers in the project areas do not do farming in Sundays. The farmers carry out the farm work for rice such as breaking clods, sowing to nursery bed, puddling and transplanting and weeding even in rainy days. Sowing and weeding for maize are also done even in rainy days. The farm work other than the above is carried out in fine day. The record of working hours mentioned in the above tables does not always indicate the actual working hours for the farm work. During the busy crop season, the farmers spend the time in the field not only for farm work but also for taking meals and so forth. Moreover, the farmers sometimes take a lot of rest because all the farm work should be carried out only by man power. Taking into consideration of the above situations, actual working hours per one cropping season are estimated for maize and rice cultivation. The total working hours are estimated to be 650 hours for maize and 2,100 hours for rice per crop season. Details are shown in **Table 2.13.1** and **Table 2.13.2**.

2.13.4 CROP YIELDS

The past Salima ADD record of the crop yield in the Bwanje valley RDP area including the project areas is shown in **Table 2.13.3**. The yield of maize and paddy in the 1992/93 crop season in the project areas is estimated based on the results of the farmers' interview for 160 farmers in the project areas as shown in **Table 2.13.4**. The yield of paddy under irrigated condition is estimated by the interview survey in the Mtandamula scheme and shown in **Table 2.13.5**.

With the exception of the Mtandamula scheme, all the paddy fields are rain-fed lands. The yield of paddy is liable to climatic conditions and low in general. The results of the farmers' interview survey indicate that the average yield of paddy is 1.15 ton /ha , ranging from a minimum of 0.6 ton/ha to a maximum of 1.54 ton/ha. The Salima ADD

data show the yield of paddy is 1.45 ton/ha in 1992/93 season. The yield of paddy in the Mtandamula scheme is estimated to be 2.72 ton/ha ranging from a maximum of 4.65 tons/ha to a minimum of 0.2 tons/ha.

It is roughly evaluated that the present yield of paddy in the project areas are 1.0 to 1.5 tons/ha in the rain-fed land and about 2.7 ton/ha in the present irrigated lands.

In general, the main causes of such low yield of paddy are considered to be : (i) low quality of paddy seeds, (ii) a poor land levelling of the paddy field , (iii) shortage of irrigation water, (iv) excess water, (v) weed infestation and (vi) crop damages by wild animals such as hippos and birds.

The paddy fields of the project areas are not level. Especially a poor land levelling of the paddy field seems to seriously affect the yield of paddy even in the Mtandamula scheme. A negative effect for paddy yield due to a poor land levelling is checked in the Mtandamula scheme. Because of limited time for the survey, the data of paddy yield obtained from the farmers' interview survey and the rice cutting survey (details are mentioned later) is compared for this purpose. The data of paddy yield are obtained from the same farm plot, covering the whole area of the farm plot for the farmers' interview survey and an area of 3 m^2 for the rice cutting survey, respectively. The sampling site in the farm plot is selected from the site that the yield of paddy among the farm plot seems moderate in the cutting survey. The average yield of paddy in the cutting survey is about one ton/ha higher than that of the interview survey. T-test shows that this difference is significant with 95 % confidence. It can be said roughly that this difference results in the degree of land levelling. Because water supply conditions to the farm in the Mtandamula scheme was good in this crop season and there are no serious damages due to pests and diseases.

The results of the farmers' interview survey shows that the yield of maize in the project areas is 1.24 ton/ha for local varieties and 1.26 tons/ha for hybrid varieties. The difference between them is not found, which may result in the fact that only 24% of the farmers use fertilizer among the hybrid variety-use farmers. The yield of maize in Bwanje valley RDP area is 1.0 ton/ha for local variety and 1.94 ton/ha for hybrid.

It is roughly evaluated that the present yield of maize is about one ton/ha for local varieties and one to two tons/ha for hybrid varieties.

The hybrid variety has a potential yield of over 5 tons/ha. Low level of fertilizer dosage application, however, basically hampers the present yield of maize in the project areas.

The yields of the other main crops per ha are 0.8 ton for cotton, 0.8 ton for pulses, 2.1 tons for sweet potatoes and 2.4 tons for cassava.

2.13.5 A RICE CUTTING SURVEY AND RICE YIELD COMPONENTS

The rice cutting survey was conducted to identify the constraints and problems in irrigated paddy yield in the Mtandamula scheme during the period of 1st and second July. Twenty samples were selected at random. The paddy sample was taken from an area of 3 m^2. The survey method is illustrated in **Figure 2.13.1.** An analysis of the yield rice component was carried out in the laboratory of Lifuwu Rice Research Station.

The results of the survey are shown in **Table 2.13.6.** The average yield is 4.3 tons/ha ranging from 2.7 ton/ha to 6.4 ton/ha. All the paddy sampled are Faya 14-M-69. No application of fertilizers and chemicals is done. It may be considered that relatively high yield of paddy is dependent on high soil fertility, high rate of solar radiation and ideal temperature during the ripening stage of the rice in the Mtandamula scheme area.

The average values of the yield components are as follows;

(i)	number of panicle per m^2	:	136
(ii)	number of spikelets per panicle	:	128.4
(iii)	number of spikelets per m^2	:	17,201
(iv)	percentage of ripened grain	:	87.5 %
(v)	weight of 1,000 ripened grains	:	29 grams

It is noticeable that the percentage of ripened grains is very high. Such a high figure is probably caused by the environmental conditions at the ripening stage of paddy mentioned above.

The relation between yield and yield components is analyzed and shown in **Table 2.13.7.** The yields of paddy are closely related to the number of spikelets per unit area.($r = 0.944$) and the number of spikelets per unit area are strongly affected by the number of panicles per unit area. It may be concluded that an increase of panicles per unit area is basic for increasing paddy yield in the project area.

2.14 FARMERS' VIEW AND EXPECTATION

Farmers' view and expectation of the farmers in the project areas are identified based on the results of the farmers' interview for 160 sample farmers.

2.14.1 INCREASE OF FARM INCOME

Farmers' view and their expectation for increase of farm income in the project areas are summarized in **Table 2.14.1**.

Most of the farmers in the project areas are eager to increase farm income through expansion of the cultivated lands. The farmer respondents in the Mtandamula scheme area desire to expand an area of 0.6 ha of paddy land and an area of 0.5 ha of upland in addition to the present cultivated land. The farmers other than Mtandamula farmers desire additional lands of 0.2 to 0.3 ha of paddy land and 0.5 to 1.0 ha of upland.

100 percent of the Mtandamula farmers' respondents considers that they contribute labour services to the project when implementation of expansion of paddy lands starts. In the other hand, 33 to 48 % of other farmer respondents agree to contribute their labour to the construction of paddy land.

With future land use for the expanded new lands, about 75 % of all the farmer respondents expect to use the land by vegetables such as tomato, cabbage and turnip, followed by rice, maize and other crops such as cotton and groundnuts.

2.14.2 LABOUR SHORTAGE

Farmers' view and their expectation on labour shortage in the project areas are summarized in **Table 2.14.2**.

Fifty to sixty % of the total farmer respondents report that family labour force is not sufficient to perform at the present farming activities. It is considered that there are several countermeasure to solve shortage of labour force for the farming: (i) reducing a scale of the cultivated land, (ii) employment of casual labour, (iii) introducing draft animals, (iv) introducing small agricultural machinery and (v) alleviating house work of the females by construction of boreholes and rice/maize mills and shifting female's labour force to farming activity. The view and expectation for the above countermeasure for solving shortage of labour force is checked upon for the farmer respondents.

Alleviating female's house work by construction of wells for drinking (about 30 % of the total respondents) ranks first among the countermeasure that the farmers expect, followed by employing casual labourer, reducing a scale of cultivated land, introducing draft animals, alleviating female's house work by construction of maize/rice mills and introducing small machinery. There is less than one % of the respondents who expect introducing small machinery to solve shortage of labour force.

The view and expectation, however, is different depending on the type of farmer. The main countermeasure is reducing a scale of the cultivated land for the Mtandamula farmers, alleviating female's house work by construction of wells for drinking and employing causal labourer for MHH farmers not participated to the farmers' club, alleviating female's house work by construction of wells for drinking and reducing a scale of cultivated land for FHH farmers not participated to the farmers' club and employing casual labourer for the farmers participated to the farmers' club.

As a result, it may be concluded that many farmers in the project areas understand that alleviating female's house work is essential for solving shortage of labour force for the farming and most effective countermeasure is construction of wells for drinking.

2.14.3 EXTENSION SERVICES AND CREDIT SERVICES

The view about extension and credit services are shown in **Table 2.14.3.**

About 60 % of the total farmer respondents feel that extension services of the Salima ADD is satisfactory. All the farmers who take part in the farmers' club, however, express to satisfy extension services of the Salima ADD. 50 to 60 % of the farmers who do not participate to the farmers' club feel unsatisfactory to extension services. The above fact suggests that the non-farmers' club farmers do not receive extension services from Salima ADD as the farmers' club members do.

The view for farmers' club is surveyed for the farmer respondents who do not participate to the present farmers' club. The causes why such farmers do not participate the club may be divided into four categories:

(i) farmers' healthy and personal conditions: sick, old, not interesting in farmers' club
(ii) hard conditions of credit services: high interest rate, penalty in case that repayment is outstanding, hard conditions of credit terms

(iii) disapproval of the SACA's concept: concept on fertilizer application, so on and

(iv) shortage of extension activities: lack of farmers' club in villages, no extension workers, so on

The perception of the farmer respondents to the causes is 23 % for item (i), 35 % for item (ii), 12 % for (iii) and 30 % for item (iv).

As to the credit with a short term in the package programme of SACA, it is noticeable that most of the farmers in the Mtandamula scheme area complain credit services as follows;

(i) To receive credit is very difficult due to shortage of SACA's credit fund

(ii) The conditions of the credit are very hard especially repayment condition and

(iii) Relief of repayment of credit is seldom applied in the unexpected natural disaster such as serious drought and floods

Also another farmers with a membership of the farmers' club have complaint as the Mtandamula farmers do.

2.14.4 WELLS FOR DRINKING WATER

The present conditions of the wells for drinking and the farmers' view are shown in **Tables 2.9.1** and **2.12.6.**

Since a density of borehole for drinking water in the project areas is low and one borehole per 290 households or 1,200 peoples, the farmers cannot use a lot of water for daily life. Furthermore, work of fetching water becomes one of the heaviest work for females.

According to the results of the farmers' interview survey, the farmers in the project areas expect one borehole per one village at least and want to increase daily quantity of water from one bucket (20 litters) used at present to 2 buckets (40 litters) in the future. The farmers who use water sources for the lake and shallow wells, encounter problems of water with respect to water quality and quantity of water and strongly expect to obtain stable drinking water with good quality by construction of boreholes.

2.14.5 MILLING FACILITIES

The present condition of milling facilities and the farmers' view are shown in **Tables 2.9.1** and **2.12.7.** All the farmers in the project areas have a great desire of one mill for maize and one for rice per one village.

2.14.6 ROADS

The road conditions in the project areas are surveyed from social viewpoints such as (i) a distance from farmers' home to main social infrastructures, (ii) condition of the road in the wet season and (iii) farmers' expectation to repairing road facilities. The results are summarized in **Table 2.14.4.**

The table indicates that the distance to the main social infrastructures are very far. The average distance from the farmers' house is 4.3 to 8.9 km to ADMARC marketing centre, 2.3 to 3.7 km to school, 3.2 to 9.4 km to shopping centre, 6 to 11.3 km to hospital, 0.6 to 1.6 km to wells for drinking and 1.4 to 1.6 km to the field, respectively.

The farmers in the project areas except the Lower Livulezi project area feel that road conditions in the wet season are very bad or bad.

About 80 % of the farmers give the highest priority of repairing for the village and farm roads.

2.14.7 CONTRIBUTION OF FARMERS' LABOUR FORCE AND COLLECTION OF WATER CHARGE AFTER IMPLEMENTATION OF THE PROJECT

In the interview surveys for the farmers, and group village headmen and village headmen, the view for the farmers' participatory approach to the project during and after implementation of the project is investigated. The results of the survey are shown in **Tables 2.12.4** and **2.14.1.**

Since the farmer respondents in the Mtandamula scheme area fully understand that the irrigation project will bring about a great benefit to the farmers accrued from increase of rice production, 100 % of the respondents report that they willingly contribute their labour force to the construction of the irrigation systems as well as to maintenance of the systems. About 40 % of the farmers other than the Mtandamula farmers express to contribute their labour to the project. It seems that these 40 % -

farmers have seen the Mtandamula self-help irrigation scheme and known the higher yield of paddy there.

All the group village headmen and village headmen who are interviewed have seen the Mtandamula scheme. All headmen express that the farmers in their villages will contribute labour force to the project.

All the headmen considered that management of the irrigation system should be carried out by Salima ADD at initial stage and by farmers' association in and after full stage.

All the headmen express that they will pay water charge in the form of in kind for operation and maintenance of the irrigation system in addition to contribution of labour force to the project.

2.15 AGRICULTURAL SUPPORT SYSTEM AND FARMERS' ASSOCIATION

2.15.1 AGRICULTURAL SUPPORT SYSTEM

(l) Extension Services in Bwanje Valley RDP

Extension work is the channel to transfer new technologies from adaptive research work to farmers. Administratively, extension work in Malawi is performed through the eight (8) ADDs under DAET, MOA. The project areas is covered by extension network by Bwanje Valley RDP under the control of Salima ADD. Bwanje Valley RDP is divided into six (6) EPAs, which are further divided into 46 Sections. Field Assistant plays the extension work in each Section. Mtakataka EPA covers the five project areas except for Lower Livulezi area which is under Golomoti EPA.

Staff members for extension activities are headed by Project Officer, who are followed by Assistant Project Officer and Subject Matter Specialist in RDP, and Development Officer, Assistant Development Officer and Subject Matter Specialist in EPA, and Field Assistants (FAs, extension workers) in Section. Number of Field Assistants in Bwanje Valley RDP is 43.

The main extension activities in Bwanje Valley RDP are (i) field demonstration of new technology, (ii) field visit by FAs, (iii) film show, (iv) annual agricultural show and (v) monthly meeting and block meeting. Major constraints against extension work are lack of trained staff, shortage of budget and shortage of transportation means for Field

Assistants. As has been stated on the farmers' view about extension services in the project areas, therefore, all the farmers who take part in the farmers' club express ~o satisfy extension services of the Bwanje Valley RDP, but 50 to 60 % of the farmers who do not participate to the farmers' club feel unsatisfactory to extension services.

(2) Credit services in Bwanje Valley RDP

The farm credit under SACA is available through farmers' clubs. According to the credit application from farmers' club are assessed by the Loan Committee in every EPA, of which members comprise chairman seconded by DO, Credit/Marketing Assistant as secretary, Field Assistant and at least two farmer representatives.

The interest rate is 18 % per annum for short term and 20 % for the medium term. Both loans are provided to farmers in kind through the form of approved credit packages. It is estimated that about 20 % of farmers obtain both credits in the project areas.

The amounts of farm inputs released by Salima ADD in 1992/93 are presented in **Table 3.14.6** of Annex I. Amounts of fertilizer used in Bwanje Valley RDP are 1,516 tons and 88% of the amounts are supplied by the short term credit. Amounts of seeds of maize and paddy used in Bwanje Valley RDP are about 80 tons and 2,541 tons, and 82% and 98% of the amounts are supplied by the short term credit, respectively. The recovery rate has exceeded 85% except the recent two years of 1990/91 and 1991/92 due to crop damages caused by the drought.

According to the 160 farmers' interview survey, most of the farmers in the project areas complain high interest rate and severe repayment condition. The major reasons are hard conditions of credit services, followed by farmers' healthy and personal conditions, shortage of extension activities and disapproval of the SACA's concept.

2.15.2 FARMERS' ASSOCIATION

(l) Farmers' club

Farmers' club is a spontaneous farmers' association having no legal basis, however, is traditionally recognized as development body. It has played an important role in a parent receiver of agricultural credit from SACA and a unit to manage resources in local community and to conserve its catchment area. There are two types of the farmers' club, mixed farmers' club and women's club.

According to the farmers' interview survey, membership rate of mixed farmers' club and women's club for total households in each project area is 13 % and 9 % of 530 households in the Lower Nadzipulu project area, 49 % and 20 % of 854 households in the Lower Namikokwe project area and the Mtandamula scheme area, 20 % and 13 % of 948 households in the Upper Namikokwe project area, 21 % and 7 % of 1,452 households in the Lower Livulezi project area.

(2) Mtandamula Farmers' Irrigation Scheme Committee

There is only farmers' irrigation scheme in the project area, Mtandamula scheme. The committee is organized by 480 smallholders for the eight villages around the scheme. The scheme committee is composed of four sub-committees such as land allocation, scheme management, block and farmers' club. land allocation committee. The committee is represented by one chairman, one secretary and eight committee members. The committees except for Land Allocation Committee is organized by one chairman, one vice chairman, one secretary, one vice secretary, one treasurer and four committee members.

The Land Allocation Committee has a right to allocate vacant land to the farmers who want to cultivate by an assessment of farmers' capability for farming. In the case that farmers can not afford to cultivate land owing to shortage of labor, the farmers should report an annual trust to the Land Allocation Committee and get its approval.

O&M of the irrigation system is carried out by the farmers themselves under the control of the Scheme Management Committee. Each farmer annually contributes labor services of about 10 man-days per household to O&M of the irrigation system.

3. PROSPECTIVE DEVELOPMENT PLAN

3.1 BASIC CONCEPT

3.1.1 DEVELOPMENT NEEDS

(1) Needs of irrigation development

The study area is one of the most rainless area in Malawi. The average rainfall is 980 mm. There is a considerable variation of annual rainfall . Ninety-nine % of the annual rainfall falls in the wet season from November to April and are erratic, which becomes one of the most important factors to hinder an agricultural development in the area in spite of the favourable climatic conditions such as high solar radiation, fine wind speed, and so forth.

The Nadzipulu, Namikokwe, and Livulezi river can afford to supply irrigation water to arable lands in the study area. The certain amount of water flows down these rivers and the high potentiality of irrigation farming exists in the area. However, no irrigation activity except for that in the existing Mtandamula self-help irrigation scheme is carried out without any effective use of the water resources of these rivers. Even in the Mtandamula scheme, the diversion water from the Namikokwe river is unsteady since only the flood water has been used for irrigation by free-intake method.

The effective use of the water resources of the rivers for irrigation development, is essential and has been desired for the regional development and the improvement of social welfare in the study area.

(2) Needs of agricultural development

The yields of the main crops in the study area are low. The yield of maize is 1.1 to 1.5 ton /ha for local varieties and 1 to 2 ton/ha for hybrid varieties. The yield of paddy is 1 ton/ha for the rainfed paddy and 2.7 ton/ha in the Mtandamula irrigation scheme. The main constraints which cause the low crops yield are:

(1) limited use of improved varieties and farm input,
(ii) water shortage during the cropping season,
(iii) poor drainage condition,
(iv) poor land levelling of the paddy field, and
(v) damages by birds and hippos.

The above phenomena are led by the lack of modern farming technique and invest. From agricultural development points of view, the introduction of the improved farming technique is vital to solve the above constraints and to increase crop yields consequently. For this purpose, an institutional support including research works, demonstration activities, and training of the governmental staff and key farmers, is needed.

(3) Needs of improvement of social infrastructure

Social infrastructure around the villages in the study area are very poor. The study area have a favourable position to link the main national roads of M-17 and M-18 which play an important role in passenger and commodity flow within the inter-regional traffic. The roads connecting the inside of the study area and the national roads are short in length and all unpaved and only jeepable during the dry season. For enhancement of the regional economy as well as the improvement of public welfare in the study area, the consolidation of the rural road networks is urgently needed. The road networks including the routes of road connecting the proposed irrigation project sites to the national roads will well support the irrigation/agricultural development in smooth operation and maintenance of the projects, transportation of farm inputs, and activation of crop marketing.

The work load of women in the study area are very heavy not only in the farm work but also in the house work. Among the house work, fetching drinking water work is most important and heavy. A woman fetches drinking water 3.6 times a day per household and spends two (2) hours a day for this work. A distance to water sites averages 1 km, ranging form 0.3 km to 1.4 km. This house work becomes serious especially for female headed households with small labour to cultivate a proper scale of the farm land. Under this condition, the income of the female headed households is generally lower than that of the others. Moreover, milling of maize and rice is also serious work for female. For improvement of the above situation and consequent increasing of income of the female headed households, the construction of village water supply systems with deep-boreholes and pumping equipment, and mills is desired.

3.1.2 THE BASIC CONCEPT AND STRATEGY FOR THE DEVELOPMENT

The overall objectives of the Project are to generate more farm income and improve social welfare in the development areas. The basic concepts of the Project are:

(i) Maximum exploitation of land and water resources for irrigation purposes,

(ii) Enhancement of crop yields by the introduction of improved farming techniques,
(iii) Strengthening the supporting organization for irrigation and agricultural development, and
(iv) Improvement of primary rural infrastructure.

The stable discharge of the relevant rivers will be fully utilized for irrigation water supply with much attention being paid to river morphological conditions, i.e. high susceptibility to river course change and enormous sediment loads during the flood season.

In view of the high demand for rice on the domestic market, irrigated paddy will be a main crop grown in the development areas. Crops with a low water requirement other than paddy, such as maize, beans, and vegetables will be sown immediately after harvesting the paddy and grown by utilizing supplemental irrigation supply, i.e. rainfall and the remaining soil moisture.

The crop productivity can be enhanced not only by irrigation water supply but also through improved farm inputs and practices. All the technical possibilities were taken into account for increasing crop production. The introduction of improved farming techniques is essential to increase crop yields. For this purpose, institutional support should be strengthened, particularly in: (i) research and demonstration work and (ii) training of the government staff and key farmers. Such support will be organized and systematically promoted by the proposed core body for the Project.

The Study emphasizes the rationalized use of human resources to ensure adequate development of the regional economy. Improvement of primary rural infrastructure was strategically incorporated in the Project with a specific objective. Rural infrastructure development is planned to ensure adequate allocation of the work force directly to farming activities. The components concerned are (i) boreholes, (ii) rice mills, and (iii) rural roads. The installation of more boreholes and the introduction of rice mills will mitigate work load of farmers' daily housework, i.e. fetching water and pounding unhusked paddy. With these components, farmers will be able to allocate more working hours to the farm. Improvement of rural access is another central issue in rural infrastructure development. Expansion of the rural road network is envisaged to ensure the smooth operation of the irrigation and agricultural activities.

3.2 AGRICULTURAL DEVELOPMENT PLAN

3.2.1 PROPOSED LAND USE

The development areas will be administrated under the jurisdiction of Kachindamoto TA as it is. Under the Project, the land use intensity of the project areas will be drastically changed. Suitable land within the project areas will be developed for irrigation purposes with the following principles.

(i) All the existing rainfed paddy field and upland fields located within the project areas will be changed to irrigated paddy fields.
(ii) In addition, suitable land which is currently covered by natural vegetation will become irrigated paddy fields.
(iii) Part of the project areas will be occupied by the project works such as canals, rural road networks, and other farming facilities.

The future land use of the development areas in the 3 river basins is shown below:

River basins	wet season	dry season	
	Irrigated Paddy	Irrigated maize	Irrigated vegetables
Nadzipulu			
the Lower Nadzipulu area	250	205	19
Namikokwe			
the Upper Namikokwe area	570	80	43
the Mtandamula area	230	106	17
the Lower Namikokwe area	160	111	12
Livulezi			
the Lower Livulezi area	520	200	39

3.2.2 CROP AND VARIETY SELECTION

(1) Crop selection

The main crops for the Project was selected taking account of the following conditions:

(i) Plant physiological suitability for local climatic conditions and soil conditions
(ii) Marketability and profitability of crops
(iii) Yield response by Irrigation water supply
(iv) Farmers' familiarity with crops cultivation
(v) Farm labour requirement and availability of workforce in and around the project areas
(vi) Easy storing and processing

Several crop alternatives can be conceived for the main crop season such as paddy, maize, cotton, beans, and vegetables. The Study selected paddy as main crop for the Project due to the following reasons.

The natural conditions of the project area are highly suitable for irrigated rice. Though the other crops can be grown, poor drainage conditions of the project areas will not allow their proper growth during the wet season. Rice is the marketable and profitable among crop alternatives.

The most crucial condition of second crops is short growth period, when the double cropping is introduced under the Project. Due to limitation of water resources in the dry season, early matured crops are more advantageous in terms of stabilized crop yield. In fact, beans of growth period less than 90 days are currently grown in the dry season in and around the project areas. The Study proposes use of early matured maize with the growth period of 90 days and vegetables such as tomato, cabbage, onion and so forth.

(2) Variety selection

To enhance productivity and cropping intensity under the Project, the Study discussed the introduction of new rice varieties. Suitable rice varieties for the Project will have the following variety characteristics.

(i) High tolerance to pests and disease
(ii) Stable and reasonable yielding capacity without application of fertilizers
(iii) Early matured with growth period shorter than 120 days
(iv) None or weak photoperiodic sensitivity (photo-sensitivity)

In view of environmental conservation, firstly, use of agro-chemicals should be avoided as much as possible. High tolerance against pests and diseases is essential variety characteristic. High yielding varieties are generally of higher fertilizer response.

More nitrogen is applied, more yield is obtained. Availability of fertilizers, however, is not ascertained under the current conditions of SACA. Secondly, therefore, the priority is attached to reasonable yielding capacity even with little input of fertilizers.

The introduction of early matured varieties will contribute to stabilize crop productivity of a second crop. Faya, which has a growth period of 150-day, is generally planted in December and harvested in May. Assumed with early matured varieties with a growth period shorter than 120 days, rice harvesting could be completed by the end of April. This shortened growth would allow to sow the second crops one month earlier. Since varieties with photo-sensitivity will be planted to adjust its heading stage to a period from the end of March to June. None or weak photo-sensitivity is a prerequisite when an attempt is to be made for shifting crop season and early harvesting.

3.2.3 PROPOSED CROPPING PATTERN

An advantage is recognized in introduction of rice varieties with the above-mentioned characteristics. However, it might be less appropriate to introduce those varieties without research data in variety selection under the local conditions. Therefore, the Study proposes use of Faya for years.

The framework of the cropping pattern of paddy in the wet season was determined by taking account of the following conditions.

(i) The harvest time should avoid the wettest period.
(ii) Photosensitive characteristics of Faya varieties (heading period is from the end of March to June).
(iii) The calendar is designed so as to benefit from sunny weather in the critical growth periods in terms of sunlight requirement as much as possible. The critical growth period is from about 15 days before heading to about 25 days after heading.
(iv) Available rainfall and river discharges are fully utilised.

The growth period of paddy is about 150 days and the staggering period is set at 1 month. Planting is from December to January and harvesting is from May to June.

For determination of the dry season crop, a comparative study was carried out on the following alternatives:

Alternative - 1 : Maize having a growth period of 90 days and vegetables with a short growth period and

Alternative - 2 : Maize having a growth period of 130 days and vegetables which are presently used in the development areas.

The alternative cropping patterns were evaluated by means of a water balance study in the dry season using the available water and crop water consumption in order to estimate the possible irrigation area of each alternative cropping pattern. The results of the comparative study are indicated below:

River Basin	Alternative - 1	Alternative - 2
Nadzipulu	224 ha	0
Namikokwe	123 ha	0
Livulezi	239 ha	60 ha
Total	589 ha	60 ha

As mentioned in the above table, only a few areas can be irrigated in the case of alternative - 2 since the available water in the dry season is limited. The most crucial condition for dry season crops is the short growth period when the double cropping is introduced for irrigation development. Early maturing crops are more advantageous in terms of stabilized crop yields. Use of early maturing maize and vegetables that have a less than 90 days growth period is proposed. In accordance with the results of the comparative study, alternative - 1 will be employed as the proposed cropping pattern in the dry season.

Vegetables comprise cabbages, onions, tomatoes and so forth. The proposed varieties of vegetables would be Giant Drumhead, Sugarloaf and Chago for cabbages, Early Texas Grano, De Eildt, and Red Creole for onions, and Money Maker, Marglobe, and Roma VF for tomatoes. It is necessary to confirm the adaptability of these varieties to the development areas.

The proposed cropping pattern is illustrated in **Figure 3.2.1.**

3.2.4 PROPOSED FARMING PRACTICES FOR PADDY

(1) Prospect of farm mechanization

Mechanized farming in Malawi is practiced in some estate farms, but is seldom carried out in the smallholder farms at present. The possibility of the introduction of mechanized farming into the project areas has been checked. The following conditions are a prerequisite to introducing mechanized farming into the project areas.

(i) The mechanized farming should be beneficial and profitable in financial management from the following viewpoints.
- an increase of crop yield and gross income can be expected by mechanized (increasing land productivity)
- an gross income can be expected by enlarging a scale of the cultivated lands by mechanization
- reducing labour requirement for paddy cultivation by mechanization in the case that farmers have an opportunity to earn higher farm income from the intensive and profitable farming such as vegetables and horticulture
- reducing labour requirement for farming by mechanization in the case that farmers have an opportunity to earn higher non-farm income except farming and
- an mechanized farming is cheaper than a labour intensive farming with respect to operation cost

(ii) The farm machinery is able to be properly maintained after the introduction of machinery in the following viewpoints
- a supply of spare parts of the machinery be reliable
- trained staff and equipment necessary for workshop be available
- a supply oil and fuel be properly obtained
- daily and periodical check for the machinery be available

(iii) There should be suitable organization to use and manage the machinery effectively and properly

Increasing land productivity in the project areas is not expected by the use of mechanized farming. Most of the lands in the project areas are cultivated and allocated to the farmers. Thus, enlargement of the land to be cultivated will not be expected. Moreover, there is no industry to provide an opportunity for the farmers to earn higher

non-farm incomes. With respect to the operation cost for land preparation, a comparative study was carried out which compared mechanized farming equipment, a 50 PS tractor, and rotary cultivator, and draft animals. The operation cost per 0.4 ha or one acre was calculated at MK 225 for mechanized farming and MK 50 for farming by draft animals. The higher operation cost of mechanized farming is dependent upon the expensive cost price of the machinery, high cost of fuel and oil and higher interest rate. Basically labour is cheap in the project areas.

(2) Farming practices for paddy

Standard farming practices for paddy will be started on 1st December and completed on 30th June.

(i) Land preparation

The farming practices for irrigated paddy is to be initiated by impounding water, by which standing water will be raised up to 15 cm. After three days after impounding, land preparation will be practiced by either manpower with hoe or draft animals. For early planting, rotational grouping system is to be applied for land preparation.

(ii) Nursery preparation

Farmers will prepare their own nurseries within their paddy plots. Nursery beds with an area of 500 m^2 for one ha of a main field ha will be prepared manually and sown at the rate of 64g/m^2. Therefore, seed requirement is not less than 32 kg/ha. Taking damage during storing and impurity of seeds into consideration, it is recommended to store 60 kg of seeds for next crop season.

(iii) Transplanting

After keeping seedlings on nursery for 20 days, seedlings will be transplanted at the rate of 2 or 3 seedling per hill. Planting density will be about 25 hill per m^2 to ensure high tiller numbers.

(iv) Fertilizer application

Nitrogen and phosphate will be applied at the rates of 80 kg/ha and 25 kg/ha in forms of urea (42% N) and TSP (46% P_2O_5), of which application amounts are

190 kg/ha and 54 kg/ha. As a basal dosage, 20 kg-N and 25 kg-P_2O_5 per ha will be applied at the time of five days before transplanting. Top dressing with 30 kg-N will be given twice at about 15 days after transplanting (6th leaf stage) and at late spikelet initiation stage.

(v) Field maintenance

Weeding is the main practice after 6th leaf stage. Weeding will be manually done several times. Damaged hills will also be eliminated to prevent out-break of pest and disease. Water level will be maintained at 7.5 cm in depth after transplanting.

(vi) Harvesting

Before harvesting, the paddy field will be drained and dried out for three weeks. Harvesting will be made manually with sickle. Hills cut will be left on paddy fields and dried for one to two weeks until moisture content of 14%. Threshing, winnowing and bagging will also be practiced manually.

3.2.5 ANTICIPATED YIELD AND PRODUCTION

After completion of the Project, the crop yields will be stabilized and increased by flood protection and stable irrigation water supply with improved farming practices under the institutional measures. The future crop yields are targeted to be 4.5 ton/ha for paddy 2 ton/ha for maize and 10 tons/ha for vegetables under the with-project conditions. The crop production will increase gradually during build-up period of three (3) years after completion of construction. The production under with- and without-project conditions are estimated below.

Unit: ton

	Name of Project	With-Project			Without-Project	
		Rice (Faya)	Maize	Vegetables	Rice (Faya)	Maize
1.	Lower Nadzipulu Irrigation Project	1,130	220	190	0	80
2.	Namikokwe river basin Irrigation Project	4,320	120	720	980	260
	- Upper Namikokwe Irrigation Project	(2,565)	-	-	(360)	(150)
	- Existing Mtandamula scheme	(1,035)	-	-	(620)	(0)
	- Lower Namikokwe Irrigation Project	(720)	-	-	(0)	(110)
3.	Lower Livulezi Irrigation Project	2,340	240	390	290	0
	Total*	7,790	580	1,300	1,270	340

3.2.6 FARM INPUTS

In association with the project activities, farm inputs supply is expected to be encouraged. The main inputs concerned and their standard application rates are:

Unit: kg/ha

Crop	Seed	Urea (46%N)	TSP (46% P_2O_5)
(1) Irrigated paddy	40	190	54
(2) Irrigated maize	25	-	-

The total farm input requirement by project is presented below.

Unit: ton

	Name of Project	Irrigated Area	Paddy Seed	Maize Seed	Urea	TSP
1.	Lower Nadzipulu Irrigation Project	250	10.0	2.8	47.5	13.5
2.	Upper Namikokwe Irrigation Project	570	22.8	(1.5)*	98.8	30.8
3.	*Mtandamula Scheme Rehabilitation*	230	9.2	*	43.7	12.4
4.	Lower Namikokwe Irrigation Project	160	6.4	*	30.4	8.6
5.	Lower Livulezi Irrigation Project	520	20.8	3.0	98.8	28.1
	Total	1,730	69.2	7.3	319.2	93.4

Remark: * 1.5 tons for upper and the lower Namikokwe and Mtandamula scheme

3.2.7 LABOUR REQUIREMENT

The farm labour balance was analyzed for a typical farmer under both the with- and without project (present) conditions. The analysis aims to clarify whether an average farmer would be able to cultivate his farmland without a serious labour shortage. Under the Project, 0.4 ha of irrigated plot will be allocated to each household. Since most of households will plant rainfed maize in the wet season outside the project area even after the Project, the analysis was conducted to prove that the overall labour balance in the households was based on the labour requirement for the cultivation of rainfed maize.

Unit rates applied to this analysis are set up according to the results of the interview survey in the Phase II study. The details are described in Sections 2.12 and 2.13.3 of this Annex II. The average farm family size is 4.1 persons per household, of which 2.45 persons are expected to be available for farming. The average smallholder manages the farm land of 1.23 ha, of which 0.38 ha is irrigated or rainfed paddy field and 0.85 ha is rainfed upland fields for maize, cotton, beans and other cereals. Taking

those rates into consideration, the farm management conditions of the typical farmer were set up for both with- and without project conditions.

	Item	With Project	Without Project
1.	Farm size (ha)		
	- Irrigated paddy (wet season)	0.40	-
	- Rainfed paddy (wet season)	-	0.40
	- Irrigated maize (dry season)*	0.03	-
	- Irrigated vegetables	0.03	-
	- Rainfed maize (wet season)	0.86	0.86
2.	Unit labour requirement (man-hours/ha)		
	- Irrigated paddy (wet season)	6,460	-
	- Rainfed paddy (wet season)	-	5,930
	- Irrigated maize (dry season)	650	-
	- Irrigated vegetables	2,920	-
	- Rainfed maize (wet season)	650	650
3.	Main power for farming practices	Manual (without animal)	Manual (without animal)
4.	Available farm labour force per family		
	- Working member (persons/household)	2.45	2.45
	- Available labour force per year (man-hr) (2.45 persons x 10 hrs x 365 days x 0.8)	7,150	7,150

Remark: * Planted area of irrigated maize in dry season, 0.06 ha, was estimated referring to irrigated areas in wet season (800 ha) and dry season (123 ha) in the Namikokwe scheme, i.e. irrigated area in dry season is to be 15% of the scheme area.

Large increase of labour requirement is not appropriate in the project areas. In addition to the prevailing farming practices, only fertilization (30 man-hours/ha) and O&M work for irrigation canals (500 man-hours/ha) are taken into account.

It should be noted that farmers generally spend over 10 hours a day in his farmland during high season. The labour requirement in the table include all the time consumption for moving between his house and farm land, cooking in the filed, and parts of housework as describe in Section 3.1.3 of Annex I. Therefore his actual working hours are estimated to be as low as 7 hours.

The labour balance was calculated as difference between availability of farm labour per households and farm labour requirement obtained from direct interview to farmers. The analysis was made on 5-day basis. The results of analysis is presented in **Table 3.2.1** and summarized as follows.

(i) Without Project Conditions

- Total labour requirement will be sustained at 3,015 man-hours per year at the present level giving the overall average daily working hours of 4.21 hours per person, excluding Sundays, throughout the year.
- The peak labour requirement appears in October when ploughing for paddy and clearing for maize are practices. Since the farmers start ploughing in September and completed by end October, actual labour shortage would not occur.
- Another peak appears at end June when harvesting paddy and threshing, winnowing and storing of paddy are operated. In the actual conditions, however, the farmers avoid the shortage by elongating post-harvest practices.

(ii) With Project Condition

- The total labour requirement will be increased to 3,266 man-hours per year from 3,015 at the present level.
- To mitigate a serious labour requirement, rainfed maize should be sown a half month earlier before the puddling and transplanting of paddy start.
- The peak labour requirement is in December when transplanting of paddy and weeding for maize carried out with a labour shortage of 72 man-hours (about 10 man-days). These shortage would be made up by hired labour for the time being. This results imply the needs for improvement of farming practices for labour saving with more use of draft animals.

3.2.8 *POST HARVEST*

In order to increase value-added of rice produced under the projects, sets of post harvest facilities will be provided in each irrigation project. The set of facilities comprises a rice mill equipment of 1.0 ton/hour capacity, a mill house and a storage of 50 m2 in total, and a dry yard of 400 m^2. The details of the required sets of post harvest facilities for 3 irrigation projects are described in **Table 3.2.2** and summarized below:

The Lower Nadzipulu Irrigation Project	2 sets
The Upper Namikokwe Integrated Irrigation Project	5 sets
The Lower Livulezi Irrigation Project	3 sets

3.3 IRRIGATION AND DRAINAGE DEVELOPMENT PLAN

3.3.1 BASIC CONCEPTS FOR IRRIGATION AND DRAINAGE PLAN

(1) Water Resources and Irrigation Method

Anticipated water resources for the irrigation and drainage development in the study area are:

(i) Water from the Lake Malawi,
(ii) Ground water,
(iii) Natural river flow, and
(iv) Regulated water by construction of the dam and reservoir.

There is huge amount of water in Lake Malawi and the ground water cultivated by the lake are nominated as the main water sources for the development. However, the usage of both the water resources is restricted in terms of a intake method of irrigation water from the sources. The physical limitations in the use of water in Lake Malawi and ground water are as follows:

(Lake Malawi)
- Since there is no reservoir pocket exist near the lake, water pumped from the lake can not be regulated. Therefore, the irrigation operation activities will be restrict in the day time as the existing Lifuwu Irrigation Project.
- The study area slopes down to the lake Malawi with an average land gradient of 1/300. The pipeline system will be required for irrigation and irrigation area.
- The operation cost for pumping facilities and pipe line will be higher than that of facilities for gravity irrigation system.
- It is very hard to purchase the spareparts for the large scale pumping equipment in Malawi.

(Groundwater)
- The water availability is restricted in terms of quantity of water for one borehole and pumping unit. The existing Ngolowindo Irrigation Project serves the

irrigation water to only 15 ha of land by one (1) pumping unit with regulating pond.

- Continuous irrigation method will not be suitable for pumping up the ground water. Therefore, several artificial ponds will be required and the high initial investment will be required.
- Frequent repairing and overhauling of the pump equipment will be required and the maintenance of borehole is also frequently needed.
- Uncertainty in terms of quantity of ground water .

As mentioned above, the lake water and the ground water are inconvenient as the main water source for the irrigation and drainage development.

As for the water regulated by construction of a dam and a reservoir, selection of possible dam sites were carried out based on the topographic maps of 1/50,000. Topographically, there are no good sites of a reservoir with a huge effective storage capacity in all the rivers in the study area. Possible dam sites, however, is available in the upper basins of the Nadzipulu and Livulezi rivers. There is no possible dam sites in the Namikokwe and Bwanje river basins.

A possible dam site on the Nadzipulu river is located near Chilasamongo village on the Mwachikula river, a tributary of the Nadzipulu river, and has a catchment area of about 45 km^2. The possible reservoir capacity is estimated at 25 million m^3. A dam site on the Livulezi river is located near Thondoya village and has a catchment area of about 320 km^2. The possible reservoir capacity is 12 million m^3.

However, there are constraints with the design and construction of these dams on the above rivers as follows:

- There are villages in the reservoir areas of the dams.
- It is reported that an average sediment transportation rate is more than 0.4 kg/m^3. The considerable dead capacity of the dams should be designed and the effective storage capacity of the dams becomes smaller.
- The work volume of dam embankment, in case of dam construction on the Livulezi river, is estimated more than 500,000 m^3 and the direct constriction cost of the dam is roughly estimated at more than one billion Japanese Yen. This construction cost is very expensive, which leads low economic viability compared with irrigation benefits accrued form the beneficial area.

According to the above, water regulated by with the dam and the reservoir is also not prospective for the irrigation and drainage development in the study area.

Under the above condition, the gravity water of the rivers without any regulation will be only the suitable water source for irrigation and drainage development in the study area. The use of natural river flow under gravity irrigation system has also some limitations because of the large seasonal variation in flow water discharge between the wet and the dry season.

There are 4 major rivers in the study area, namely the Nadzipulu, Namikokwe, Livulezi, and Bwanje rivers. Of them, the river water flow of the Bwanje river is far less stable; a huge flood discharge in the wet season and few water in the dry season. The river course is unstable and liable due to annual flood. Moreover, no hydrological record and no study results on the river runoff mechanism. From the view point of safety operation and maintenance of the irrigation facilities as well as efficiency of the initial investment, the Bwanje river is ommitted from the proposed water source for the irrigation development.

The basic concepts for the irrigation and drainage development from the view points of water resources and irrigation method are, therefore, as follows.

(i) to employ the gravity water of the natural river flow and
(ii) to employ the three (3) rivers: the Nadzipulu, the Namikokwe, and the Livulezi, as the main water source.

(2) Delineation of the Project Area

The delineation of the irrigation project area in each river basin was carried out on the following 4 steps:

Step 1: to assess land resources in view of irrigation farming and delineate suitable lands for irrigation development,
Step 2: to assess water resources in the study area and identify the maximum potential area for irrigation development on the basis of water balance study
Step 3: to delineate the irrigation development areas by preliminary design using existing topographic maps on a scale of 1/50,000 and

Step 4: to delineate the project irrigation area by the preliminary design of irrigation and drainage system using topographic maps on a scale of 1/5,000 which were prepared in December 1992 by JICA.

In the Step-1, the land resources were evaluated. The details of this land evaluation are explained in section 3.3, Annex I. The results indicate that 47,500 ha of land is suitable for paddy cultivation and 71,800 ha is suitable for upland crops in the study area.

In the Step-2, water resources in the 3 rivers was assessed. The river flow discharge in 1969/70, a 5-year return period or the design year, is set as water sources for the irrigation development. The water balance study in the 3 rivers was carried out using the available water and irrigation water demand calculated based on the proposed crops. The maximum potential areas for the irrigation development was assessed by the water balance study. The maximum areas are 1,658 ha for the Nadzipulu river basin, 1,104 ha for the Namikokwe river basin and 946 ha for the Livulezi river basin.

In the Step-3, the preliminary design of the irrigation and drainage system for each irrigation project was carried out using the topographic maps on a scale of 1/50,000 and study results of the previous steps. The development areas were preliminarily identified as follows:

(i) The Nadzipulu River Basin
- The Lower Nadzipulu Irrigation Project (270 ha)

(ii) The Namikokwe River Basin
- The Upper Namikokwe Irrigation Project (290 ha)
- The Mtandamula Rehabilitation Project (230 ha)
- The Lower Namikokwe Irrigation Project (650 ha)

(iii) The Livulezi River Basin
-The Lower Livulezi Irrigation Project (750ha)

In the Step-4, the delineation of the above irrigation project areas was finalized by the preliminary design of the irrigation and drainage system including alternative plans using the topographic maps of 1/5,000 taking into consideration topographic conditions, detailed soil survey results, hydrological study results, and the study results of the previous steps.

The results of the delineation of the project area are summarized below and detailed discussions are made in hereinafter.

	Step-2 maximum potential area	Step-3 preliminarily delineated project area	Step-4 final delineated project area
	(ha)	(ha)	(ha)
The Nadzipulu River Basin	1,658	(270)	(250)
The Lower Nadzipulu Irrigation Project		270	250
The Namikokwe River Basin	1,104	(1,170)	(960)
The Upper Namikokwe Irrigation Project		650	570
The Mtandamula Rehabilitation Project		230	230
The Lower Namikokwe Irrigation project		290	160
The Integrated Irrigation project -1			800
The Integrated Irrigation Project-2			730
The Integrated Irrigation Project-3			960
The Livulezi River Basin	946	(750)	(520)
The Lower Livulezi Irri. Project (Alternative-1)			520
The Lower Livulezi Irri. Project (Alternative-2)			360

Note: (-) ; total area in the basin

(3) Basic concepts for irrigation and drainage planning

The results of field surveys and the inspection of the existing irrigation schemes in Salima ADD reveal the following crucial points to be solved for future planning and designing the irrigation and drainage system.

(i) Gravity water from the rivers is the sole water source for the projects.
(ii) Available water is restricted.
(iii) The project areas mainly lie in the flood plains.
(iv) The heavy siltation and consequent river meandering due to floods occur.
(v) Modern irrigation farming is not familiar with the farmers in the project areas.

Analyses of the above crucial points in the project area lead the following basic concepts for planning and designing of the irrigation and drainage systems in the areas.

(i) to use the restricted water effectively for maximizing the irrigation area,

(ii) to stabilize the irrigation water supply,

(iii) to protect the project area and facilities from floods and sand sedimentation, and

(iv) to ensure easiness for operation and maintenance of the project facilities.

3.3.2 IRRIGATION WATER REQUIREMENT AND WATER RESOURCE

(1) Irrigation water requirement

Irrigation water requirement is calculated based on the cropping pattern as illustrated in **Figures 3.3.1** and **3.3.2**. No sufficient daily meteorological data for calculating evapotranspiration are available within the project areas. Data of evapotranspiration are available only in the monthly average data stated in "Climatological Tables for Malawi". These data are arranged as a standard potential evapotranspiration value of Malawi by Planning Division, Ministry of Agriculture, Meteorological Department, Ministry of Transport and Communications, and Food and Agriculture Organization of the United Nation (FAO) in October 1989. In estimation of evapotranspiration in the project areas, data at the Monkey Bay meteorological station was used because meteorological conditions at this station are similar with those in the project areas.

Unit water requirement was calculated under the following conditions and assumptions.

- Evapotranspiration (ETo) at the Monkey Bay meteorological station in "Climatological Tables for Malawi" prepared by the Meteorological Department is used.
- Crop coefficient (Kc) is quoted from FAO technical paper No. 25.
- Water requirement for puddling of paddy is assumed to be 150 mm
- Percolation losses for paddy during cultivation period is assumed to be 3 mm/day
- Water requirement for the nursery is neglected due to too small amount, and
- Computation is done by the 10-day basis

The unit water requirement for the cropping pattern mentioned above was calculated in **Figures 3.3.1** and **3.3.2** and summarized below:

(unit: lit/sec/ha)

Month		Rice (Faya)		Month		Maize	
		Puddling	Cultivation			pattern-1	pattern-2
	early		0		early	0	0
Dec.	middle		0	Jun.	middle	0.03	0.03
	late	0.5	0		late	0.07	0.76
	early	0.5	0.17		early	0.17	0.13
Jan.	middle	0.5	0.51	Jul.	middle	0.27	0.20
	late	0.18	0.86		late	0.35	0.29
	early		1.00		early	0.56	0.42
Feb.	middle		1.00	Aug.	middle	0.62	0.50
	late		1.00		late	0.63	0.69
	early		1.01		early	0.58	0.78
Mar.	middle		1.02	Sep.	middle	0.30	0.79
	late		1.01		late	0.06	0.76
	early		0.91		early	0	0.88
Apr.	middle		0.93	Oct.	middle	0	0.62
	late		0.76		late	0	0.30
	early		0.39		early	0	0
May	middle		0.14	Nov.	middle	0	0
	late		0		late	0	0

(2) Water resource assessment and maximum potential area for the irrigation development

To assess water resources in the project areas, the design year of rainfall is first determined by calculating the rainfall with once in five year probable drought using data at Mua mission meteorological station. The design year is estimated at 1969/70 having about 750 mm.

The three rivers are main water sources for irrigation development for the project areas: the Nadzipulu, Namikokwe and Livulezi rivers. For an assessment of river water sources for irrigation development, the river flow discharge in 1969/70 is used on the 10-day basis.

The water balance study in each river basin is made in 1969/70 under the following conditions and assumptions:

(i) The minimum river discharge in 1969/70 is considered as a river maintenance water for domestic use of habitants living downstream each project site.

(ii) Considering the maximum and effective use of the limited water resources, lining canal is proposed to minimize conveyance losses below 10 %. The distribution efficiency consisting of conveyance efficiency ratio and field canal efficiency ratio is estimated at 0.90. Field application efficiency ratio

is normally 0.80 in case of paddy. As a result, an overall irrigation efficiency is assumed to be 0.72.

The results of water balance study in each river basin are shown in **Tables 3.3.1** to **3.3.6** and summarized below: The maximum potential irrigation area for each river basin is about 1,700 ha for the Nadzipulu, 1,100 ha for the Namikokwe and 950 ha for the Livulezi.

River basin	Rice (Faya)	pattern-1	pattern-2
Nadzipulu	1,658	224	0
Namikokwe	1,104	123	0
Livulezi	946	239	60

3.3.3 DRAINAGE REQUIREMENT

Selected irrigation areas in this project were planned like a polder which is flood-free area. The drainage system in each project area has mainly two objects. One is to drain rainfall within the project area and the other is to prevent river floods intruding into the project area. Regarding river floods, discussion is made in another section. In this section, floods by rainfall is discussed.

Land use of the area in and around each project is upland fields, villages, bush, and so on. Normally upland fields and villages do not allow to pond and paddy field can allow 24 hours. Therefore, 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 daily rainfall with five year return period was estimated to be 94.2 mm/day by using daily rainfall data at Mua mission station on the basis of normal distribution method.
The rainfall intensity within the time of concentration is obtained by the following equation.

$$rt=R24/24(24/t)n$$

where :

R24 : maximum daily rainfall with five year return period (mm/hr)
t : time of flood concentration (hr)
rt : rainfall intensity within the time of concentration (mm/hr)
n : normally 0.5

Considering the drainage duration of the area, rainfall intensity within time of concentration of each paddy and upland fields were estimated to be 3.93 mm/hr and 9.61 mm/hr, respectively.

A peak discharge was estimated by the rational formula as shown below. The design peak discharge per km^2 for paddy and upland field are 0.764 and 1.601 m^3/sec, respectively.

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

where :

Qp : design flood discharge (m3/sec)

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

A : drainage area (km2)

$re=rt \cdot fp$

where :

fp : runoff coefficient — paddy field 0.7, upland field 0.6

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

3.3.4 CRITERIA FOR PRELIMINARY DESIGN OF PROJECT FACILITIES

(1) Irrigation system

The irrigation system consists of a headworks, the main and branch canals, and tertiary canals. The design capacities of the intake and the main and branch canals are determined on the basis of 24 hour continuous water supply at the peak demand period in the design year; 80 % of dependability level.

The design capacity of the tertiary canals is determined based on the rotational irrigation method within the certain rotational block. 10-day rotation is applied in water supply to the paddy field on the approximate eight (8) ha of lands.

(2) Head works

The basic concepts for designing the head works are;

(a). to ensure stable water diversion ,

(b). to secure the surroundings and the upstream banks from flood damages and sedimentation, and

(c) to simplify the structures for easy operation and maintenance of the intake facilities.

(3) Irrigation canals

The main and branch canals are lined with in-situ concrete. The tertiary canals are of earth canals with dual functions: irrigation canal and field drain. The maximum allowable velocity is determined for avoiding the uplifting of the lining in the lined canals and for erosion control in the earth canals. The design condition for the irrigation canals are as follows.

- Maximum velocity
  - lined canal : 1.5 m/sec.
  - earth canal : 0.6 m/sec.
  - Minimum velocity : 0.3 m/sec.
- Roughness coefficient
  - lined canal : 0.015
  - earth canal : 0.030
- Minimum freeboard : 0.20 m
- Lining
  - thickness : 0.1 m
  - under drain and weepholes with 5 m interval be provided in case of excavated portion
- Design unit water requirement : 1.42 lit/sec./ha

Details of canal design are shown in **Figure. 3.3.31.**

(4) Drainage canals

The drainage canals comprise the main drainage canals and the catch drains. The main drainage canals collect surplus water through tertiary canals and drain out to the natural streams. The catch drains are provided mainly at the edge of the project area to protect the project area from intrusion of heavy runoff of rainfall from the surrounding areas. Then, the catch drains lead the runoff to the natural river/stream.

(5) Canal related structures

A number of canal related structures are provided : bifurcation structure, turnouts, culverts, and drop structures on the irrigation canals and drainage culverts and drainage drops on the drainage canals.

The typical features of the canal related structures are shown in **Figure. 3.3.32** to **3.3.36**.

(6) Inspection roads and connecting road

To smooth operation and maintenance of the irrigation system, an inspection road is to be provided on each main and branch canal. The road is designed as of laterite paved with an effective width of 3 m; total width of 5 m. The minimum embankment is to be 0.6 m. In order to connect the project area to the trunk roads, the connecting road with the same design features as those of inspection road is provided.

The inspection roads are to be constructed as the flood protection dikes with certain height including the freeboard of 0.5 m, as required.

(7) Tertiary development

One (1) tertiary canal commands about eight (8) ha of paddy fields. A unit of paddy field of 30 m along the tertiary canal by 150 m is commanded by an inlet device provided on the tertiary canal. Within the unit, plot to plot irrigation will be carried out.

An inlet structure consists of a check plate and a precast concrete pipe of 0.2 m diameter. Details of the tertiary development is shown in **Figure.3.3.37**.

(8) Rice mill and related facilities

The rice mill equipment and related facilities are to be provided as the project facilities for mitigating the husking works which is the most labour intensive work and for allocate the work force more to the on farm works.

The rice mill component consists of a rice mill equipment of design capacity of 1.0 ton/hr, a dry yard of 400 m2 in area , and a mill house and a storage of 50 m2 area in total.