CHAPTER 4 DEVELOPMENT POTENTIAL AND DELINEATION OF THE DEVELOPMENT AREAS

4.1 LAND RESOURCES

The land resources were evaluated from the standpoint of irrigation development with both paddy and upland crops. The soil study indicates that 47,500 ha of land or 19 % of the Study area is suitable for paddy cultivation and 71,800 ha or 29 % is suitable for upland crop cultivation. The suitable land is mostly located on the rift valley floor extending between Lake Malawi and the escarpments as presented below:

Name of river	Total catchment area of river (ha)	Suitable land area			
		Paddy		Upland crops	
		TA (ha)	DOE (ha)	TA (ha)	DOE (ha)
Nadzipulu	36,100	2,630	2,630	4,210	4,210
Namikokwe	35,700	5,000	4,790	6,790	6,790
Livulezi	70,200	11,670	9,680	20,150	15,270
Bwanje	108,000	28,210	26,860	40,640	39,290
Total	250,000	47,510	43,960	71,790	65,560
% of total catchment area		19	18	29	26

Note: TA : Suitable lands within the whole catchment area
DOE: Suitable lands within the catchment area of the river lying between Lake Malawi and the escarpments

4..2 WATER RESOURCES

There are 4 kinds of water resources for irrigation development in the Study area: (i) surface water of rivers, (ii) river water regulated by dam, (iii) the Lake Malawi, and (iv) groundwater. The major rivers in the Study area are the Nadipulu, Namikokwe, Livulezi, and Bwanje rivers. Of the 4 rivers, the Bwanje river was excluded as a water source for irrigation because of: (i) no hydrological record and no study results on the river runoff mechanism and floods, (ii) an unstable river course due to floods, (iii) extremely limited river flow during the dry season, and (iv) no suitable dam site.

There are possible dam sites in the upper basins of the Nadzipulu and Livulezi rivers, while no suitable dam site is available on the Namikokwe river. A 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 25,000,000 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 12,000,000 m^3. There will be constraints with the design and construction of the dams on the above 2 rivers. The constraints are: (i) large-scale dam and reservoir capacity which should include the dead water capacity for huge sedimentation, (ii) large construction cost; 1 billion Japanese Yen for the dam embankment of 500,000 m^3, and (iii) compensation for the inhabitants in and around the reservoir area. Since the technical, economic, and social viabilities would be low in accordance with the above constraints, the usage of regulated water by the construction of dams will be excluded from the water resources study for irrigation development.

To use water from Lake Malawi for irrigation, irrigation water has to be elevated by a pump(s), first to a distribution pond to be located at a higher point than the proposed development area for applying gravity irrigation systems. The development area should be extended along the lakeshore to minimize both the construction and operation costs of irrigation using pumped lake water. Despite the fact that Lake Malawi has the most stable and inexhaustible water resource, it is excluded because of: (i) unfavourable soil conditions along the lakeshore areas, (ii) unsuitable topographic conditions: no favourable areas for the distribution pond, and (iii) difficulty in purchasing the spare parts for the pump equipment in Malawi.

The groundwater yield data are too limited to ensure the technical assessment for irrigation development. Although some possibility for groundwater irrigation was identified through the same investigation, further investigation is required to confirm its potential. Taking such groundwater development conditions in the Study area into consideration, the present Study excludes groundwater as the water resource for the Bwanje Valley Irrigation Project.

It is considered that the water resources for irrigation development in the Study area are the surface water of the Nadzipulu, Namikokwe, and Livulezi rivers. The river flow discharge in 1969/70, design year as shown hereinafter, is given on the next page.

Month	River discharge		
	Nadzipulu river (m3/s)	Namikokwe river (m3/s)	Livulezi river (m3/s)
Nov.	0.31	0.13	0.17
Dec.	0.58	0.80	0.27
Jan.	5.25	1.83	6.66
Feb.	2.85	1.60	3.63
Mar.	5.71	3.68	8.77
Apr.	2.50	1.79	3.34
May	1.17	0.73	1.22
Jun.	0.91	0.52	0.90
Jul.	0.67	0.35	0.64
Aug.	0.46	0.23	0.36
Sep..	0.31	0.15	0.20
Oct.	0.18	0.09	0.11

4.3 MAXIMUM POTENTIAL AREA FOR IRRIGATION DEVELOPMENT

In order to estimate the maximum potential area for irrigation development, a preliminary water balance study was carried out using the available water and irrigation water demand for the design year. The design year is defined as the year with an annual rainfall depth of a 5-year return period. The design year is 1969/70 with a rainfall depth of 750 mm.

Irrigation water demand includes crop water consumption, water losses in the conveyance of water and irrigation activities (water requirement; shown in Annex II.3.3), and river maintenance water. The required river maintenance flow water discharge is the minimum flow discharge in 1969/70 in each river. The available water is the river flow and precipitation in 1969/70. The results of the preliminary water balance study are shown below:

River basin	Irrigation potential in the rainy season	Irrigation potential in the dry season
	(ha)	(ha)
Nadzipulu	1,658	224
Namikokwe	1,104	123
Livulezi	946	239
Total	3,708	586

4.4 IDENTIFICATION OF THE DEVELOPMENT AREAS

On the basis of the land suitability, available water resources, and the results of the preliminary water balance study, the proposed irrigation development area in each river basin was identified. The identification of the areas was carried out using the following steps: (a) preliminary delineation of the areas using 1/50,000 maps and preliminary alignment of the irrigation facilities (Phase I Study) and (b) detailed surveys and investigations in the areas and preliminary design and alignment of the facilities using 1/5,000 maps, which were prepared by JICA in February 1992. The preliminary design and alignment of the irrigation facilities included alternative studies on the intake method, irrigation and drainage system, irrigation method, farm road networks, etc. For identification of the irrigation areas, special attention was paid to the following:

(i) application of gravity irrigation using river water flow without any regulation,
(ii) land suitability for irrigation farming, and
(iii) required measures for protecting the areas and facilities from flood damage.

Based on the above, the following 5 irrigation development areas in 3 river basins were identified.

River Basin	Irrigation Development Area	Area in ha	Note
Nadzipulu	The Lower Nadzipulu Area	250	newly developed
Namikokwe	The Upper Namikokwe Area	570	newly developed
	The Mtandamula Area	230	rehabilitated
	The Lower Namikokwe Area	160	newly developed
Livulezi	The Lower Livulezi Area	520	newly developed
Total		1,730	

4.5 PRESENT CONDITIONS IN THE IRRIGATION DEVELOPMENT AREAS

(a) Social aspects

The 5 irrigation development areas come under the jurisdiction of the Kachindamoto Traditional Authority (TA). There are 42 villages in and around the areas with a total population of 15,800 and total households of 3,780, thus there are 4.2 persons per household on average. The female headed households

account for about 40 % of the total households. Over 90 % of the societies in the areas are matrilineal with matrilocal marriages.

(b) Agriculture

The development areas are extensively used for agricultural purposes. About 42 % of the total area is cultivated and about 10 % is irrigated. The present land use is summarised below:

(unit: ha)

Land Use Category	Irrigation Development Area					
	Upper Namikokwe	Mtandamula Area	Lower Namikokwe	Lower Livulezi	Lower Nadzipulu	Total
Agricultural land	300	230	110	190	80	910
Irrigated rice	0	230	0	0	0	230
Rainfed rice	150	0	110	0	80	340
Upland crops	150	0	110	0	80	340
Non-agricult. land	350	0	180	560	190	1,280
Total area	650	230	290	750	270	2,190
Net irrigable area	570	230	160	520	250	1,730

Crop production in the development areas is under rainfed conditions except that for irrigated rice in the Mtandamula Area. The main crops are maize and rice. About 90 % of the total cultivated lands are covered by both crops followed by such crops as cotton and beans/pulses. Single cropping of maize or rice prevails, while double cropping is practised only to a limited extent. Most of the crops are planted at the onset of the rains. Farming activities, from land preparation to harvesting are carried out manually.

Maize is planted from November to December and harvested from May to June. About 60 % of the farmers in the development areas use local varieties, 16 % use hybrid varieties, such as NSCM-42 and MH-16, and 24 % use both local and hybrid varieties. Fertilizers and chemicals are applied by 24 % of the total farmers who grow hybrid maize, but they are not applied to local varieties.

Paddy is planted from November to December and harvested from May to June. Direct seeding is the common planting method, while the transplanting method is practised only in the Mtandamula scheme. Rice varieties in the areas are represented by Faya, which is used by about 75 % of the rice farmers. Fertilizers and chemicals are not applied.

Maize yield in the areas is about 1 ton/ha for local varieties and 1 to 2 tons/ha for hybrid varieties. Paddy yield is about 1 to 1.5 tons/ha for rainfed land and

about 2.7 tons/ha under irrigated conditions. Limited use of improved varieties and fertilizers is one of the major factors depressing maize yield. The main causes of the low yield of paddy are considered to be : (i) low quality of paddy seeds, (ii) poor land levelling of paddy fields, (iii) shortage of irrigation water, (iv) poor drainage of excess water, (v) weed infestation, and (vi) crop damage by wild animals. The poor land levelling of paddy fields most seriously affects the current productivity of rice.

A rice cutting survey indicated that an increase of panicles per unit area is the basis for increasing paddy yield in view of the cultivating practices. The details are explained in section 2.13.5 of Annex II.

(c) Infrastructure

The social infrastructure in and around the development areas is still poor. The jeepable roads or all weather roads, which connect the areas with the national roads or the major villages, are about 60 km in length and the density of jeepable roads is less than 0.3 km/km^2. Moreover, the 3 main rivers flowing from southwest to northeast divide the areas into several blocks. Since there are no structures, especially for river crossing, except the national roads, the traffic in the rainy season between the blocks as well as between villages has been frequently impeded by river floods.

It is estimated that 23 % of the total farmers in the development areas use shallow wells, 50 % use boreholes and 27 % use lake or rivers. Thirteen boreholes and 4 shallow wells are functioning in the areas. The densities are 3.4 boreholes and 1.1 shallow wells per 1,000 households. The water supply conditions of these wells are not always good and water is often exhausted in the dry season.

(d) Farmers' economy

The economic condition of the farmers in the development areas was examined by the preparation of a farm budget. The farm budget was prepared for the farmers selected from the farmers' interview survey and the diary keeping method for 3 farmers selected from the Mtandamula scheme. The farm budget for the typical farmers is shown below. The detailed results are shown in section 2.12.3 of Annex II.

Items	Mtandamula farmer	Rainfed farmer
1. Family size (people)	4	4.3
2. Cultivated land (ha)	1.4	1.2
3. Income (MK)	2,281	705
4. Total outgo (MK)	1,979	756
(living expense)	1,685 (402*)	689 (160*)
5. Balance (MK)	302	-51

*: living expenditure per person per annum MK = Kwacha

The living expense per person per annum is only MK 160 for the rainfed farmers and MK 402 for the Mtandamula farmers. The rate of living expenditure/total income is 98% for the rainfed farmers and 74 % for the Mtandamula farmers. It may be concluded that the farmers in the areas remain at the subsistence level of living.

Women in the development areas undertake the majority of all daily activities and have a very heavy work load. The total farm working hours contributed by a housewife is about 1,000 hours for 1 rice cropping season. All housewives work longer than any other member of their family. In addition, housewives have to perform many traditional kinds of daily work. Among this work, cooking, fetching drinking water and firewood, milling rice and maize, housekeeping, and child care are important. Especially the work for fetching drinking water is important owing to the shortage of boreholes and wells. The average distance to the boreholes, wells, and lake/rivers is about 1 km per one way for this work. Fetching water work is done 4 times per day per family in total. It takes 2 hours per day per family. Also the maize mills are 4 to 8 km from the villages in and around the areas and this work takes 0.5 to one hour per day.

Such a situation concerning women's daily work creates crucial problems especially for housewives with no husband. Therefore, in female headed households the scale of cultivated land is smaller due to the shortage of labor. For solving such problems, alleviating the females' house work by construction of wells for drinking ranks first, followed by construction of maize/rice mills.

(e) Farmers' intention for development

Farmers' views and expectations for development in the development areas were identified through the interviewing of 160 farmers sampled at random.

Most of the farmers are eager to increase farm income through expansion of the cultivated land. Also about 75 % of the respondents expect to use land under vegetables. A considerable number of farmers experience a shortage of labor for farming.

It is considered from the interview survey that 100 % of the farmers in the existing Mtandamula scheme and 40 % of the farmers on the rainfed land willingly contribute labor to the construction and maintenance of the irrigation facilities. All the village headmen and group village headmen stated that management of the irrigation system should be undertaken by Salima ADD at the initial stage and by the farmers' association in the full stage of the project. They will pay water charges in the form of O&M of the irrigation scheme.

CHAPTER 5 THE PROJECT

5.1 BASIC DEVELOPMENT CONCEPT

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.

5.2 AGRICULTURAL DEVELOPMENT PLAN

5.2.1 PROPOSED LAND USE

The development areas will be administrated under the jurisdiction of the Kachindamoto TA as it is. The land use intensity of the development areas will be drastically changed. Suitable land within the areas will be developed for irrigation purposes according to the following principles:

(i) All the existing rainfed paddy fields and upland fields located within the development 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 irrigation and agricultural works such as canals, farm road networks, and other farming facilities.

The future land use of the 5 development areas in the 3 river basins is shown below:

(Unit : ha)

River Basin Irrigation Development Area	Wet Season Irrigated Paddy	Dry Season Irrigated Maize	Dry Season Irrigated Vegetables
Nadzipulu			
The Lower Nadzipulu Area	250	205	19
Namikokwe			
The Upper Namikokwe Area	570	80	43
Mtandamula Area	230	106	17
The Lower Namikokwe Area	160	111	12
Livulezi			
The Lower Livulezi Area	520	200	39

5.2.2 PROPOSED CROPPING PATTERN

Selection of the main crops for the development areas was carried out taking account of the following conditions:

(i) plant physiological features for climatic conditions and soil conditions,
(ii) marketability and profitability of crops,
(iii) yield response by irrigation water supply,

(iv) farmers' labor requirement and the availability of a work force in and around the development areas,
(v) farmers' familiarity with crop cultivation, and
(vi) easy storing and processing.

It is considered that there are several prospective crops for the wet season to be introduced into the development areas, such as maize, paddy, cotton, beans, and vegetables.

Among these crops, paddy is the most prospective crop from the standpoint of the above conditions. Plantphysiologically, paddy is suited to the climatic conditions in the areas. The profitability of paddy is the highest, except for vegetables and the effectiveness of irrigation is also higher than for any other crop. The marketing of paddy has been sufficiently guaranteed by ADMARC. Though cotton has a high effectiveness for irrigation and ranks second in profitability in the proper soil conditions, it is considered that soils in the development areas are too wet to grow cotton properly during the wet season. Beans rank third in profitability. However, the soil conditions in the wet season are too wet for them to grow properly. The outlet of the beans seems uncertain. Maize is the main foodstuff for the farmers in the development areas and in the high lands. Maize ranked fourth in terms of profitability of crops and relies less on irrigation. Though vegetables are the most profitable crop, these are very difficult to cultivate in the wet season due to too the wet soil conditions. In accordance with the above, it is proposed that paddy be grown in the wet season.

There are alternative new high yielding rice varieties with a shorter growing period which could be introduced. These varieties, however, require large amounts of fertilizers and agricultural chemicals to grow properly. Also a strict control of irrigation water is vital to obtain a higher yield. It is planned that for this development plan Faya rice varieties will be used in view of the present condition of supply of farm inputs and the capability of the farmers. It is considered necessary that improved Faya varieties, higher yielding and better quality, will be bred in the development areas.

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 5.2.1.**

5.2.3 PROPOSED FARMING PRACTICES

(a) 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 development areas.

(i) The mechanized farming should be beneficial and profitable in terms of financial management.
(ii) The farm machinery is able to be properly maintained after the introduction of machinery.
(iii) There should be suitable organization to use and manage the machinery effectively and properly.

Increasing land productivity in the development areas is not expected by the use of mechanized farming. Most of the lands in the development areas are cultivated and allocated to the farmers. Thus, an 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 labor is cheap in the development areas. In accordance with the above, the agricultural development plan excludes farm mechanization. The details are presented in section 3.2.4 of Annex II.

(b) Farming practices

Proper farming practices are essential for realizing the full agricultural potential in the development areas. It is necessary to carry out farming using an appropriate farming practice along with the development and strengthening of institutional support. The proposed farming practices were formulated by referring to the farming guideline prepared by MOA of Malawi, data from the Ngolowind

irrigation scheme, and data from countries neighbouring Malawi. The details are presented in section 3.2.4 of Annex II.

5.2.4 ANTICIPATED YIELDS AND PRODUCTION

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 under the with-project condition are estimated on the basis of the yield survey for the Mtandamula irrigation scheme and the Ngolowind scheme, data from the existing experimental stations, and so on. The future crop yields are targeted to be 4,500 kg/ha for paddy, 2,000 kg/ha for maize, and about 10 tons/ha for vegetables under the with-project condition. The crop production will increase gradually during the build-up period of 3 years after the completion of construction. The production under the with- and without-project conditions are estimated below.

(unit: ton)

Development Area	With-project			Without-project	
	Rice	Maize	Vegetables	Rice	Maize
1. Lower Nadzipulu Area	1,130	220	190	0	80
2. Namikokwe River Basin	4,320	120	720	980	260
- Upper Namikokwe Area	(2,565)			(360)	(150)
- Existing Mtandamula Area	(1,035)			(620)	(0)
- Lower Namikokwe Area	(720)			(0)	(100)
3. Lower Livulezi Area	2,340	240	390	290	0
Total	7,790	580	1,300	1,270	340

5.2.5 FARM INPUTS

In association with the development 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 is presented in the next page.

Unit: ton

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

Remark: * total maize seed requirement of the Upper and Lower Namikokwe and Mtandamula Areas

5.2.6 LABOR REQUIREMENT

The farm labor 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 labor shortage. In the development plan, 0.4 ha of irrigated plot will be allocated to each household. Since most of the households will plant rainfed maize in the wet season outside the development areas, the analysis was carried out to prove that the overall labor balance in the households based on the labor requirement for the cultivation of rainfed maize. The result of the analysis is presented in **Table 5.2.1** and summarized as follows:

(a) Without-Project Conditions

- Total labor requirement will be sustained at 3,015 man-hours per year at the present level giving the overall average daily working hours at of 4.21 hours per person, excluding Sundays, throughout the year.
- The peak labor requirement is in October when ploughing for paddy and clearing for maize are practiced. Since the farmers start ploughing in September and complete it by the end of October, an actual labor shortage would not occur.
- Another peak is at the end of June when carried out harvesting, threshing, winnowing, and storing of paddy are carried out. Actually the farmers avoid shortage by elongating the post-harvest practices.

(b) With-Project Condition

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

5.2.7 POST HARVEST

In order to increase the value-added price of rice produced under the projects, sets of post harvest facilities will be provided at each irrigation project. The sets of facilities comprise rice mill equipment of 1.0 ton/hr capacity, a mill house and a storage of 50 m^2 in total, and a dry yard of 400 m^2. The required sets of post harvest facilities for 3 irrigation projects described hereinafter are shown below:

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

Table 5.2.2 shows the estimation of required sets of post harvest facilities for each irrigation project.

5.3 IRRIGATION AND DRAINAGE PLAN

5.3.1 PROJECT OPTIMIZATION

On the basis of the results of investigations and studies on land and water resources, the 5 irrigation development areas in the 3 river basins are identified as follows:

The Nadzipulu River Basin
- (i) The Lower Nadzipulu Irrigation Development Area

The Namikokwe River Basin
- (i) The Upper Namikokwe Irrigation Development Area
- (ii) The Mtandamula Rehabilitation Area
- (iii) The Lower Namikokwe Irrigation Development Area

The Livulezi River Basin
- (i) The Lower Livulezi Irrigation Development Area

In order to optimize the scale of the irrigation development in the above development areas technically and economically, an alternative study in each river basin was carried out according to the development potentials which are based on land capability and water availability. The alternative study included the preliminary design of

the possible irrigation and drainage system especially for the intake structures, cost estimate, economic evaluation, and evaluation of the technical viability.

(1) The Nadzipulu river basin

The Lower Nadzipulu irrigation development area is located in the Nadzipulu basin. The area which slopes down to the northeast with an approximate land gradient of 1/250 is located in the lower reaches of the Nadzipulu river. The Nadzipulu river which bounds the area in the southeast is the sole water source for the irrigation development of the area. The area is isolated and there is no jeepable road connecting the area with the trunk road.

The development area lies on the floodplain of the Nadzipulu river and floods frequently flow over the river course into the area. The Nadzipulu river, a huge sediment load carrier, has changed its river course due to sedimentation and floods.

In the formulation of the Lower Nadzipulu Irrigation Project in the development area identified, the following points were considered.

(i) to select a stable intake site,
(ii) to keep a certain area for passing floods on the left bank of the Nadzipulu, and
(iii) to protect the project area from flood intrusion by construction of flood protection dikes which will be used as the inspection roads.

In conformity with the above points to be considered and the results of field investigations and survey, the project area for the Lower Nadzipulu Irrigation Project was delineated according to the an alignment of the irrigation and drainage system. Since topography, soils, and land capability for irrigation farming restrict to the irrigation area, no alternative plan for the irrigation system was prepared, except these for the intake site and construction method of the headworks. The alternative plans for the intake site and construction method are shown below:

Alternative -1 : The site is located 2.5 km upstream of the project area. The headworks will be constructed on the inside bank of the river meander using the original river course as a temporary diversion channel. No river work is required for construction of the headworks. The design flood discharge is 266.1 m^3/sec.

Alternative - 2 : The site is located at 4.0 km upstream of the project area. The headworks is constructed in the original river course under dry condition by means of constructing an artificial diversion channel. Design flood discharge is 266.1 m^3/sec.

Of 2 alternatives, alternative-1 is superior based on the accuracy and safety of construction of the intake facilities. The direct construction cost of each alternative is 76.6 million Yen for alternative - 1 and 80.0 million Yen for alternative - 2. On the basis of the above, alternative - 1 will be employed for the Lower Nadzipulu Irrigation Project. The details of the alternative plans are shown in **Table 5.3.1.**

(2) The Namikokwe river basin

The following 3 irrigation development areas have been identified in the Namikokwe river basin.

The Upper Namikokwe Development Area	: newly developed,	570 ha
The Mtandamula Rehabilitation Area	: rehabilitation,	230 ha
The Lower Namikokwe Development Area	: newly developed,	160 ha

Since topography, soils, and land capability for irrigation farming restrict the irrigation area, no alternative study on the location of the project site, irrigation area, and the irrigation and drainage system for each development area was conducted. In the formulation of the optimum irrigation development plan for this river basin, the following steps were applied:

(i) Study on the intake site and construction method of the intake facilities,
(ii) Study on the identified development areas as individual irrigation projects,
(iii) Study on the integration of the above 3 development areas, and
(iv) Technical and economic evaluation of the individual and integrated irrigation projects elaborated from the previous step.

(a) Intake site and construction method of intake facilities

The Namikokwe river is fed by the Nadzipokwe river, one of the major tributaries of the Namikokwe, 1.5 km upstream of the Upper Namikokwe development area. The river course of the Namikokwe becomes unstable after a point about 2.0 km downstream of the confluence. Therefore, the intake site for the 3 development areas will be restricted to a narrow area; from the confluence to about 2.0 km downstream. For selecting the proposed intake site and construction method of the intake facilities, the 2 alternative plans were prepared as shown in the next page:

Alternative -1 : The site is located 0.6 km downstream of the confluence. The headworks will be constructed on the inside bank of the river meander using the original river course as a temporary diversion channel. No river work is required for construction of the headworks. The design flood discharge is 205.4 m^3/sec.

Alternative - 2 : The site is located 1.3 km downstream of the confluence. The headworks will be constructed in the original river course under dry conditions by constructing an artificial diversion channel. The design flood discharge is 205.4 m^3/sec.

The construction cost for alternative - 1 amounts to 76.9 million Yen and that for alternative - 2 is 86.2 million Yen. Since alternative -1 is superior based in the accuracy and safety of construction of the intake facilities and cost, alternative-1 is employed as the proposed intake site for the projects delineated in the Namikokwe river basin and the construction method.

(b) Individual irrigation project

(b - 1) The Upper Namikokwe Irrigation Project

The Upper Namikokwe Irrigation Project is located in the upper floodplain of the Namikokwe river, extending from about 3 km east of Mua railway station to the northeast with a land gradient of 1/170 - 1/250. The project area covers 570 ha of land on the left bank of the Namikokwe. Every rainy season, the floodwater overspills the river course about 2 km downstream of the confluence of the Namikokwe and the Nadzipokwe and inundates the floodplain of the selected project area. There are jeepable roads connecting the area and the national road.

In the formulation of the proposed irrigation development plan for the Upper Namikokwe Irrigation Project, the following points were carefully considered:

(i) to maintain stable water intake,
(ii) to keep a certain area for passing floods on the left bank of the Namikokwe,
(iii) to protect the project area from flood intrusion by construction of flood protection dikes aligned in parallel with the river course, which will also be used as the inspection roads, and
(iv) to provide drainage canals for collecting runoff water from the western hilly area.

An outline of the Upper Namikokwe Irrigation Project is shown in the next page:

Net irrigation area	:	570 ha
Project Facilities	:	
Headworks	:	1 site, design intake discharge 0.81 m^3/sec.
Main irrigation canal	:	6.7 km
Branch irrigation canal	:	3.8 km
Tertiary canal	:	43.1 km (dual purpose, irrigation and drainage)
Drainage canal	:	12.2 km
Inspection road	:	10.1 km
Flood protection dike/road	:	7.0 km
Connecting road	:	1.2 km
Rice mill and related facilities	:	3 sites

(b - 2) The Mtandamula Rehabilitation Project

The Mtandamula Rehabilitation Project is proposed to rehabilitate the deteriorated irrigation facilities of the existing Mtandamula Self-help Scheme. The project area is located 9 km east of national road M - 17. It extends to the northeast and slopes down to Lake Malawi with an approximate land gradient of 1/250. The Mtandamula Self-help Scheme which developed on the floodplain of the Namikokwe river was constructed in 1987 and has been managed by farmers with the government's support.

Since floodwater overspills the river course which is the sole water source for the scheme, the availability of irrigation water is unstable and the irrigation activities in the scheme have been restricted within the wet season. The technical constraints in formulating the optimum irrigation development plan for the project are as follows:

(i) unstable irrigation water source,
(ii) deterioration of the irrigation facilities, especially at the intake gate on the dike, main feeder canal, and related structures,
(iii) poor quality land leveling of paddy fields, and
(iv) poor transportation system.

In order to solve the technical constraints mentioned above, construction of a new intake structure at the same site as the Upper Namikokwe Irrigation Project, rehabilitation of the existing facilities, land leveling works for the existing paddy fields, etc. were taken into account in the project formulation. The main features of the Mtandamula Rehabilitation Project are shown in the next page:

Net irrigation area	:	230 ha
Project Facilities	:	
Headworks (new)	:	1 site, design intake discharge 0.33 m^3/sec.
Main irrigation canal (new)	:	6.7 km
Branch irrigation canal	:	4.5 km
Tertiary canal	:	12.6 km (dual purpose, irrigation and drainage)
Inspection road (new)	:	6.0 km
Flood protection dike/road	:	6.9 km (rehabilitation : 1.0 km)
Connecting road (new)	:	2.4 km
Rice mill and related facilities(new)	:	2 sites

(b - 3) The Lower Namikokwe Irrigation Project

The project area of the Lower Namikokwe Irrigation Project is adjacent to the Mtandamula Rehabilitation Project area in the south. The area which extends over the relatively high elevated lands has been scarcely affected by the flooding of the Namikokwe river. The area slopes down to the northeast with an approximate gradient of 1/250. A jeepable road is available for approaching the area from national road M-17. The technical constraints to be solved in formulating the optimum irrigation development plan are as follows:

(i) no stable water resources and intake site near the project area,
(ii) low land suitability for paddy cultivation,
(iii) residential areas in the project area, and
(iv) small labor force.

The irrigation development plan for the Lower Namikokwe Irrigation Project with the following features was elaborated on consideration of the above constraints.

Net irrigation area	:	160 ha
Project Facilities	:	
Headworks	:	1 site, design intake discharge 0.23 m^3/sec.
Main irrigation canal	:	6.7 km
Branch irrigation canal	:	4.7 km
Tertiary canal	:	11.1 km (dual purpose, irrigation and drainage)
Drainage canal	:	5.6 km
Inspection road	:	5.1 km
Flood protection dike/road	:	4.2 km
Connecting road	:	1.8 km
Rice mill and related facilities	:	2 sites

(c) Integrated irrigation projects

The economic return of the initial investment for the above individual irrigation projects seems to be low due to the high construction cost of a new intake structure and long distance main canal and the restricted irrigation area. In order to increase the economic efficiency and maximize the usage of water and land resources, the integrated development plans were formulated by coupling 2 and/or 3 individual irrigation projects mentioned above. An alternative study on the following 3 integrated irrigation projects was carried out:

(i) Integrated irrigation project - 1 (irrigation area : 800 ha)	:	The Upper Namikokwe Irrigation Project The Mtandamula Rehabilitation Project
(ii) Integrated irrigation project - 2 (irrigation area : 730 ha)	:	The Upper Namikokwe Irrigation Project The Lower Namikokwe Irrigation Project
(iii) Integrated irrigation project - 3 (irrigation area : 960 ha)	:	The Upper Namikokwe Irrigation Project The Mtandamula Rehabilitation Project The Lower Namikokwe Irrigation Project

The above 3 integrated irrigation projects are technically viable from the viewpoints of land capability and the quantity of water available from each source and the maximum possible irrigation area is calculated as 1,104 ha of land as described in the previous chapter. The main features of each integrated irrigation project are shown in **Table 5.3.1**.

(d) Selection of the optimum irrigation plan

On the basis of the results of field investigations and surveys, studies, design of the irrigation system and facilities, construction cost estimate, and economic evaluation, the optimum irrigation development plan was selected from among the 3 individual irrigation projects and the 3 integrated projects. The main emphasis was placed on the following points in selecting the optimum plan:

(i) technical viability,
(ii) economic viability,
(iii) maximum use of natural resources, and
(iv) availability of labor .

The table in the next page shows the results of the evaluation of the 6 development plans:

Development plan	Irrigation area (ha)	FIRR (%)	Available labor force
The Upper Namikokwe Irrigation Project	570	11.6	A
The Mtandamula Rehabilitation Project	230	1.7	A
The Lower Namikokwe Irrigation Project	160	2.1	C
Integrated Irrigation Project - 1	800	11.9	A
Integrated Irrigation Project - 2	730	10.2	B
Integrated Irrigation Project - 3	960	10.2	B

where, A : enough labor , B : partly short, C : short

In accordance with the above table, the Upper Namikokwe Irrigation Project and the 3 integrated irrigation projects are superior to the others in terms of economic viability. Since most of the farmers in the Lower Namikokwe Irrigation Project area are beneficiaries of the existing Mtandamula self-help scheme, a small labor force will be available for new irrigation development under the Lower Namikokwe Irrigation Project. The Integrated projects - 2 and - 3, which comprise the Lower Namikokwe Project, will have the same problem. The Integrated irrigation project - 1 is superior to the others in all the evaluation items; economic viability, maximum use of natural resources, and available labor. The Integrated irrigation project - 1, therefore, is to be employed as the proposed project in the Namikokwe river basin. The details of the selection of the optimum irrigation plan for the river basin are shown in 3.3.5 of Annex II.

(3) The Livulezi river basin

The Lower Livulezi Irrigation Project was identified in the Livulezi river basin, . The project area extends over the floodplain of the Livulezi river and slopes down to the north with a land gradient of about 1/350. The area is bounded by the river to the west and hilly areas to the east. The area is accessible by using national road M - 18, crossing the river 1.5 km upstream of the project area.

The sedimentation and consequent river meandering are the most serious problems to be solved in the formulation of the irrigation development plan for the basin. The river crossing structures on national road M - 18 are frequently silted in the wet seasons and annual desilting works are required. In the 1992/93 floods, the main river crossing structures were buried by the sediments due to the poor design of the structures. In early 1993, MOW of GOM changed the main course of the Livulezi river to make floodwater flow across the other culverts. Consequently, the Livulezi river detours the upper part of the project area and flows into the original course 7.0 km downstream of

national road M - 18. In the formulation of the irrigation development plan for the Lower Livulezi Irrigation Project, 2 alternative plans were prepared which mainly emphasised the treatment of the upper part of the river course by rehabilitation of the river crossing structures and dredging of the original river course. The outline of the alternative plans are as follows:

Alternative - 1 : to maximize the irrigation area by dredging the original river course upstream of national road M - 18 and rehabilitation of river crossing structures on M - 18. Irrigation area : 520 ha,
Alternative - 2 : to provide no river works and take irrigation water downstream of the confluence of the present river course and original river course. Irrigation area : 380 ha.

The above 2 alternatives were evaluated according to the following points:

(i) technical viability,
(ii) economic viability, and
(iii) maximum use of land and water resources.

The 2 alternatives are technically viable. Alternative - 1 is superior in terms of the economic efficiency of the initial investment for the Project with a financial internal rate of return (FIRR) of 7.6 % against 6.9 % for alternative - 2. Since the alternative - 1 is also superior to alternative - 2 in in terms of the maximum use of natural resources, alternative - 1 is employed as the proposed development plan for the Lower Livulezi Irrigation Project. An outline of each alternative is shown in **Table 5.3.1.**

5.3.2 PROPOSED IRRIGATION PROJECT

(1) Irrigation water requirement

Irrigation water requirement was calculated based on the proposed cropping pattern as illustrated in **Figure 5.2.1.** Unit water requirement on ten day basis was calculated under the following conditions and assumption.

- Evapotranspiration at the Monkey Bay station was used.
- Crop coefficient 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 the cultivation period is assumed to be 3 mm/day.
- Water requirement for the nursery is neglected due to small amount.

The results are shown in the next page:

		Paddy (Faya)			Maize	
		puddling	cultivation			
Dec.	early		0	Jun.	early	0
	middle		0		middle	0.03
	late	0.50	0		late	0.07
Jan.	early	0.50	0.17	Jul.	early	0.17
	middle	0.50	0.51		middle	0.27
	late	0.18	0.86		late	0.35
Feb.	early		1.00	Aug.	early	0.56
	middle		1.00		middle	0.62
	late		1.00		late	0.63
Mar.	early		1.01	Sep.	early	0.58
	middle		1.02		middle	0.30
	late		1.01		late	0.06
Apr.	early		0.91	Oct.	early	0
	middle		0.93		middle	0
	late		0.76		late	0
May	early		0.39	Nov.	early	0
	middle		0.14		middle	0
	late		0		late	0

(Unit: lit/sec/ha)

The table shows that the maximum unit field water requirement is calculated at 1.02 lit/sec/ha in the middle of March. Considering the maximum and effective use of the limited water resources, lining canal is proposed to minimize conveyance losses below 10 %. It is assumed that conveyance of canals and application efficiency ration is 0.9 and 0.8, respectively. An overall irrigation efficiency is set at 0.72. Based on these figures, the maximum diversion water requirement is estimated at 1.42 lit/sec/ha for paddy and 0.88 lit/sec/ha.

(2) Drainage water requirement

The drainage water requirement is estimated in accordance with the following criteria:

- The maximum daily rainfall with the 5 year return period is applied as design rainfall.
- Design rainfall shall be drained of for 24 hours for paddy fields and 4 hours for uplands.
- Runoff coefficient of 0.7 for paddy fields and 0.6 for uplands is applied.

The design rainfall with the 5 year return period is calculated at 94.2 mm, based on the data at Moa station. Using this design rainfall, the unit drainage water requirement is thus determined at 7.64 lit/sec/ha for paddy fields and 16.01 lit/sec/ha for uplands.

(3) Basic plan of irrigation facilities

(i) Irrigation canal system

The irrigation system consists of a headworks, 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. The design capacity of tertiary canals is determined on the rotational irrigation method within the certain rotational block. The 10-day rotation of water supply to rotational irrigation blocks (8 ha of lands) is applied.

(ii) Head works

The basic concept for designing the head works is:

- to maintain stable water
- to protect the project area from flood intrusion and sand sediments
- to simplify the structures for easy O/M of the intake facilities

The design flood with a 50-year return period is applied to the head works. The flood was estimated based on Draytons' equation. The design flood at the head work is 266.1 m^3/sec for the Nadzipulu, 205.4 m^3/sec for the Namikokwe and 373.2 m^3/sec for the Livulezi. The details of the design of the head works are presented in 3.3.4 of Annex II.

(iii) Irrigation canals

The main and branch canals are lined with in-situ concrete. The tertiary canals are of earth canals with dual functions. The design condition for the irrigation canals are shown below:

- Maximum velocity:	lined canal:1.5 m/sec, earth canal:0.6 m/sec
- Roughness coefficient:	lined canal:0.015, earth canal:0.030
- Minimum freeboard:	0.20 m
- Lining:	thickness:0.1 m

The details are shown in section 3.3.4 of Annex II.

(iv) Drainage canals

The drainage canals comprise the main drainage canals and the catch drains. The natural streams flowing in the irrigation area are incorporated into the drainage canal system as many as possible.

(v) *Related canal structures*

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

(vi) Inspection roads and connecting roads

Inspection roads is to be provided on each main and branch canal to the smooth O/M of the irrigation system. The road is designed as gravel road paved with an effective width of 3 m and a total width of 5 m. The minimum embankment is to be 0.6 m. The inspection roads also function as flood protection dikes in this plan. The maximum height of the dike is designed on the basis of the flood discharge at a 25-year return period. A freeboard of 0.5 m is considered. The maximum height is shown below:

Irrigation project	maximum height (m)	design flood (m^3/sec)
Lower Nadzipulu Irr. Project	1.2	217.5
Namikokwe Integrated Irr. Project	1.5	167.9
Lower Livulezi Irr. Project	1.5	305.0

In order to connect the project area with the trunk roads, the connecting roadswith the same design of the inspection roads is provided.

(vii) Tertiary development

One tertiary canal commands about 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 an a precast concrete pipe o 0.2 m diameter.

(4) Project works

Through the alternative studies on each irrigation project and the integrated projects, the proposed irrigation projects were elaborated on as described in the previous section. The main features of the proposed irrigation project in each river basin are shown below:

River Basin Irrigation Project	The Nkupulu The Lower Nkupulu I	The Namikokwe The Integrated I	The Livulezi The Lower Livulezi
-Irrigation area	250 ha	800 ha	520 ha
-Project facilities			
-Headworks	1 site	1 site	1 site
-Main irrigation canals	7.0 km	6.7 km	11.1 km
-Branch canal	0.6 km	8.3 km	1.0 km
-Tertiary canals	18.4 km	55.7 km	38.3 km
-Drainage canals	5..2 km	12.2 km	13.7 km
-Inspection roads	7.9 km	12.8 km	8.5 km
-Road/flood protection dikes	4.5 km	7.0 km	6.1 km
-Connecting road	2.0 km	2.4 km	2.5 km
-Rehabilitation of river crossing structures			required
-River dredging			1.0 km

The general layout and location of the 3 proposed projects are shown in **Figures.5.3.1 to 5.3.3.**

5.4 RURAL INFRASTRUCTURE DEVELOPMENT PLAN

5.4.1 RURAL ROAD NETWORK

In order to improve the poor roads and road network conditions in the Study area, the road network development plan was formulated based on the following basic concepts:

- to increase the density of jeepable roads and all season roads,
- to maintain a smooth access between the irrigation project areas and national roads M-17 and M-18,
- to ensure traffic between the blocks intersected by the rivers even in the wet season, and
- to connect the major villages with all weather roads.

In conformity with the basic concepts, the road network development plan, comprising the rehabilitation works of the existing roads and construction of jeepable roads on the 5 proposed routes, was formulated. The five routes will be connected with

national roads M-17 and M-18 and/or linked with each other. The salient features of the proposed routes are shown in the next page and illustrated in **Figure.5.4.1.**

Route A : - M-18 - Njoka village - The Lower Nadzipulu Irrigation Project site - Chatala
- Rehabilitation works : 6.5 km
- Construction works : 2.5 km

Route B : - Mtakataka (M-17) - Chatala - Chitula
- Rehabilitation works : 13.0 km
- Construction works : 2.5 km

Route C : - Mua station (M-17) - Mwasinja
- Rehabilitation works : 12.0 km

Route D.: - Chatala - Mwasinja - Mtembanji (The Namikokwe Integrated Irrigation Project, Mtandamula portion)
- Rehabilitation works : 9.0 km

Route E : - Mtembanji (The Namikokwe Integrated Irrigation Project, Mtandamula portion) - The Lower Livulezi Irrigation Project site
- Construction works : 10.0 km

5.4.2 VILLAGE WATER SUPPLY

The number of boreholes and shallow wells for rural water supply in the project area is low for the 42 villages and about 3,800 inhabitants. Only 13 boreholes and 4 shallow wells function and the density is 3.4 / 1,000 persons for boreholes and 1.05 /1,000 persons for shallow wells. Under such conditions, fetching drinking water has pressed women, especially these women who head households in the project area, as they carry heavy loads and spending much time fetching water; about 2 hours a day.

In order to improve the above situation, the village water supply development plan was formulated. The basic concept for development is that 1 water supply system, at least, is to be installed in every village. The plan comprises the construction of a total of 29 boreholes with manual pumping equipment. Since no data and information on water quality of the groundwater in the Study area are available, a detailed investigation on water quality is required prior to the implementation of the village water supply development plan.

5.5 SUPPORTING ACTIVITIES FOR IRRIGATION AND AGRICULTURAL DEVELOPMENT

In order to ensure the expected irrigation/agricultural benefits and maintain the high project sustainability of the proposed irrigation projects over their useful life, irrigation and agricultural supporting activities are required. The following issues are crucial for sustaining the projects:

(a) Government support system in Salima ADD:

- lack of site offices and office equipment,
- lack of vehicles for O/M of the project facilities,
- lack of a communication system between the head office, branch offices, and site offices, and
- shortage of irrigation engineers, project management staff, extension workers, and operators of the irrigation facilities.

(b) Technical aspects of the governmental staff in Salima ADD

- not much experience of irrigation farming, irrigation water management, and O & M works for the irrigation facilities,
- lack of technique and know-how for management of the irrigation projects, and
- lack of institutional support for agricultural research works.

(c) Farmers' experience of the O & M works of the irrigation projects

- lack of experience of water management of irrigation on-farm facilities,
- lack of experience of and technique for the O & M works of irrigation on-farm facilities, and
- lack of experience of and technique for irrigation farming of paddy and upland crops.

For strengthening the agricultural support activities of the proposed irrigation projects in consideration of the above crucial points, the following concepts are to be included in the supporting plans for irrigation / agricultural development.

- to strengthen the facilities concerning the development support and the projects,
- to train the government staff key farmers on the management and O & M works of the irrigation projects and core farmers on irrigated farming,
- to provide equipment and machinery for the present research works, and
- to prepare the long-term supporting plan for staff training, research works, and extension of the irrigation farming techniques.

In order to realize the above concepts, a supporting plan, comprising (i) a short / medium-term component and (ii) a long-term component, was formulated which

depended on the urgency for realization, required time for preparation, and a target for realization. The following are the main features of both of the components of the supporting plan:

(a) Short / medium-term component

- Improvement of facilities concerning the supporting activities

  - to rehabilitate and improve the field office (EPA office) of Salima ADD
  - to construct site offices for the proposed irrigation projects,
  - to provide vehicles for the O & M works of the proposed irrigation projects, and
  - to provide office equipment for the field office and site offices.

- Training of the government staff and key farmers

  - to train government staff in irrigation practices, water management, irrigation farming, and post harvest works through training courses abroad,
  - to inspect irrigation projects which are successfully managed in neighbouring countries,
  - to train the key farmers on irrigation farming and O & M of on-farm facilities.

- Support of the present research activities

  - to provide equipment and tools for research and testing,
  - to provide seed and fertilizer, and
  - to prepare the primary research fields required.

(b) Long-term component

- Establishment of a development center with the objectives of training the government staff and farmers, extension of the advanced irrigation farming techniques, and agricultural research works.

  - to construct the facilities of the development center,
  - to construct an experimental farm, and
  - to provide the required equipment and machinery.

- Consecutive training of the government staff and farmers.

5.6 OPERATION AND MAINTENANCE PLAN

5.6.1 IRRIGATION DEVELOPMENT COMPONENT

The main concept of O/M plan for the irrigation projects is that the O/M works shall be executed by the beneficiaries with the assistance of the government. However, the farmers' association, which will bear the cost of the O/M works, is not organized in the proposed irrigation project areas and the farmers are not familiar with the irrigation farming and management of largescale irrigation schemes.

On the basis of the above situation, the proposed O/M plan for the irrigation development component recommends the step-by-step O/M plan. The plan comprises 2 steps: Step-1 for the initial period and Step-2 for the full development stage, as described below:

Step-1:The government will execute all the O/M works in the initial period of about 5 years after completion of the project implementation. The government will carry out the training of the farmers and assist in organizing the farmers' association. The beneficiary farmers will supply participate labor for the O/M works, as required.

Step-2:The O/M works will be handed over to the newly organized farmers' association. The government will carry out the training of the farmers continuously.

The annual O/M expenses comprise the administration expenses, O & M expenses for machinery, and those for the irrigation facilities. Since the farmers' association will be accountable for the running cost of the administration expenses by the participation of the farmers' labor force, the annual O/M expenses in the full development stage of the Project will be far lower than those in the initial stage. The annual O & M expenses for the 3 proposed irrigation projects are shown below.

Projects	Irrigation Area	Step - 1 Annual Expense	Step - 1 Unit O/M Cost	Step - 2 Annual Expense	Step - 2 Unit O/M Cost
	(ha)	(1000 MK)	(MK)	(1000 MK)	(MK)
Lower Nadzipulu	250	539	2,156	294	1,176
Namikokwe Integrated	800	640	800	384	480
Lower Livulezi	520	624	1,200	371	713

5.6.2 AGRICULTURAL DEVELOPMENT COMPONENT

The O/M works for the agricultural development facilities, such as the rice mill equipment, drying yards, and storage houses will be carried out by the beneficiary farmers. In the initial stage, the farmers will handle the management and O/M works of the facilities through the existing village organization and/or the temporary organization established by the farmers only for the agricultural development facilities. In the full stage of the Project, the management and O/M works will be handed over to the farmers' association which will be established for the O/M works of all of the Project as mentioned in the previous section 5.6.1.

5.6.3 SOCIAL INFRASTRUCTURE DEVELOPMENT COMPONENT

In conformity with the present official duties for the O/M works of the rural roads, the O/M works for the rural road networks will be carried out by MOW.

As for the O/M works for the village water supply system, the beneficiaries have to execute the works. After completion of the construction and installation of the boreholes and manual pumping equipment, the water supply system will be handed over to the administrative unit at the village level. The O/M works will be executed by the village administrative unit and the villagers will help with labor and costs.

CHAPTER 6 IMPLEMENTATION PLAN AND ORGANIZATION

6.1 IMPLEMENTATION

6.1 .1 PRINCIPLE APPROACH TO THE PROJECT IMPLEMENTATION

The projects hereby formulated include the irrigation and drainage development plan, agricultural development plan, and consolidation of the related infrastructure facilities as well as reinforcement of the supporting functions as described below.

(a) Irrigation and drainage development plan
- The Namikokwe Integrated Irrigation Development Project,
- The Lower Livulezi Irrigation Development Project, and
- The Lower Nadzipulu Irrigation Development Project.

(b) Agricultural development plan
- Consolidation of the post harvest facilities: rice mill and related structures.

(c) Social infrastructure development plan
- Improvement of the rural road networks
- Consolidation of village water supply system

(d) Supporting activities plan
- Short / medium-term plan
- Long-term plan

As for the implementation of the development components, 3 packages were formulated to realize the development goals. The packages include the irrigation project as a core, agricultural development plan, and social infrastructure development components. It is proposed that these development components will be implemented on a package-by-package basis in accordance with the priority order for implementation of the irrigation project discussed hereinafter. The implementation of the long-term plan of the supporting activities component is set as the 4 th package.

(a) First Package
  (i) The Namikokwe Integrated Irrigation Development Project
    - Construction of the irrigation and drainage system
  (ii) Agricultural development plan
    - Construction of the rice mills and related facilities (5 sites),
  (iii) Construction and installation of the village water supply system

(iv) Improvement of the rural road networks: route C and part of D

(v) Supporting activities

- Short / medium-term plan

(b) Second Package

(i) The Lower Livulezi Irrigation Development Project

- Construction of the irrigation and drainage system

(ii) Agricultural development plan

- Construction of the rice mills and related facilities (3 sites),

(iii) Improvement of the rural road networks: Route A, B and part of D

(c) Third Package

(i) The Lower Namikokwe Irrigation Project

- Construction of the irrigation and drainage system

(ii) Agricultural development plan

- Construction of the rice mills and related facilities (2 sites),

(iii) Improvement of the rural road networks: Route E

(d) Fourth Package

(i) Supporting activities component

- Long-term plan

6.1.2 IMPLEMENTATION SCHEDULE

(a) Irrigation and agricultural development component

The project works for irrigation and agricultural development are to be implemented within 3 years, including 1 year for the project preparatory works such as selection of consultants, detailed design, tendering, mobilization for implementation, and land compensation. All construction works and procurement works for the irrigation system, rural road improvement, and rice mill facilities will be carried out for 2 years on a contract basis. The implementation schedules of the 3 irrigation development projects and the rice mill facilities are shown in **Figure. 6.1.1.**

(b) Social infrastructure development and the short / medium-term plan of the supporting activities

Implementation of the social infrastructure development plan and short / medium-term plan of the supporting activities will be in the same way as that for the irrigation and agricultural development components. The construction and procurement works for these components will be carried out within 2 years, comprising 1 year for the preparatory works and 1 year for the construction / procurement works. Training of the government staff and inspection of the irrigation projects in neighbouring countries will be performed during the period of construction.

(c) Long-term plan of the supporting activities

Establishment of the development center will include the construction of buildings, irrigation facilities, and an experimental farm, and the procurement of the required equipment and machinery. The construction and procurement works will be carried out in the same way as those for the irrigation and agricultural development components. GOM will carry out the preparatory works for the establishment of the center as well as for the training of the government staff and farmers during the period of construction of the irrigation and agricultural development components. The actual implementation of the long-term plan of the supporting activities will begin depending on the progress of the short / medium-term plan and implementation of the irrigation / agricultural development components.

(d) Implementation of all of the development components

The implementation schedule for each package and the flow chart of the implementation of whole the development components are shown in **Figure 6.1.2 and Figure 6.1.3,** respectively.

6.2 ORGANIZATION AND MANAGEMENT

6.2.1 ORGANIZATION IN THE CONSTRUCTION STAGE

DOI, MOA shall be primarily responsible for implementation of all the development components under the project. As for the actual execution of the

construction works, the Construction Office under DOI will be established at the site. It will be responsible for the design of the construction works and supervision of the project facilities.

To implement the social infrastructure components of the Project, close coordination among the relevant agencies and DOI is essential and crucial. The Construction Committee in conjunction with the relevant ministries and agencies will be organized for the management of the implementation of the rural road improvement and village water supply component.

The proposed organization for the construction stage is shown in **Figure 6.2.1.**

6.2.2 ORGANIZATION IN THE OPERATION AND MAINTENANCE STAGE

DOI shall be responsible for O/M of the irrigation and agricultural development components in the initial stage. To execute the O/M works of such development components, the Project Committee headed by the representative of DOI will be organized. The Committee in conjunction with the local administrations and farmers' representatives shall be responsible for all the O/M works. Under the Committee, an O/M office will be established by reorganizing the construction office. The O/M Office will execute all the actual O/M works in conformity with the policies and guideline on the O/M works formulated by the Project Committee. The proposed O/M organization chart for the O/M Office is shown in **Figure 6.2.2.** After a certain period, the O/M works will be handed over to the farmers' organization established by the beneficiaries. DOI will act as the consultancy for technical and administrative matters concerning the O/M works. The handing over is expected to be about 5 years after the commencement of the O/M works. The detailed programme will be prepared by the Project Committee depending on the progress of the establishment of the farmers' organization.

The O/M works of the rice mill facilities under the agricultural development plan will be carried out by the beneficiary farmers through the existing village organization and/or the temporary farmers' organization in the initial stage. After establishing the farmers' association for the irrigation facilities of the irrigation development plan, the O/M works will be handed over to the farmers' association.

As mentioned in the previous chapter, the O/M works for the rural road networks and village water supply system will be carried out by MOW and the village administration units, respectively.

As for the development center in the long-term plan of the supporting activities, DOI shall be responsible for all the O/M works. The Management Office directly controlled by DOI will be established at the site of the Center. The Office shall execute the actual O/M works in conformity with the O/M programme prepared by DOI. The organisation of the office is shown in **Figure 6.2.3.**

CHAPTER 7 COST ESTIMATE

7.1 CONDITION S FOR THE COST ESTIMATE

The project cost was estimated on the basis of the following conditions:

(i) The unit prices were estimated based on the market prices in the middle of 1993 in Malawi in conformity with the Japanese standard on unit price estimation. The unit prices were checked by using current construction costs from data and information collected in MOW, MOA, and the foreign and local contractors.

(ii). The exchange rate used in the cost estimate was Malawi Kwacha 1.0 = Japanese Yen 24.0.

(iii) The main construction works will be carried out on a contract basis.

(iv) The unit price of the works was divided into the foreign currency portion and local portion. The foreign currency portion of the materials and equipment to be imported was estimated on the basis of CIF Lilongwe.

(v) The physical contingency of the cost estimate was 10 % of the total construction cost. The price contingency was assumed to be 10 % per annum for the local currency portion and 3 % for the foreign currency portion.

7.2 COST ESTIMATE FOR THE IRRIGATION AND DRAINAGE PROJECTS

7.2.1 PROJECT COST

The project cost comprises the construction cost, procurement cost of equipment and machinery, land compensation cost, engineering services cost, administration cost, and contingencies. The total cost of the proposed irrigation and drainage projects in the Study is summarized below and the details are shown in **Table 7.2.1.**

(Unit: 1,000)

Irrigation project	Local Currency (MK)	Foreign Currency (J.Yen)	Total (J.Yen)
Lower Nadzipulu Irrigation Project	16,492	517,132	912,932
Namikokwe Integrated Irrigation Project	27,523	849,990	1,510,553
Lower Livulezi Irrigation Project	28,547	860,348	1,545,467

7.2.2 OPERATION AND MAINTENANCE COST

The O/M cost comprises the administration cost, equipment cost, and O/M cost of the irrigation system. The annual O/M cost in the full operation stage for the respective irrigation projects is summarized below:

(1,000 MK)

Project	Administration Cost	O/M Equipment	Maintenance of Facilities	Total
The Lower Nadzipulu Irri. Project	300	167	72	539
The Namikokwe Integrated Irri. Project	310	204	126	640
The Lower Livulezi Irri. Project	307	183	134	624

7.2.3 REPLACEMENT COST

The metal works of the irrigation facilities and rice mill equipment will be replaced periodically. The O&M equipment and gates should be replaced 20 years after commencement of the Project. The replacement cost for the respective irrigation projects is summarized below:

(1,000 MK)

Project	Metal Works	Rice mill Equipment	Total
The Lower Nadzipulu Irri. Project	337	577	914
The Namikokwe Integrated Irri. Project	719	1,442	2,161
The Lower Livulezi Irri. Project	578	865	1,443

7.3 COST ESTIMATE FOR THE IMPROVEMENT OF SOCIAL INFRASTRUCTURE

The construction costs for the improvement of the rural road networks and village water supply were estimated on the direct cost basis. The costs are summarized below:

Route of Road	Local Currency	Foreign Currency	Total
	(1,000 MK)	(1,000 J.Yen)	(1,000 J.Yen)
(Rural road networks)			
Route A	1,375	56,315	89,324
Route B	2,235	91,512	145,152
Route C	2,321	95,032	159,735
Route D	1,547	63,354	100,490
Route E	1,719	79,393	111,656
(Rural water supply; boreholes and equipment)			
29 villages	1,330	0	31,900

7.4 COST ESTIMATE FOR THE SUPPORTING ACTIVITIES

The costs of the supporting activities for irrigation / agricultural development are shown below.

Items	Local Currency	Foreign Currency	Total Currency
	(1,000 MK)	(1,000 J.Yen)	(1,000 J.Yen)
(a) Short / medium-term plan			
- Improvement of supporting facilities	630	34,600	49,700
- improvement of field and site offices	630	14,700	29,800
- procurement of vehicles for O/M works	0	12,700	12,700
- procurement of office equipment	0	7,200	7,200
- Training of government staff and key farmers	0	35,000	35,000
- training under overseas training courses	0	22,600	22,600
- inspection of irrigation projects in neighbouring countries/training of key farmers	0	12,400	12,400
- Support of present research activities			
- procurement of tools and equipment	0	6,100	6,100
(b) Long-term plan			
- Establishment of the development center	6,200	167,700	316,100
- construction of facilities	6,200	125,900	274,300
- procurement of equipment and machinery	0	41,800	41,800

CHAPTER 8. PROJECT EVALUATION

8.1 OBJECTIVES

In order to clarify the viability of 3 irrigation and drainage projects in the 3 river basins, which were optimized and selected in Chapter 5, an evaluation of those projects was made from the viewpoints of economic feasibility, financial aspects, social affects, and environmental aspects. The following are the projects that were evaluated:

Project	Irrigation area (ha)	
	Rainy season	Dry season
Nadzipulu River Basin		
- Lower Nadzipulu irrigation project	250	224
Namikokwe River Basin		
- Namikokwe Integrated irrigation project	800	123
Livulezi River Basin		
- Lower Livulezi irrigation project	520	239

8.2 ECONOMIC EVALUATION

8.2.1 BASIC ASSUMPTION

Since no data and information concerning export subsidy, shadow exchange rates, import/export tax, etc. are available, the conversion factors for the adjustment of financial and economic prices cannot be calculated according to the standard methodology of economic evaluation. Instead of the economic internal rate of return (EIRR), a financial internal rate of return (FIRR) was used for the economic evaluation. The evaluation was based on the following basic assumptions:

(i) The construction period of each scheme would be 3 years, including 1 year for the detailed design and preparatory works.

(ii) The economic useful life of the Project would be 30 years, including the construction period of 2 years.

(iii) All prices are expressed in constant 1993 prices.

(iv) No conversion factors were applied to adjust financial cost to economic cost due to the lack of data and information.

(v) The exchange rate of US$1.00 = MK 4.33 = ¥ 104 as of 1993 was applied.

8.2.2 PRICE SETTING

The prices of farm products and inputs applied in the evaluation are summarized below.

Inputs	Unit	Financial Price
1. Farm Products		
Rice at mill gate (including value of bran)	(MK/ton)	4,000
Paddy at farm gate	(MK/ton)	1,500
Maize at farm gate	(MK/ton)	430
2. Farm Inputs		
Paddy seed	(MK/kg)	1.50
Maize seed	(MK/kg)	3.31
Urea	(MK/kg)	1.22
TSP	(MK/kg)	1.32

As seen in the table, the current paddy prices set under the government price policy are slightly higher than those on the international market, while the price of milled rice is remarkably higher. The prices of chemical fertilizer under SACA are favourable for farmers, but they are subject to change under the scheduled reformation of SACA.

8.2.3 PROJECT BENEFIT

The project benefit is defined as the difference in primary profit from crops between the future with-project and without-project conditions. On the basis of production cost and gross income, the primary profit from crops per ha was estimated for both the with-and-without project conditions. In this Study the primary profit from crops under the without-project condition was considered as the profit at present. The primary profits from crops under both the without-project and with-project conditions are shown in **Table 8.2.1.** Irrigation benefit is to be generated in the 3 rd year after the project implementation. The irrigation benefit in the full development stage in the 3 proposed irrigation and drainage projects was estimated as shown in **Table 8.2.2.**

8.2.4 PROJECT COST

(a) Capital Cost

The details of the project cost are presented in Chapter 7. The project cost consists of (i) direct construction cost,(ii) engineering services cost, (iii)

administration expenses, (iv) land acquisition expenses, (v) physical contingency, and (vi) price contingency. Excluding price contingency from the project cost, the capital cost was obtained for the purpose of the calculation of FIRR. The total capital cost and annual disbursement of it for each project are summarized below.

Projects	L/C (Million MK)	F/C (Million Yen)	Total (Million Yen)
Lower Nadzipulu Irrigation Project			
- 1st year	1.41	61.16	96.06
- 2nd year	7.34	210.23	386.37
- 3rd year	4.78	214.36	328.94
- Total capital cost	13.53	485.75	810.37
Namikokwe Integrated Irrigation Project			
- 1st year	2.30	82.28	137.43
- 2nd year	12.47	364.56	663.91
- 3rd year	7.81	351.13	538.62
- Total capital cost	22.58	797.97	1,339.96
Lower Livulezi Irrigation Project			
- 1st year	2.17	75.68	127.66
- 2nd year	14.03	406.11	724.81
- 3rd year	7.28	326.49	501.31
- Total capital cost	23.48	808.28	1,371.78

(b) Annual O&M Cost and Replacement Cost

The annual O&M cost and replacement cost discussed in Chapter 7 are summarized below.

Project	Annual OM Cost (1000 MK)	Replacement Cost (1000 MK)
Lower Nadzipulu Irrigation Project	539	914
Namikokwe Integrated Irrigation Project	640	2,161
Lower Livulezi Irrigation Project	624	1,443

8.2.5 INTERNAL RATE OF RETURN (IRR)

The value of FIRR for each irrigation project is listed below.

Project	FIRR Value (%)
Lower Nadzipulu Irrigation Project	5.5
Namikokwe Integrated Irrigation Project	11.9
Lower Livulezi Irrigation Project	7.6

8.3 FINANCIAL ANALYSIS

The farm budget was analyzed to assess whether the Project would cause sufficient incentive among the farmers in the project areas and bring about a sufficient income increase in the farmers' economy. The farm budget analysis was carried out on the typical farmers in the Mtandamula irrigation scheme and the rainfed area. The results are summarized below.

Description	unit	Mtandamula irrigation scheme		Rainfed area	
		With project condition	Without project condition	With project condition	Without project condition
Farm size	person	4.0	4.0	4.3	4.3
Cultivated land					
irrigated paddy	ha	0.4		0.36	
irrigated maize	ha	0.03		0.03	
irrigated vegetables	ha	0.03		0.03	
rainfed paddy	ha		0.4		0.36
rainfed maize	ha	1.0	1.0	0.83	0.83
Total farm income	MK	4,053	2,240	3,679	395
Livestock income	MK	41	41	126	126
Off-farm income	MK	0	0	0	184
Total income	MK	4,094	2,281	3,805	705
Total expenditure	MK	2,493	1,979	2,680	756
Balance/capacity to pay	MK	1,601	302	1,125	-51

As shown in the above table, the capacity to pay of the farmers in the Mtandamula irrigation scheme and rainfed area is MK 1,601 and MK 1,125, respectively. The farmers in both Mtandamula scheme and rainfed area will be able to afford to pay for the O/M cost after the government hands over the management of the project to the farmers' association. The farm economy, after sharing the O/M cost of the with-project condition under the 3 proposed irrigation projects, is shown in the following table:

	O/M Cost		Surplus	
	share / ha	share/ household	before sharing	after sharing
Lower Nadzipulu Irri. Project				
- rainfed area	1,176	470	1,125	655
Namikokwe Integrated Irri. Project				
- rainfed area	480	192	1,125	933
- Mtandamula	480	192	1,601	1,409
Lower Livulezi Irri. Project				
- rainfed area	713	285	1,125	840

The table shows that the farmers in the project areas will have a financial surplus after sharing the O/M cost of the with-project condition.

8.4 SOCIAL IMPACT

In addition to the direct benefits counted in the project evaluation, various secondary and intangible benefits and/or favourable socioeconomic impacts are expected under the project.

(a) Increase in employment opportunity

The opportunity for self-employment in and around the project area will be increased through the Project and this will activate monetary movement in the regional economy. Irrigation will improve the crop productivity. The increased crop production will generate other agro-industries and commercial activities. The employees will gain more work experience and technical skillfulness not only in the irrigation sector but also in the industrial and commercial sectors.

(b) Demonstration effects

The Project will play a leading role in the irrigation sector in the Central Region. With the completion of the Project, the farmers in the potential areas for further irrigation development will become more familiar with irrigated rice farming. In addition, qualified seed will be available for farmers who will cultivate rainfed paddy around the project area.

(c) Improvement of local transportation

The local transportation system will be much improved by the construction of the flood-free O&M roads along the irrigation canals and on the flood protection dikes. The road extension will not only enhance the economic activities, but will also contribute to inter-regional accessibility and communication.

(d) Improvement of farm products

The quality of rice grains will be much improved by the sufficient water supply, which minimizes crop damage and assures uniform maturing of the rice. Such improved quality would increase the marketability of the products.

(e) Increased feed sources to animals

Plant residues including rice straw and bran will be used as feed sources for local animals. It is estimated that the paddy field after harvesting can provide a stocking rate of 0.3 livestock unit s (LU) per ha (1 LU is equivalent to 300 kg of liveweight of animals).

(f) Improvement of the nutritional status of the rural population

The Project will contribute to the improvement of the nutritional status of the rural population by supplying more cereals and vegetables.

(g) Improvement of the present water supply condition

The Project should produce easy water fetching conditions by providing a deep well with pump equipment in every village in the Study area. The irrigation canals to be constructed for distributing water to the paddy fields are also water sources for the everyday use of the inhabitants.

(h) Improvement of womens' works

Installation of a deep well in every village under the Project will cause a reduction in improvement of womens' heavy work load of fetching drinking water, which has been the womens' traditional role in the Study area.

Bilharzia is recognized as a significant health problem in the smallholder irrigation schemes in Malawi. Two types of Bilharzia have been identified in Malawi: *Schistosoma haematobium* (SH) and *Schistosoma mansoni* (SM), which infest the bladder and stomach, respectively. The Bilharzia monitoring survey is carried out annually in the existing irrigation schemes by the Public Health Officer in Salima ADD. The records for 1993 showed that the proportional extent of persons with Bilharzia ranged from 12.7% to 40.9% in the existing irrigation schemes in Salima ADD. The risk of contracting Bilharzia, therefore, is much higher in relation to irrigation development.

8.5 INFLUENCE ON THE ENVIRONMENT OF THE PROJECT IMPLEMENTATION

The environmental analysis of the proposed irrigation and drainage projects was carried out from the viewpoints of: (i) effects on the ecological environment and (ii) water pollution in the rivers and Lake Malawi.

As for the ecology, no deforestation will be included in the irrigation development and the area where the specific animals and birds inhabit will not be touched under the Project. It is judged, therefore, that few effects on the ecological environment will occur under the Project.

It is supposed that fertilizers to be applied under the agricultural development plan may affect river water quality in the downstream portion of the project areas. Since there are few residential area in the downstream portion of the project areas, no effect on the everyday services of the farmers will occur. It seems that the usage of fertilizers under the Project will not cause water pollution in Lake Malawi, because of a difference in the scales of water-inflow and the lake water.

8.6 EVALUATION RESULTS

In accordance with the economic evaluation, the Namikokwe Integrated Irrigation Project has the highest economic efficiency. The Namikokwe Project, which has the largest irrigation area of the 3 proposed irrigation projects, is superior to the others in terms of the maximum use of natural resources and improvement of farm economy. In addition, the noteworthy social effects under this project can be expected as well as those under the other 2 projects.

The results of the economic evaluation and priority order for the implementation of the 3 proposed irrigation projects is shown below:

			FIRR value (%)
1 st. priority	:	The Namikokwe Integrated Irrigation Project	11.9
2 nd. priority	:	The Lower Livulezi Irrigation Project	7.6
3 rd. priority	:	The Lower Nadzipulu Irrigation Project	5.5

On the basis of the priority order for the implementation of the irrigation projects, the priority for the implementation of the proposed development packages is set out as shown in the next page:

1 st. priority : Package 1

- The Namikokwe Integrated Irrigation Project including construction of post harvest facilities
- Consolidation of the village water supply system (100%)
- Improvement of the rural road networks (C route and a part of D route)
- Supporting activities for irrigation / agricultural development (Short medium-term plan)

2 nd. priority : Package 2

- The Lower Livulezi Irrigation Project including construction of post harvest facilities
- Improvement of the rural road networks (A,B routes and a part of D route)

3 rd. priority : Package 3

- The Lower Nadzipulu Irrigation Project including construction of post harvest facilities
- Improvement of the rural road networks (E route)

(a) Early implementation of Package 1

The Namikokwe Integrated Irrigation Project has the highest economic viability of the proposed irrigation projects. The project is technically sound and achieves the maximum use of land and water resources. The project aims at the improvement of the farm economy and social welfare. Since the project includes the rehabilitation of the existing Mtandamula irrigation scheme where the farmers are familiar with irrigated agriculture, it is expected that the earlier project effects can be realized.

The improvement and construction of the rural road (route C and part of D) aim at raising the welfare of the local people and marketability of the farm products from the Project. The alleviation of the heavy work load of daily home activities is essential for women in the Project area. Among the daily home activities, fetching drinking water is the heaviest work. The consolidation of the village water supply system aims at alleviating the heavy work load of women.

In order to ensure the expected benefits from the implementation of the Project and maintain the high sustainability of the Project, the supporting activities, such as rehabilitation / construction of the field/ site office of Salima ADD, training of government staff and key farmers, and support of the present research works, are essential.

On the basis of the above, it can be strongly recommended that Package 1 should be implemented as soon as possible. The project cost for the implementation of Package 1 is shown below:

		(Million J.Yen)
1. The Namikokwe Integrated Irrigation Project	:	1,545
2. Consolidation of the village water supply system (100 %)	:	32
3. Improvement of the rural road networks (C and a part of D route)	:	193
4. Supporting activities for irrigation / agricultural development (short / medium-term plan)	:	91
Total	:	1,861

(b) Management of the Project by beneficiaries

The basic concepts for management, operation, and maintenance of the project facilities will be carried out by the beneficiary farmers as described in Chapter 5. In order to smoothly hand over the management and O/M works to the farmers' association in the full development stage of the Project, a detailed plan and preparation for establishment of the farmers' association will be required.

(c) Establishment of the development center

For the irrigation / agricultural development in the Study area, reinforcement of the government staff, especially irrigation engineers and farmers in the Project, is necessary by means of training. Also adaptive research works and their dissemination to the farmers are necessary. For this purpose, the Development Center will be established. The center will be the core for training, extension of irrigation farming techniques, and agricultural research for future irrigation / agricultural development in the whole of Malawi and the Study area.

It is recommended that GOM should proceed with the preparatory works for the establishment of the Development Center.

(d) Watershed management plan

Since sand sedimentation coupled with floods is crucial in the proposed irrigation projects in the Study area, land and water conservation in the upper watershed area is required for maintaining project sustainability. The watershed management plan comprising afforestation, reforestation, soil conservation of the upland crop fields, and protection works for riverbank erosion is to be formulated and implemented.

(e) Detailed investigation for groundwater development

There seems a potential for groundwater usage in the Study area. Since no investigation or study concerning groundwater was carried out in this feasibility study, detailed investigation and study are to be carried out for future groundwater development in both the irrigation and rural water supply fields.

(f) Establishment of the monitoring system for Bilharzia

In the full development stage of the irrigation project, it seems that Bilharzia will become a significant health problem for the farmers. In order to take appropriate measures against Bilharzia, the Bilharzia monitoring system is to be established in close cooperation with the authorities concerned.

Tables

MAIN REPORT

TABLE 1.4.1 MEMBER LIST OF JICA STUDY TEAM AND COUNTERPART PERSONNEL

Name	Position
JICA STUDY TEAM	
Mr. K. Onaka	Team Leader / Regional Development Planner (NK)
Mr. H. Takada	Irrigation and Drainage Engineer (PCI)
Dr. M. Nozaki	Agronomist (PCI)
Dr. H. Ikeda	Institutional Expert (PCI)
Mr. F. Watanabe	Hydorologist
Mr. K. Mizushima	Irrigation and Drainage Engineer (NK)
Mr. K. Ito	Soils and Land Use Expert (NK)
Mr. M. Kouyama	Agro-economist (NK)
Mr. Y. Nakata	Topographic Survey (NK)
COUNTERPART PERSONNEL	
Mr. E.P.Chingamba	Programme Manager, Salima ADD
Mr. F.J.Chakholoma	Principal agricultural, extension officer,Salima ADD
Mr. R.H.S Padambo	Senior irrigation engineer, Salima ADD
Mr. M.S.Masoambeta	Project officer, Bwanje Valley RDP
Mr. K.F.D.Nyirenda	Evaluation officer, Salima ADD
Mr. D.K.Mitta	Land husbandry officer, Salima ADD
Mr. Mphamba	Development officer, Mtakataka EPA
Mr. Chauluntha	Irrigation officer, Salima ADD
Mr. C.R.Nkuna	Irrigation officer, Bwajne Valley RDP, Salilma ADD
Mr. F.Mtambo	Senior hydrologist, Water Department

Remarks: NK Nippon Koei Co., Ltd.
PCI Pacific Consultants International

TABLE 1.4.2 LIST OF DATA AND INFORMATION COLLECTED

I. GENERAL

- An Outline of Our Government ; GOM (Government of Malawi)
- Malawi Population Cencus, 1987 ; GOM
- Statement of Development Policies, 1987 - 1996 ; GOM
- Statistical Year Book, 1987 ; GOM
- Human Development: from Poverty to Self-Reliance, 1992-96 ; GOM / UNDP

II. METEO-HYDROLOGICAL DATA

1.Discharge Data
- R.Nkhande (Thobola)
- R.Nadzipulun (Mtakataka)
- R.Nadzipokwe (Mua Mission)
- R.Namikokwe (Kampanikiza)
- R.Namikokwe (Mua-Livulezi F.R.)
- R.Livulezi (Khwekhwelele)

2.Meteorological Data
- Monkey Bay
- Salima
- Mtakataka

4. Others
- Summary of Monthly and Annual Rainfall Averages in Malawi Since Station opened, GOM

3.Rainfall Data
- Fort Mlangeni
- Salima Meteo. Station
- Salima Airport
- Dedza Meteo. Station
- Sharpevale
- Mua Mission
- Dedza Boma
- Golomoti
- Mtakataka
- Nakumba
- Melenbo
- Mlangeni
- Mlangeni

III. REPORTS CONCERNED

- Irrigation Study, Phase II, Feasibility Study, Vol.3, Irrigation Schemes (Likangala) ; Jan. 1986, GOM
- Irrigation Study, Phase II, Feasibility Study, Vol.4, Self Help Schemes ; Jan. 1986, GOM
- Agricultural Service Project, Project Preparation Exercise, Final Report ; Jun. 1992, GOM
- National Water Resources Master Plan, Annex 1, General ; Jul. 1986, GOM
- National Water Resources Master Plan, Annex 2A, Surface Water Resources General ; Jul. 1986, GOM
- National Water Resources Master Plan, Annex 6, Groundwater Resources of Malawi ; Jul. 1986, GOM
- Irrigation Schemes in Malawi,Civil Engineering Aspects ; Jan. 1980, GOM
- Shire Valley Water Resources Study, Design Report ; Jul. 1975, GOM
- Regional Irrigation Development Strategy, Draft Final Report, Vol. 1, Main Report ; May 1992, SADCC (Southern Africa Development Coordination Conference)
- Review of SLADD IV, Small Holder Irrigation Development ; Jul. 1988, GOM

TABLE 3.4.1 RECORDED MAXIMUM FLOOD DISCHARGE AT GAUGING STATION

Recorded maximum discharge of Nakaingwa river (3.F.2)

Year	Date	Discharge (m3/s.)
1958/59	Mar.5	3.00
1959/60	Mar.15	5.96
1960/61	Mar.4	5.54
1961/62	Feb.20	33.20
1962/63	Mar.17	23.60
1963/64		*
1964/65	Feb.20	85.30
1965/66	Feb.1	5.17
1966/67	Feb.2	7.89
1967/68	Jan.27	7.98
1968/69	Jan.23	9.41
1969/70	Feb.3	7.04
1970/71	Feb.19	99.70
1971/72	Mar.25	4.52
1972/73	Jan.29	2.31
1973/74	Mar.28	3.33
1974/75	Mar.8	24.30
1975/76	Mar.5	21.80
1976/77	Mar.3	10.20
1977/78	Mar.21	92.00
1978/79	Feb.26	109.00
1979/80		*
1980/81	Dec.30	38.90
1981/82	Feb.6	7.85
1982/83	Feb.15	12.07
1983/84	Feb.25	3.11
1984/85	Mar.26	8.96

Note:Station has closed since1985.

Recorded maximum discharge of Nadzipule river (3.F.3)

Year	Date	Discharge (m3/s.)
1958/59	Feb.22	25.00
1959/60	Jan.5	32.40
1960/61	Mar.4	64.60
1961/62	Dec.17	21.00
1962/63	Mar.17	51.50
1963/64	Feb.9	31.40
1964/65	Feb.20	40.20
1965/66	Feb.19	21.80
1966/67	Mar.20	81.60
1967/68	Jan.28	91.70
1968/69	Jan.30	42.40
1969/70	Dec.19	25.80
1970/71	Dec.7	21.50
1971/72	Jan.16	59.30
1972/73	Dec.6	34.30
1973/74	Feb.2	69.80
1974/75	Mar.10	17.80
1975/76		*
1976/77		*
1977/78	Mar.11	87.80
1978/79	Feb.27	33.90
1979/80	Apr.16	35.60
1980/81	Mar.4	52.90
1981/82	Jan.8	41.24
1982/83	Mar.11	21.53
1983/84	Feb.21	29.46
1984/85	Dec.27	29.78
1985/86	Jan.13	32.87
1986/87	Mar.10	30.21
1987/88	Feb.9	26.28
1988/89	Feb.4	39.87
1989/90	Jan.2	28.47
1990/91	Jan.11	16.28

Recored maximum discharge of Nadzipokwe river (3.E.1)

Year	Date	Discharge (m3/s.)
1958/59	Feb.22	5.55
1959/60	Mar.14	4.16
1960/61	Mar.4	33.90
1961/62	Feb.19	6.96
1962/63	Feb.9	8.64
1963/64	Feb.15	5.46
1964/65	Feb.21	8.08
1965/66	Feb.3	3.39
1966/67	Feb.2	5.97
1967/68	Mar.12	17.50
1968/69	Jan.29	29.00
1969/70	Dec.25	48.40
1970/71	Dec.28	26.00
1971/72	Apr.15	1.84
1972/73	Apr.9	6.86
1973/74	Jan.31	9.33
1974/75	Mar.1	22.40
1975/76	Jan.11	14.90
1976/77	Mar.2	7.07
1977/78		*
1978/79		*
1979/80	Dec.24	7.00
1980/81	Mar.4	51.80
1981/82	Feb.6	80.50
1982/83	Feb.12	8.66
1983/84	Dec.24	16.68
1984/85	Jan.31	12.64
1985/86	Dec.14	13.18
1986/87	Jan.18	12.52
1987/88	Jan.24	14.58
1988/89	Jan.8	47.39
1989/90		
1990/91	Jan.18	7.08

Recorded maximum discharge of Namlkokwe river (3.E.2)

Year	Date	Discharge (m3/s.)
1980/81	Dec.28	41.00
1981/82	Feb.7	130.16
1982/83	Feb.14	65.70
1983/84	Dec.24	*
1984/85	Feb.8	15.84
1985/86	Dec.24	117.13
1986/87	Feb.14	31.40
1987/88	Jan.25	79.02
1988/89	Jan.30	89.01
1989/90	Dec.30	44.04
1990/91	Dec.9	22.08

Note: Daily discharge data is not available before in 1980.

Recorded maximum discharge of Livulezi river (3.E.3)

Year	Date	Discharge (m3/s.)
1958/59	Dec.12	37.30
1959/60	Mar.14	17.80
1960/61	Mar.10	59.80
1961/62	Feb.20	133.00
1962/63	Feb.10	113.00
1963/64	Jan.4	68.00
1964/65	Feb.23	147.00
1965/66	Feb.24	107.00
1966/67	Jan.2	72.20
1967/68	Jan.23	33.50
1968/69	Mar.6	32.40
1969/70	Jan.28	145.00
1970/71	Jan.28	111.00
1971/72	Feb.28	61.00
1972/73	Dec.25	30.10
1973/74	Mar.20	58.40
1974/75	Mar.1	79.00
1975/76		*
1976/77	Jan.24	47.00
1977/78		*
1978/79	Dec.21	54.10
1979/80	Dec.13	74.00
1980/81	Dec.25	76.00
1981/82	Jan.26	105.00
1982/83	Feb.12	101.16
1983/84	Feb.9	118.00
1984/85	Dec.19	176.66
1985/86	Jan.26	371.98
1986/87	Mar.25	37.37
1987/88	Feb.9	34.18
1988/89	Jan.29	26.64
1989/90	Jan.2	28.23
1990/91		*

Remarks : * is data missing.

Table 3.9.1 **PLANTED AREA AND PRODUCTION OF MAJOR CROPS IN RDPs CONCERNED**

Crop	Planted Area (ha)			Production (ton)		
	Bwanje V.	Dedza H	Ntcheu	Bwanje V.	Dedza H	Ntcheu
1. Maize						
Local	24,375	42,121	55,304	22,622	35,874	53,872
Composite	1,047	-	-	1,243	-	-
Hybrid	3,108	1,415	1,257	4,263	3,152	4,200
Total	28,530	43,536	56,140	28,128	39,027	56,086
2. Rice	1,030	0	0	1,261	0	0
3. Groundnuts	2,515	3,352	2,697	3,792	1,027	1,015
4. Pulses	1,051	9,822	11,708	670	2,338	2,909
5. Wheat	0	46	1,085	0	65	681
6. Sorghum	342	-	-	91	-	-
7. Millet	1,126	-	-	370	-	-
8. Cassava	7,114	-	-	2,302	-	-
9. Irish Potatoes	0	1,536	1,029	0	6,467	4,484
10. Sweet Potatoes	1,163	0	0	1,604	0	0
11. Cotton	4,006	-	-	2,956	-	-
12. Tobacco	60	-	28	6	-	8
13. Sunflower	18	-	-	1	-	-
14. Chillies	164	-	-	82	-	-
Total	47,119	58,292	72,688	41,263	48,924	65,183

Table 5.2.1 FARM LABOUR BALANCE UNDER WITH- AND WITHOUT-PROJECT CONDITIONS

Unit : hours/5 Day

I. PRESENT CONDITIONS (WITHOUT PROJECT)

Crop/Farming Practices	Work days	Work hr/day	Nov 1	Nov 2	Nov 3	Nov 4	Nov 5	Nov 6	Dec 1	Dec 2	Dec 3	Dec 4	Dec 5	Dec 6	Jan 1	Jan 2	Jan 3	Jan 4	Jan 5	Jan 6	Feb 1	Feb 2	Feb 3	Feb 4	Feb 5	Feb 6
1. IRRIGATED PADDY (0.4 ha)																										
1. Ploughing	25	750																								
2. Breaking clods	2	28												28												
3. Nursery/sowing	5	73													73											
4. Puddling/transplant	45	1,360																		115	115	113	113	113	113	113
5. Weeding	38	875																		53	53	53	53	51	51	51
6. Birds scaring	59	1,023																								
7. Harvesting & drying	19	853																								
8. Thresh/winnow/store	20	963																								
Total Paddy (ha)	213	5,925	0	0	0	0	0	0	0	0	0	0	0	28	73	0	0	0	0	168	168	166	166	164	164	164
A. Total Paddy (0.4ha)		2,370	0	0	0	0	0	0	0	0	0	0	0	11	29	0	0	0	0	67	67	66	66	66	66	66
2. RAINFED MAIZE (0.86 ha)																										
1. Clearing	5	80																								
2. Ridging	14	224																								
3. Ridging & sowing	4	58										58														
4. Weeding	19	190												33	33	31	31	31	31							
5. Harvesting	9	93																								
Total Paddy (ha)	51	645	0	0	0	0	0	0	0	0	0	58	0	33	33	31	31	31	31	0	0	0	0	0	0	0
B. Total Paddy (0.86ha)		555	0	0	0	0	0	0	0	0	0	50	0	28	28	27	27	27	27	0	0	0	0	0	0	0
TOTAL (A+B)		3,015	0	0	0	0	0	0	0	0	0	50	0	40	58	27	27	27	27	67	67	66	66	66	66	66
AVAIL. LABOUR		7,154	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98
BALANCE		4,139	98	98	98	98	98	98	98	98	98	48	98	58	40	71	71	71	71	31	31	32	32	32	32	32
(Working Rate)		42%																								

Crop/Farming Practices	Mar 1	Mar 2	Mar 3	Mar 4	Mar 5	Mar 6	Apr 1	Apr 2	Apr 3	Apr 4	Apr 5	Apr 6	May 1	May 2	May 3	May 4	May 5	May 6	Jun 1	Jun 2	Jun 3	Jun 4	Jun 5	Jun 6
1. IRRIGATED PADDY (0.4 ha)																								
1. Ploughing																								
2. Breaking clods																								
3. Nursery/sowing																								
4. Puddling/transplant	113	113	113	113	113																			
5. Weeding	51	51	51	51	51	51	51	51	51	51														
6. Birds scaring											88	85	85	85	85	85	85	85	85	85	85	85		
7. Harvesting & drying																				143	142	142	142	142
8. Thresh/winnow/store																								163
Total Paddy (ha)	164	164	164	164	164	51	51	51	51	51	88	85	85	85	85	85	85	85	85	228	227	227	142	305
A. Total Paddy (0.4ha)	66	66	66	66	66	20	20	20	20	20	35	34	34	34	34	34	34	34	34	91	91	91	57	122
2. RAINFED MAIZE (0.86 ha)																								
1. Clearing																								
2. Ridging																								
3. Ridging & sowing																								
4. Weeding																								
5. Harvesting																46	47							
Total Paddy (ha)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	46	47	0	0	0	0	0	0	0
B. Total Paddy (0.86ha)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	40	0	0	0	0	0	0	0
TOTAL (A+B)	66	66	66	66	66	20	20	20	20	20	35	34	34	34	34	74	74	34	34	91	91	91	57	122
AVAIL. LABOUR	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98
BALANCE	32	32	32	32	32	78	78	78	78	78	63	64	64	64	64	24	24	64	64	7	7	7	41	-24
(Working Rate)																								

Crop/Farming Practices	Jul 1	Jul 2	Jul 3	Jul 4	Jul 5	Jul 6	Aug 1	Aug 2	Aug 3	Aug 4	Aug 5	Aug 6	Sep 1	Sep 2	Sep 3	Sep 4	Sep 5	Sep 6	Oct 1	Oct 2	Oct 3	Oct 4	Oct 5	Oct 6
1. IRRIGATED PADDY (0.4 ha)																								
1. Ploughing																			125	125	125	125	125	125
2. Breaking clods																								
3. Nursery/sowing																								
4. Puddling/transplant																								
5. Weeding																								
6. Birds scaring																								
7. Harvesting & drying	142																							
8. Thresh/winnow/store	160	160	160	160	160																			
Total Paddy (ha)	302	160	160	160	160	0	0	0	0	0	0	0	0	0	0	0	0	0	125	125	125	125	125	125
A. Total Paddy (0.4ha)	121	64	64	64	64	0	0	0	0	0	0	0	0	0	0	0	0	0	50	50	50	50	50	50
2. RAINFED MAIZE (0.86 ha)																								
1. Clearing																40	40							
2. Ridging																						76	74	74
3. Ridging & sowing																								
4. Weeding																								
5. Harvesting																								
Total Paddy (ha)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	40	0	0	0	0	76	74	74
B. Total Paddy (0.86ha)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34	34	0	0	0	0	65	64	64
TOTAL (A+B)	121	64	64	64	64	0	0	0	0	0	0	0	0	0	0	34	34	0	50	50	50	115	114	114
AVAIL. LABOUR	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98
BALANCE	-23	34	34	34	34	98	98	98	98	98	98	98	98	98	98	64	64	98	48	48	48	-17	-16	-16
(Working Rate)																								

II. WITH PROJECT CONDITIONS

Crop/Farming Practices	Work days	Work hr/day	Nov 1	Nov 2	Nov 3	Nov 4	Nov 5	Nov 6	Dec 1	Dec 2	Dec 3	Dec 4	Dec 5	Dec 6	Jan 1	Jan 2	Jan 3	Jan 4	Jan 5	Jan 6	Feb 1	Feb 2	Feb 3	Feb 4	Feb 5	Feb 6
1. IRRIGATED PADDY (0.4 ha)																										
1. Ploughing	25	750	150	150	150	150	150																			
2. Breaking clods	2	28					28																			
3. Nursery/sowing	5	73						37	36																	
4. Puddling/transplant	45	1,200								200	200	200	200	200	200											
5. Basal dosage	2	10										10														
6. Top-dressing	4	20														10								10		
7. Weeding	38	875														150	145	145	145	145	145					
8. Birds scaring	59	1,023																				173	170	170	170	170
9. Harvesting & drying	19	853																								
10. Thresh/winnow/store	20	963																								
11. Irrigation O&M	10	500																								
Paddy (ha)	229	6,295	150	150	150	150	178	37	36	200	200	210	200	200	200	160	145	145	145	145	145	173	170	180	170	170
A. Paddy (0.4ha)		2,518	60	60	60	60	71	15	14	80	80	84	80	80	80	64	58	58	58	58	58	69	68	72	68	68
2. IRRIGATED MAIZE (0.03ha)																										
1. Clearing	5	80																								
2. Ridging	14	224																								
3. Ridging & sowing	4	58																								
4. Weeding	19	190																								
5. Harvesting	9	93																								
Maize (1 ha)	51	645	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B. Maize (0.03ha)		19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3. IRRIGATED VEGETABLES (0.03ha)																										
1. Land Preparation	30	300																								
2. Fertilizer Application	2	10																								
3. Transplanting	50	1,500																								
4. Pest Control	2	10																								
5. Harvesting	20	600																								
Vegetables (1 ha)	104	2920	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. Vegetables (0.03ha)		88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4. RAINFED MAIZE (0.86 ha)																										
1. Clearing	5	80																								
2. Ridging	14	224																								
3. Ridging & sowing	4	58								18	16	16	16													
4. Weeding	19	190												20	20	33	39	39	39							
5. Harvesting	9	93																								
Maize (ha)	51	645	0	0	0	0	0	0	0	18	16	16	16	20	20	33	39	39	39	0	0	0	0	0	0	0
D. Maize (0.86ha)		555	0	0	0	0	0	0	0	15	14	14	14	17	17	28	34	34	34	0	0	0	0	0	0	0
TOTAL (A+B+C+D)		3,180	79	79	79	79	91	34	14	95	94	98	94	97	97	92	92	92	92	58	58	69	68	72	68	68
AVAIL. LABOUR		7,154	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98
BALANCE		3,974	19	19	19	19	7	64	84	3	4	0	4	1	1	6	6	6	6	40	40	29	30	26	30	30
(Working Rate)		44%																								

Crop/Farming Practices	Mar 1	Mar 2	Mar 3	Mar 4	Mar 5	Mar 6	Apr 1	Apr 2	Apr 3	Apr 4	Apr 5	Apr 6	May 1	May 2	May 3	May 4	May 5	May 6	Jun 1	Jun 2	Jun 3	Jun 4	Jun 5	Jun 6
1. IRRIGATED PADDY (0.4 ha)																								
1. Ploughing																								
2. Breaking clods																								
3. Nursery/sowing																								
4. Puddling/transplant																								
5. Basal dosage																								
6. Top-dressing																								
7. Weeding																								
8. Birds scaring	170	170																						
9. Harvesting & drying			214	213	213	213																		
10. Thresh/winnow/store							163	160	160	160	160	160												
11. Irrigation O&M																								
Paddy (ha)	170	170	214	213	213	213	163	160	160	160	160	160	0	0	0	0	0	0	0	0	0	0	0	0
A. Paddy (0.4ha)	68	68	86	85	85	85	65	64	64	64	64	64	0	0	0	0	0	0	0	0	0	0	0	0
2. IRRIGATED MAIZE (0.03ha)																								
1. Clearing																					40	40		
2. Ridging																							112	112
3. Ridging & sowing																								
4. Weeding																								
5. Harvesting																								
Maize (1 ha)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	40	112	112
B. Maize (0.03ha)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	3	3
3. IRRIGATED VEGETABLES (0.03ha)																								
1. Land Preparation																	133	133	133	133	133	133		
2. Fertilizer Application																							10	
3. Transplanting																								
4. Pest Control																								
5. Harvesting																								
Vegetables (1 ha)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	133	133	133	133	133	133	10	0
C. Vegetables (0.03ha)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	4	4	4	4	0	0
4. RAINFED MAIZE (0.86 ha)																								
1. Clearing																								
2. Ridging																								
3. Ridging & sowing																								
4. Weeding																								
5. Harvesting																46	47							
Maize (ha)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	46	47	0	0	0	0	0	0	0
D. Maize (0.86ha)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	40	0	0	0	0	0	0	0
TOTAL (A+B+C+D)	68	68	86	85	85	85	65	64	64	64	64	64	0	0	0	40	44	4	4	4	4	4	0	0
AVAIL. LABOUR	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98
BALANCE	30	30	12	13	13	13	33	34	34	34	34	34	98	98	98	58	54	94	94	94	94	94	98	98
(Working Rate)																								

Crop/Farming Practices	Jul 1	Jul 2	Jul 3	Jul 4	Jul 5	Jul 6	Aug 1	Aug 2	Aug 3	Aug 4	Aug 5	Aug 6	Sep 1	Sep 2	Sep 3	Sep 4	Sep 5	Sep 6	Oct 1	Oct 2	Oct 3	Oct 4	Oct 5	Oct 6
1. IRRIGATED PADDY (0.4 ha)																								
1. Ploughing																								
2. Breaking clods																								
3. Nursery/sowing																								
4. Puddling/transplant																								
5. Basal dosage																								
6. Top-dressing																								
7. Weeding																								
8. Birds scaring																								
9. Harvesting & drying																								
10. Thresh/winnow/store																								
11. Irrigation O&M															50	50	50	50	50	50	50	50	50	50
Paddy (ha)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	50	50	50	50	50	50	50	50	50
A. Paddy (0.4ha)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	20	20	20	20	20	20	20	20	20
2. IRRIGATED MAIZE (0.03ha)																								
1. Clearing																								
2. Ridging																								
3. Ridging & sowing	58																							
4. Weeding		18	18	18	17	17	17	17	17	17	17													
5. Harvesting												47	46											
Maize (1 ha)	58	18	18	18	17	17	17	17	17	17	17	47	46	0	0	0	0	0	0	0	0	0	0	0
B. Maize (0.03ha)	2	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
3. IRRIGATED VEGETABLES (0.03ha)																								
1. Land Preparation																								
2. Fertilizer Application																								
3. Transplanting				500	500	500																		
4. Pest Control									10															
5. Harvesting												200	200	200										
Vegetables (1 ha)	0	0	0	500	500	500	0	0	10	0	0	200	200	200	0	0	0	0	0	0	0	0	0	0
C. Vegetables (0.03ha)	0	0	0	15	15	15	0	0	0	0	0	6	6	6	0	0	0	0	0	0	0	0	0	0
4. RAINFED MAIZE (0.86 ha)																								
1. Clearing																40	40							
2. Ridging																						76	74	74
3. Ridging & sowing																								
4. Weeding																								
5. Harvesting																								
Maize (ha)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	40	0	0	0	0	76	74	74
D. Maize (0.86ha)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34	34	0	0	0	0	65	64	64
TOTAL (A+B+C+D)	3	3	3	18	18	18	1	1	1	1	1	7	7	7	21	56	56	21	20	20	20	85	84	84
AVAIL. LABOUR	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98	98
BALANCE	95	95	95	80	80	80	97	97	97	97	97	91	91	91	77	42	42	77	78	78	78	13	14	14
(Working Rate)																								

TABLE 5.2.2 REQUIRED CAPACITY AND NUMBERS OF RICE MILL

	Item	Unit	Lower Nadzipulu Irrigation Project	Namikokwe Integrated Irrigation Project	Lower Livulezi Irrigation Project
1	Irrigation Area	(ha)	250	800	520
2	Production (4.0/ha)	(tons)	1,000	3,200	2,080
3	Numbers of Farmers		625	2,000	1,300
4	Self Consumption Rice				
	(1) Annual				
	(320 kg/Year/household))	(tons)	200	640	416
	(2) Required cap[acity of rice mill				
	−10 months x 20 days	(ton/day)	1.0	3.2	2.1
	−6 hours／day	(ton/hr)	0.17	0.54	0.35
5	Marketing Rice				
	(1) Max. possible amount	(tons)	800	2,560	1,664
	(2) Milling amount (50 % of (1))	(tons)	400	1,280	832
	(3) Required capacity og rice mill				
	−3 months x 20 days	(ton/day)	6.7	21.4	13.9
	−6 hours／day	(ton/hr)	1.12	3.57	2.32
6	Required Capacity and Numbers of Rice Mill				
	(1) Required Capacity (4 + 5)	(ton/hr)	1.29	4.11	2.67
	(2) Required Nos. (1.0 ton/hr)	(set)	2	5	3

TABLE 5.3.1 ALTERNATIVE PLAN FOR IRRIGATION DEVELOPMENT PROJECTS (1/2)

(1) Headworks for the Lower Nadzipulu Irrigation Project

	Alternative-1	Alternative-2
- Location	2.5 km upstream of the project area	1.5 km upstream of Alt-1 site
- Design flood Discharge	266.1 m3/sec.	266.1 m3/sec.
- Intake discharge	0.36 m3/sec.	0.36 m3/sec.
- Structures		
-Weir height	1.0 m above river bed (2.0 m in total)	1.0 m above river bed (3.0 m in total)
-Weir length	56.4 m	56.4 m
-Scouring sluice	1.2 m wide X 2 Nos.	1.2 m wide X 2 Nos.
-Intake gate	0.7 m wide	0.7 m wide
-flood dike	(construct as connecting road)	(construct as inspection road)
-Irrigation canal length	-	1.5 km longer than Alt.-1
-Construction method	dry condition by using river meandering	river diversion channel required

(2) Headworks for Irrigation Projects in the Namikokwe River Basin

	Alternative-1	Alternative-2
- Location	0.6 km downstream of the conjunction of the Namikokwe with Nadzipokwe	0.7 km downstream of Alt-1
- Design flood Discharge	205.4 m3/sec.	205.4 m3/sec.
- Intake Capacity	0.81 m3/sec.	0.81 m3/sec.
- Structures		
-Weir height	1.4 m above river bed (2.4 m in total)	1.4 m above river bed (3.4 m in total)
-Weir length	46.4 m	46.4 m
-Scouring sluice	1.2 m wide X 2 Nos.	1.2 m wide X 2 Nos.
-Intake gate	0.9 m wide X 2 Nos.	0.9 m wideX 2 Nos.
-flood dike	300 m long on the left bank	1.0 km on the left bank
-Irrigation canal length	0.55 km longer than Alt-2	
-Construction method	dry condition by using river meandering	river diversion channel be required

(3) Three Integrated Irrigation Projects in the Namikokwe River Basin

	Integrated-1	Integrated-2	Integrated-3
- Irrigation area	800 ha	730 ha	960 ha
- Project facilities			
- Head works	1 site	1 site	1 site
- Main irrigation canal	6.7 km	6.7 km	6.7 km
- Branch canals	8.3 km	7.4 km	11.9 km
- Tertiary canals	55.7 km	54.2 km	66.8 km
- Drainage canals	12.2 km	17.8 km	17.8 km
- Inspection roads	12.8 km	12.9 km	15.6 km
- Road/flood protection dikes	7.0 km	7.0 km	7.0 km
- Connecting road	2.4 km	1.8 km	2.4 km
- Rice mill and related facilities	5 sites	5 sites	6 sites

TABLE 5.3.1 ALTERNATIVE PLAN FOR IRRIGATION DEVELOPMENT PROJECTS (2/2)

(4) Alternatives for the Lower Livulezi Irrigation Project

	Alternative-1	Alternative-2
- Irrigation area	520 ha	380 ha
- Project facilities		
- Head works	1 site	1 site
- Main irrigation canal	11.1 km	7.8 km
- Branch canals	1.0 km	-
- Tertiary canals	38.3 km	21.8km
- Drainage canals	13.7 km	11.2 km
- Inspection roads	8.5 km	2.5 km
- Road/flood protection dikes	6.1 km	4.2 km
- Connecting road	2.5 km	3.6 km
- Rice mill and related facilities	3 sites	2 sites
- Additional Works		
- Rehabilitation of Culverts on M-18	Required	Not required
- River dredging	1.0 km	

TABLE 7.2.1 PROJECT COST FOR IRRIGATION PROJECTS (1/2)

(1) The Lower Nadzipulu Irrigation Project

	Description	Local Currency	Foreign Currency	Total
		(1,000 MK)	(1,000 J.Yen)	(1,000 J.Yen)
I.	Direct Construction Cost			
	1. Preparatory Works	623	19,141	34,093
	2. Head Works	1,609	37,970	76,586
	3. Main Canals	2,246	44,701	98,605
	4. Branch Canal	160	2,567	6,407
	5. Inspection Roads	741	43,650	61,434
	6. Flood Dike/Road	845	46,653	66,933
	7. Connecting Road	873	46,584	67,536
	8. Tertiary Development	1,545	71,714	108,794
	9. Drainage Canals	106	3,649	6,193
	10.Rice Mill	356	18,566	27,110
	(Sub-total)	(9,104)	(335,195)	(553,691)
II.	Engineering Services	1,190	106,400	134,960
III.	Administration Cost	1,627	0	39,048
VI.	Land Compensation	375	0	9,000
	(Total; I-V)	12,296	441,595	736,699
V.	Contingencies			
	1. Physical	1,230	44,160	73,670
	2. Price	2,966	31,378	102,563
	(Grand Total; I - VI)	16,492	517,132	912,932

(2) The Namikokwe Integrated Irrigation Project

	Description	Local Currency	Foreign Currency	Total
		(1,000 MK)	(1,000 J.Yen)	(1,000 J.Yen)
I.	Direct Construction Cost			
	1. Preparatory Works	1,120	33,036	59,916
	2. Head Works	1,607	38,311	76,879
	3. Main Canals	2,644	65,401	128,857
	4. Branch Canal	2,614	40,191	102,927
	5. Inspection Roads	1,198	70,603	99,355
	6. Flood Dike/Road	1,075	61,927	87,727
	7. Connecting Road	248	13,310	19,262
	8. Tertiary Development	4,606	216,938	327,482
	9. Drainage Canals	441	13,689	24,273
	10.Rice Mill	891	46,416	67,800
	(Sub-total)	(16,444)	(599,822)	(994,478)
II.	Engineering Services	1,398	125,600	159,128
III.	Administration Cost	1,834	0	44,016
VI.	Land Compensation	855	0	20,520
	(Total; I-V)	20,530	725,422	1,218,142
V.	Contingencies			
	1. Physical	2,053	72,542	121,812
	2. Price	4,941	52,026	170,599
	(Grand Total; I - VI)	27,523	849,990	1,510,553

TABLE 7.2.1 PROJECT COST FOR IRRIGATION PROJECTS (2/2)

(3) The Lower Livulezi Irrigation Project

	Description	Local Currency (1,000 MK)	Foreign Currency (1,000 J.Yen)	Total (1,000 J.Yen)
I.	Direct Construction Cost			
	1. Preparatory Works	1,203	35,146	64,018
	2. Culvert on M-18	971	14,206	37,510
	3. River Dredging	46	3,995	5,099
	4. Head Works	3,802	135,333	226,581
	5. Main Canals	3,822	73,412	165,140
	6. Branch Canal	393	5,879	15,311
	7. Inspection Roads	795	38,066	57,146
	8. Flood Dike/Road	1,478	84,022	119,494
	9. Connecting Road	273	14,208	20,760
	10.Tertiary Development	3,217	149,269	226,477
	11.Drainage Canals	846	33,812	54,116
	12.Rice Mill	534	27,850	40,666
	(Sub-total)	(17,380)	(615,198)	(1,032,318)
II.	Engineering Services	1,351	119,600	152,024
III.	Administration Cost	1,834	0	44,016
VI.	Land Compensation	780	0	18,720
	(Total; I-V)	21,345	734,798	1,247,078
V.	Contingencies			
	1. Physical	2,135	73,480	124,708
	2. Price	5,067	52,070	173,681
	(Grand Total; I - VI)	28,547	860,348	1,545,467

TABLE 8.2.1 PRIMARY PROFIT FROM CROPS

(1) Paddy

Items	Unit	Without Project-1 (paddy) Unit Yield (a) (kg)	Unit Price (b) (MK)	Amount (a x b) (MK)	Without Project-2 (paddy) Unit Yield (a) (kg)	Unit Price (b) (MK)	Amount (a x b) (MK)	With Project (Milled Rice) Unit Yield (a) (kg)	Unit Price (b) (MK)	Amount (a x b) (MK)
Gross Revenue	kg	2,700.0	1.5	4,050.0 (c)	1,000.0	1.5	1,500.0 (c)	2,925.0	4.0	11,700.0 (c)
Farm Inputs										
1) Seeds	kg	90.0	1.5	135.0	90.0	1.5	135.0	40.0	1.5	60.0
2) Fertilizers										
- Urea	kg	0.0	1.2	0.0	0.0	1.2	0.0	190.0	1.2	231.0
- TSP	kg	0.0	1.3	0.0	0.0	1.3	0.0	54.0	1.3	71.4
Sub-total				0.0			0.0			302.5
Miscellaneous										
(5 % of product. cost)		5%		6.8	5%		6.8	5%		18.1
Total Production Cost				141.8 (d)			141.8 (d)			380.6 (d)
Net Return per Ha										
(e = c - d)				3,908.3			1,358.3			11,319.4
(e/c %)				97%			91%			97%

Remarks: * "Without project-1" indicates crop budget for irrigated rice in the existing Mtandamula scheme, while "Without project-2" for rainfed paddy in Upper Namikokwe area and Livulezi area.

(2) Maize

Items	Unit	Without Project Unit Yield (a) (kg)	Unit Price (b) (MK)	Amount (a x b) (MK)	With Project Unit Yield (a) (kg)	Unit Price (b) (MK)	Amount (a x b) (MK)
Gross Revenue	kg	1,000.0	0.43	430.0 (c)	2,000.0	0.43	860.0 (c)
Farm Inputs							
1) Seeds	kg	60.0	1.0	58.8	25.0	3.3	82.8
Miscellaneous							
(5 % of product. cost)		5%		2.9	5%		4.1
Total Production Cost				61.7 (d)			86.9 (d)
Net Return per Ha							
(c - d)				368 (e)			773 (e)
(e/c %)				86%			90%

(3) Vegetable

Items	Unit	With Project Unit Yield (a) (kg)	Unit Price (b) (MK)	Amount (a x b) (MK)
Gross Revenue*	kg	-	-	13,902.0 (c)
Farm Inputs				
1) Seeds	kg	-	-	381.0
2) Fertil./chemi	kg	-	-	1,960.0
Miscellaneous				
(5 % of product. cost)		5%		117.1
Total Production Cost				2,458.1 (d)
Net Return per Ha				
(c - d)				11,444 (e)
(e/c %)				82.3%

Remark: * Estimated at 70% of the farm budget in Ngolowind Irrigation Scheme

TABLE 8.2.2 IRRIGATION BENEFIT AT FULL DEVELOPMENT STAGE

(1) The Lower Nadzipulu Irrigation Project

	Area (ha)	Unit Benefit (MK/ha)	Amount (MK)
A. Without Project			
1.Rainfed paddy	0	1,358	0
2.Irrigated paddy	0	3,908	0
3.Maize	80	368	29,440
Total-A			29,440
B. With Project			
1.Irrigated paddy	250	11,319	2,829,850
2.Irrigated maize	205	773	158,465
3.Irrigated vegetable	19	11,444	217,436
Total-B			3,205,751
C. Increment			3,176,311
(1,000 J¥)			(76,231)

(2) The Namikokwe Integrated Irrigation Project

	Area (ha)	Unit Benefit (MK/ha)	Amount (MK)
A. Without Project			
1.Rainfed paddy	150	1,358	203,745
2.Irrigated paddy	230	3,908	898,909
3.Maize	150	368	55,200
Total-A			1,157,854
B. With Project			
1.Irrigated paddy	800	11,319	9,055,520
2.Irrigated maize	63	773	48,699
3.Irrigated vegetable	60	11,444	686,640
Total-B			9,790,859
C. Increment			8,633,005
(1,000 J¥)			(207,192)

(3) The Lower Livulezi Irrigation Project

	Area (ha)	Unit Benefit (MK/ha)	Amount (MK)
A. Without Project			
1.Rainfed paddy	190	1,358	258,077
2.Irrigated paddy	0	3,908	0
3.Maize	0	368	0
Total-A			258,077
B. With Project			
1.Irrigated paddy	520	11,319	5,886,088
2.Irrigated maize	200	773	154,600
3.Irrigated vegetable	39	11,444	446,316
Total-B			6,487,004
C. Increment			6,487,004
(1,000 J¥)			(149,494)

Figures

MAIN REPORT

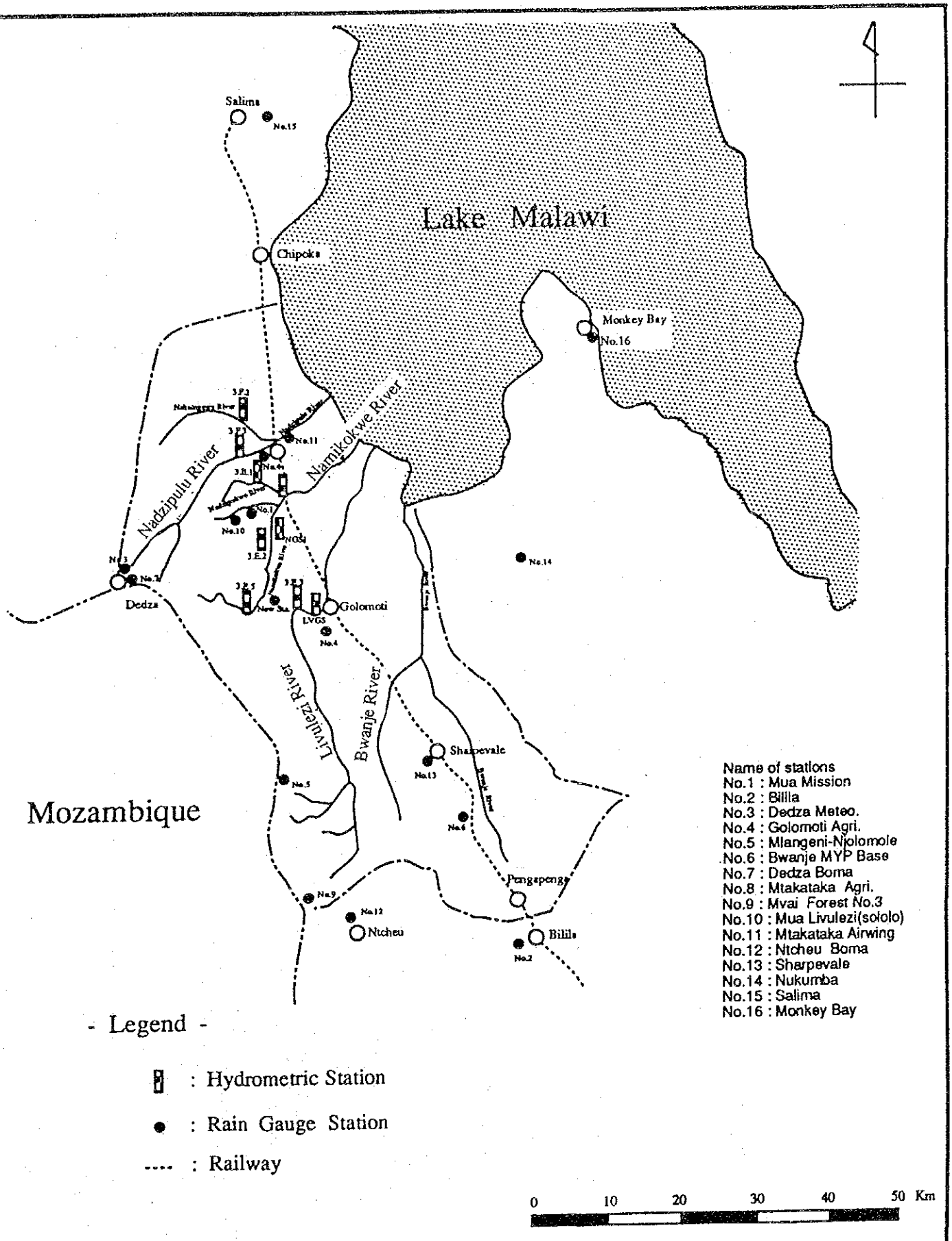


FIGURE 3.4.1 LOCATION OF METE0- AND HYDRO- OBSERVATION STATIONS

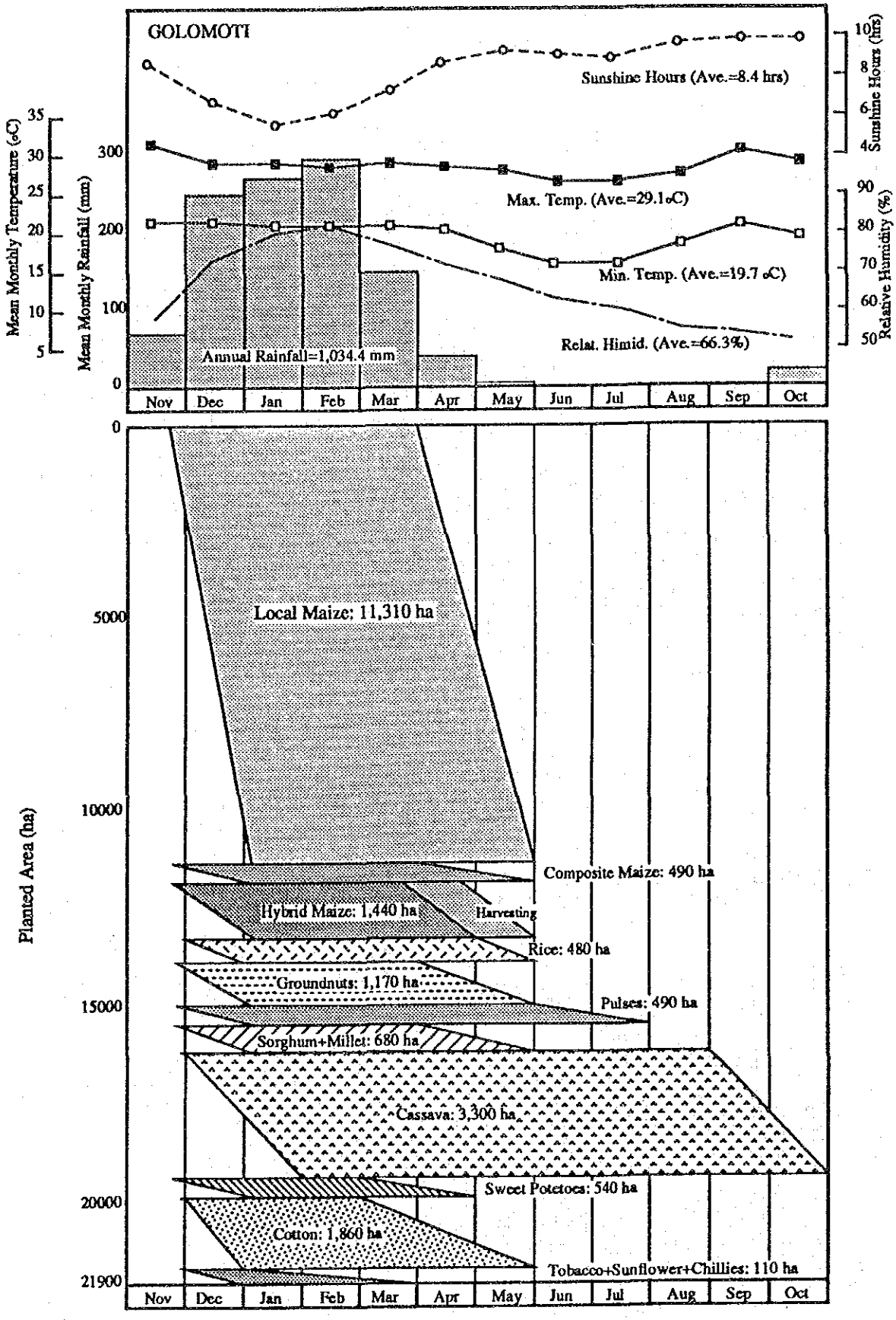


FIGURE 3.9.1 (1/3) PRESENT CROPPING PATTERNS OF THE STUDY AREA (BWANJE VALLEY RDP)

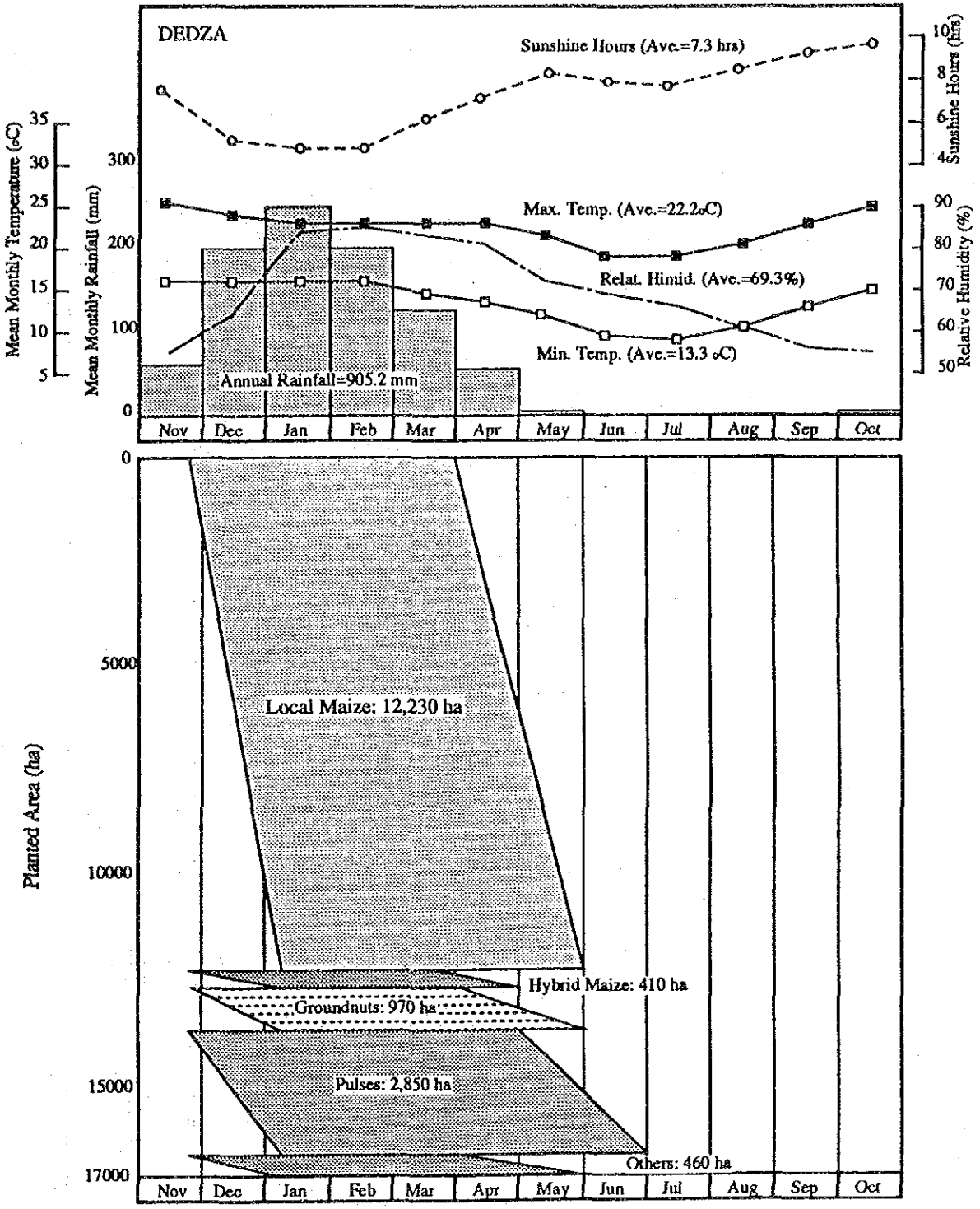


FIGURE 3.9.1 (2/3) PRESENT CROPPING PATTERNS OF THE STUDY AREA (DEDZA RDP)

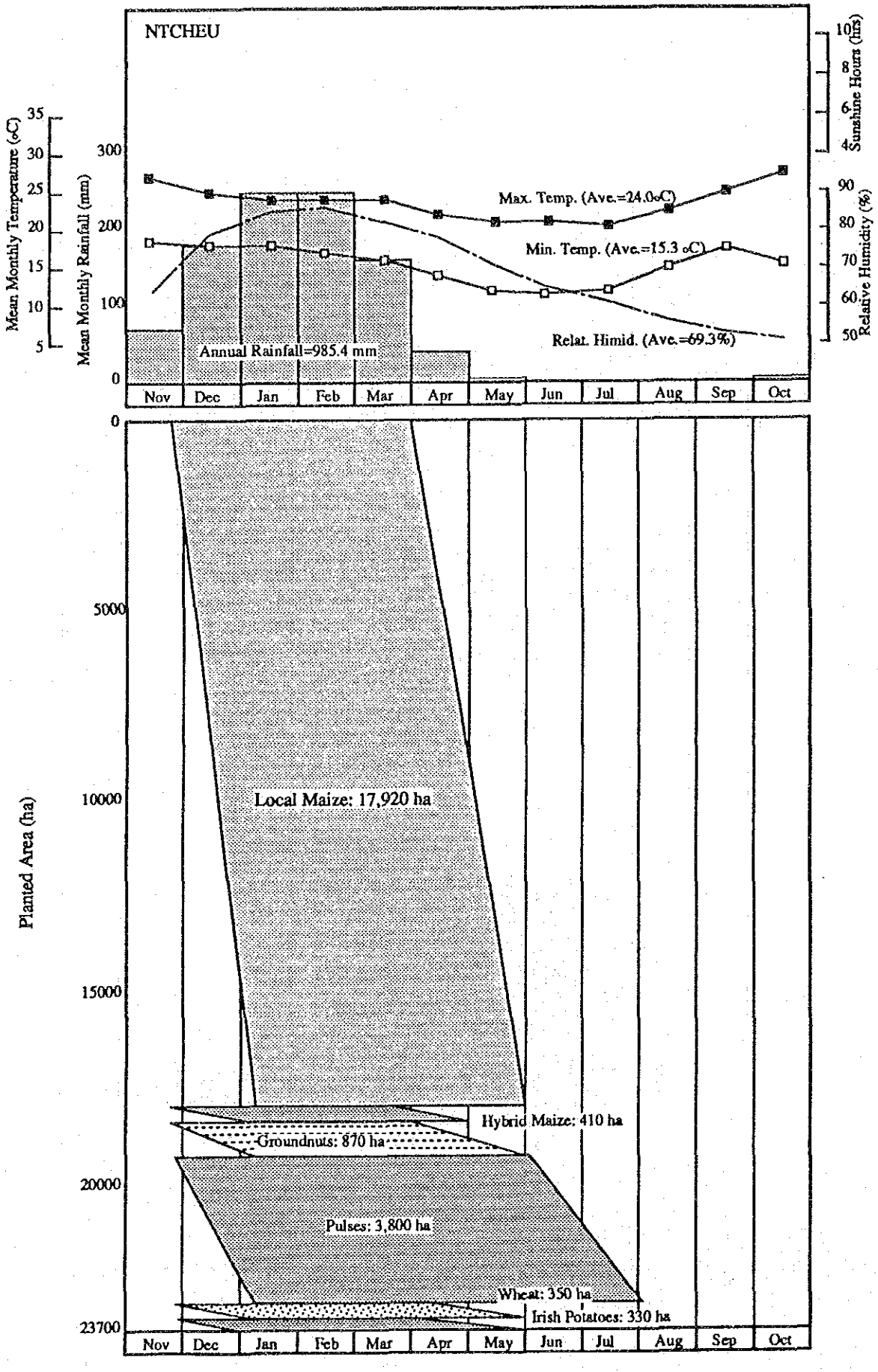


FIGURE 3.9.1 (3/3) PRESENT CROPPING PATTERNS OF THE STUDY AREA (NTCHEU RDP)

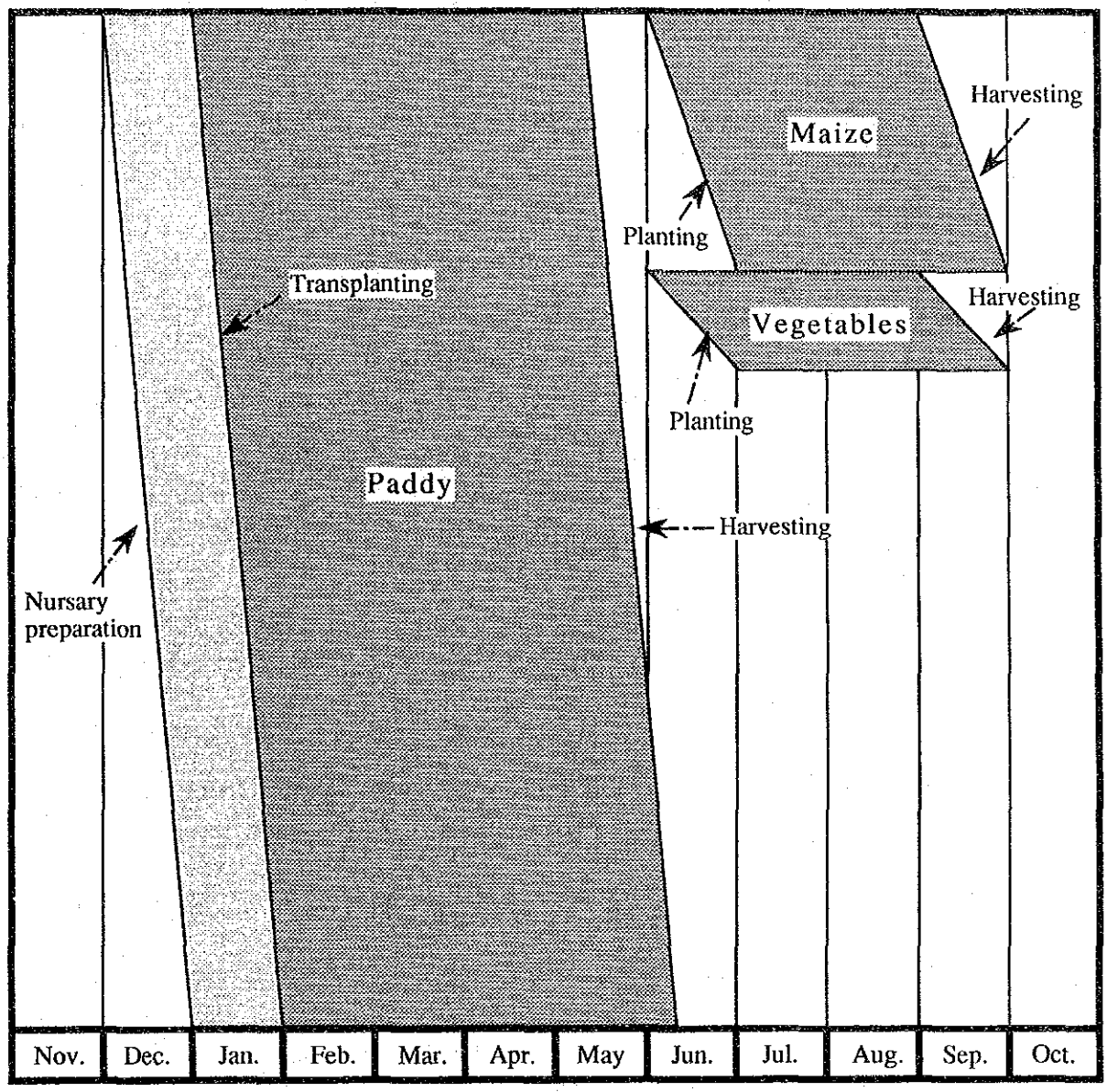


FIGURE 5.2.1 PROPOSED CROPPING PATTERN

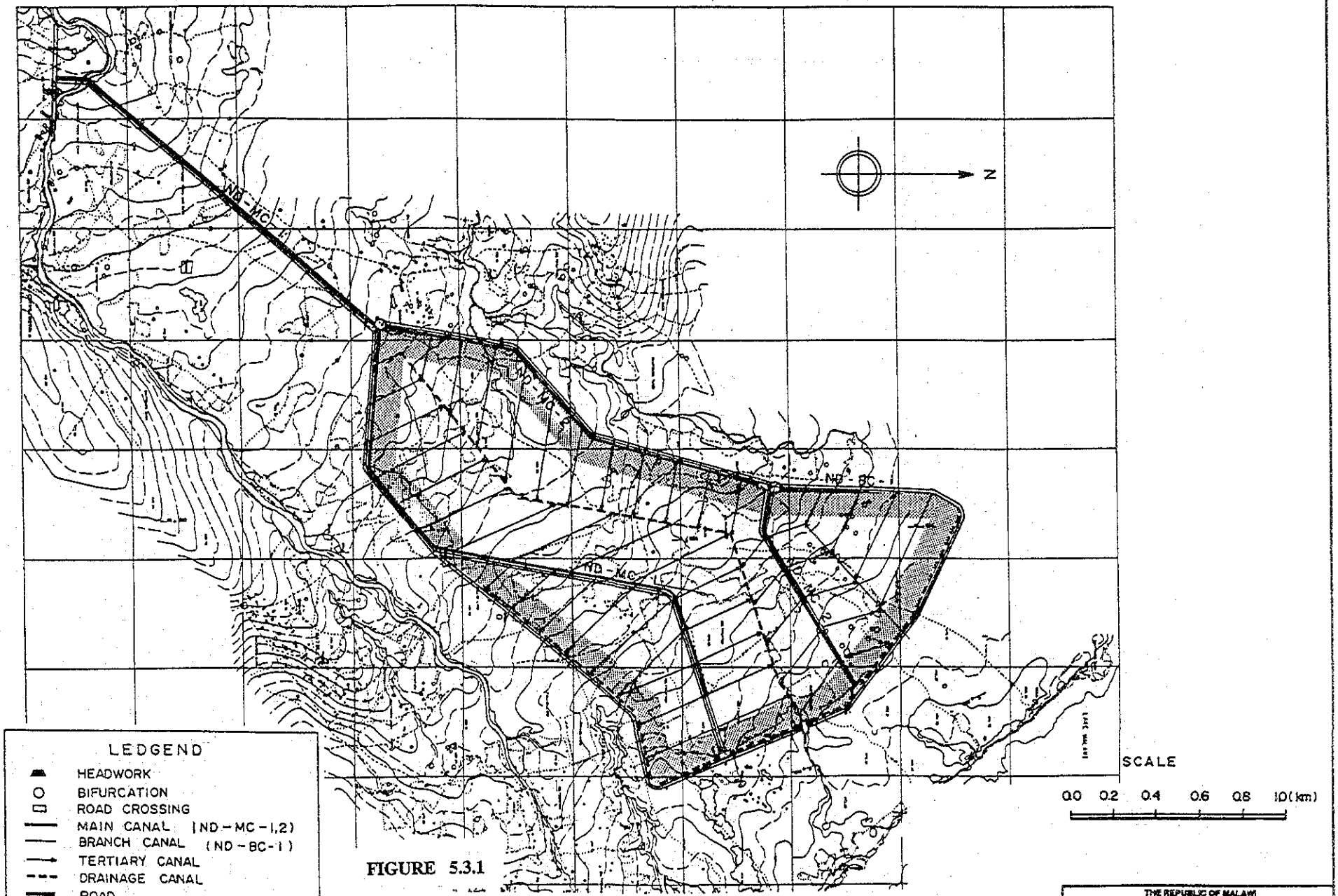


FIGURE 5.3.1

PROPOSED LAYOUT FOR THE LOWER NADZIPULU IRRIGATION PROJECT

THE REPUBLIC OF MALAWI

FEASIBILITY STUDY ON BWANJE VALLEY SMALLHOLDER IRRIGATION DEVELOPMENT PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

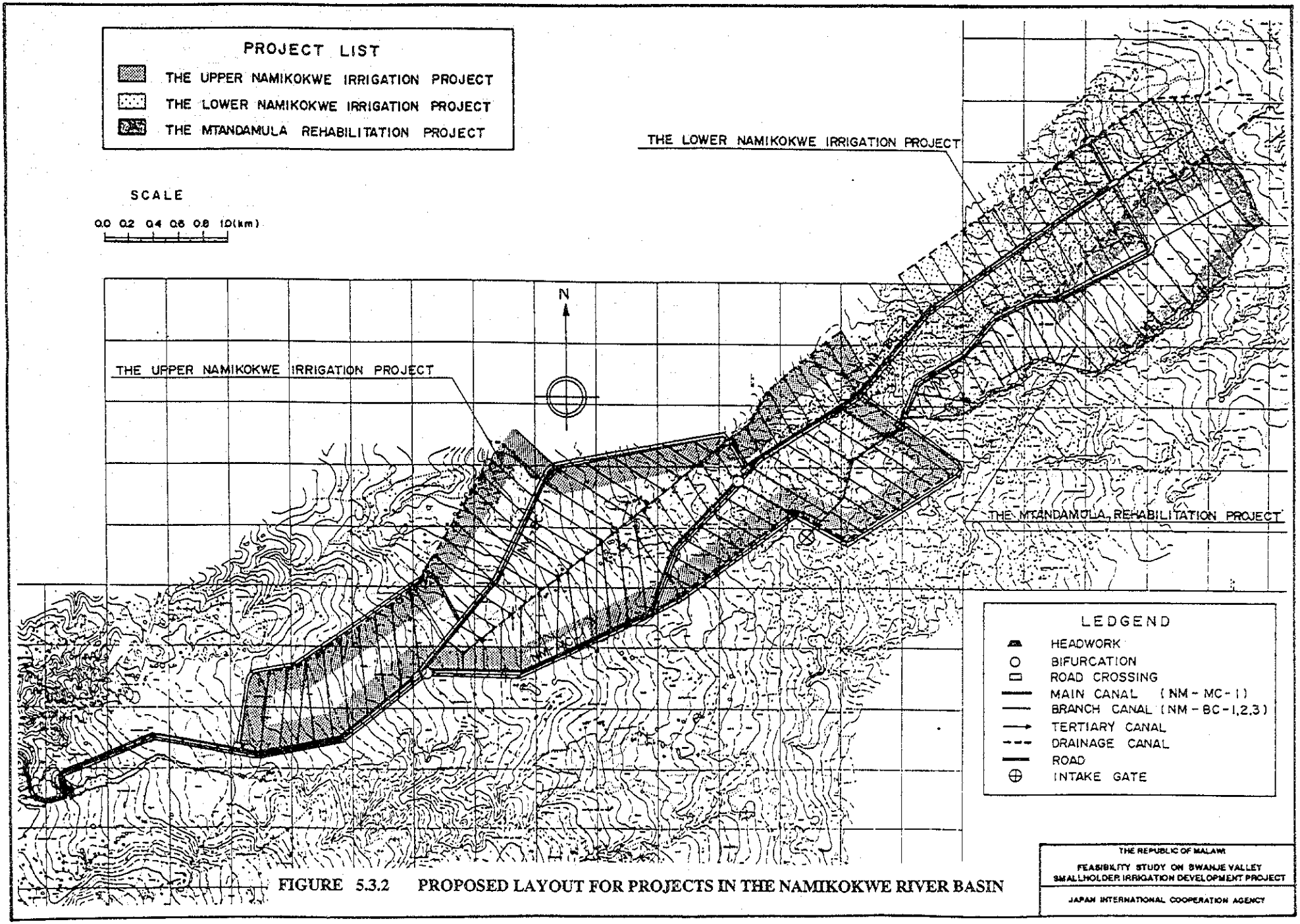
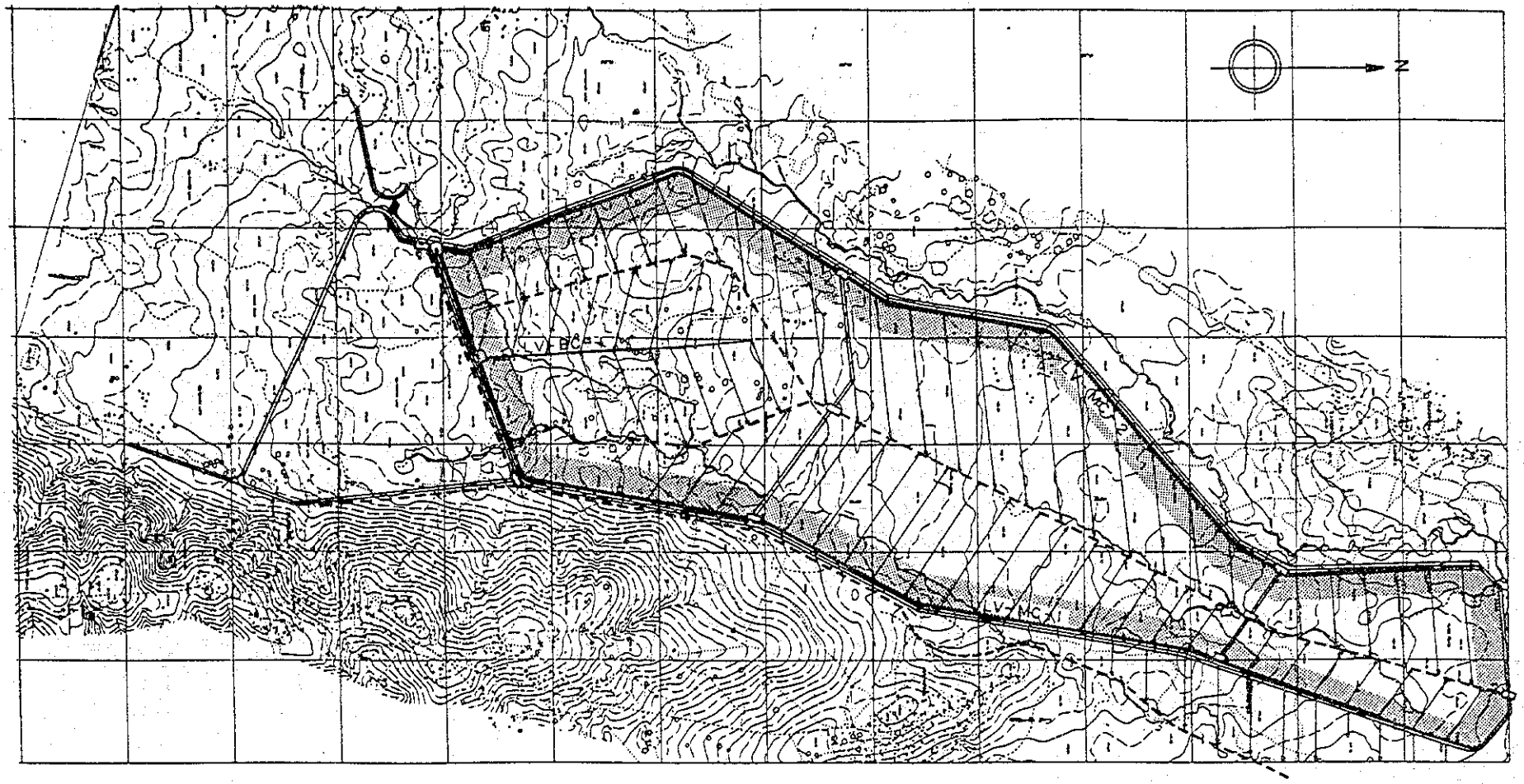


FIGURE 5.3.2 PROPOSED LAYOUT FOR PROJECTS IN THE NAMIKOKWE RIVER BASIN



LEDGEND

- HEADWORK
- BIFURCATION
- ROAD CROSSING
- MAIN CANAL (LV-MC-1, 2)
- BRANCH CANAL (LV-BC-1)
- TERTIARY CANAL
- DRAINAGE CANAL
- ROAD
- IRRIGATION AREA

SCALE

0.0 0.2 0.4 0.6 0.8 1.0(km)

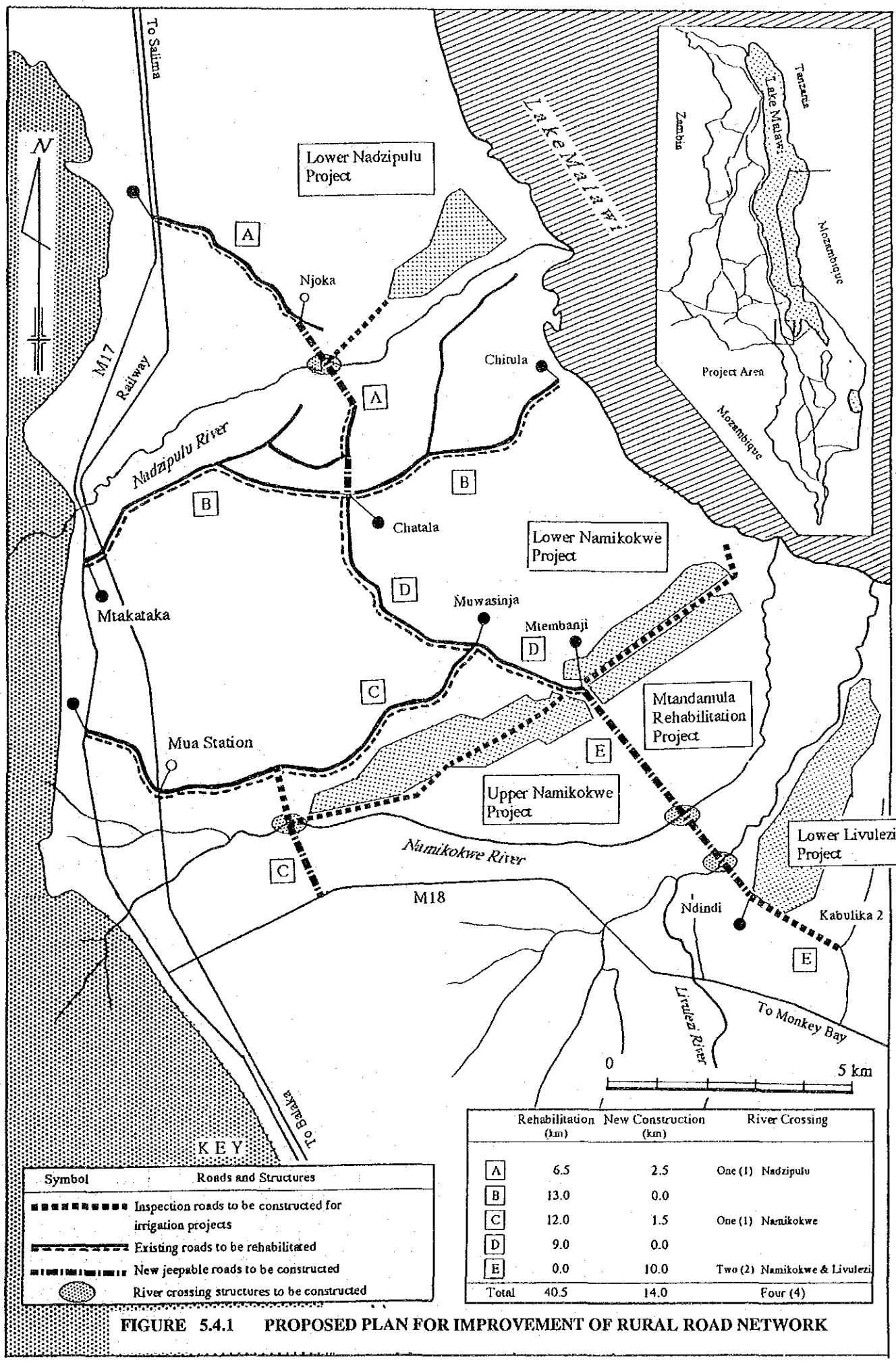
FIGURE 5.3.3

PROPOSED LAYOUT FOR THE LOWER LIVULEZI IRRIGATION PROJECT

THE REPUBLIC OF MALAWI

FEASIBILITY STUDY ON BWANJE VALLEY SMALLHOLDER IRRIGATION DEVELOPMENT PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

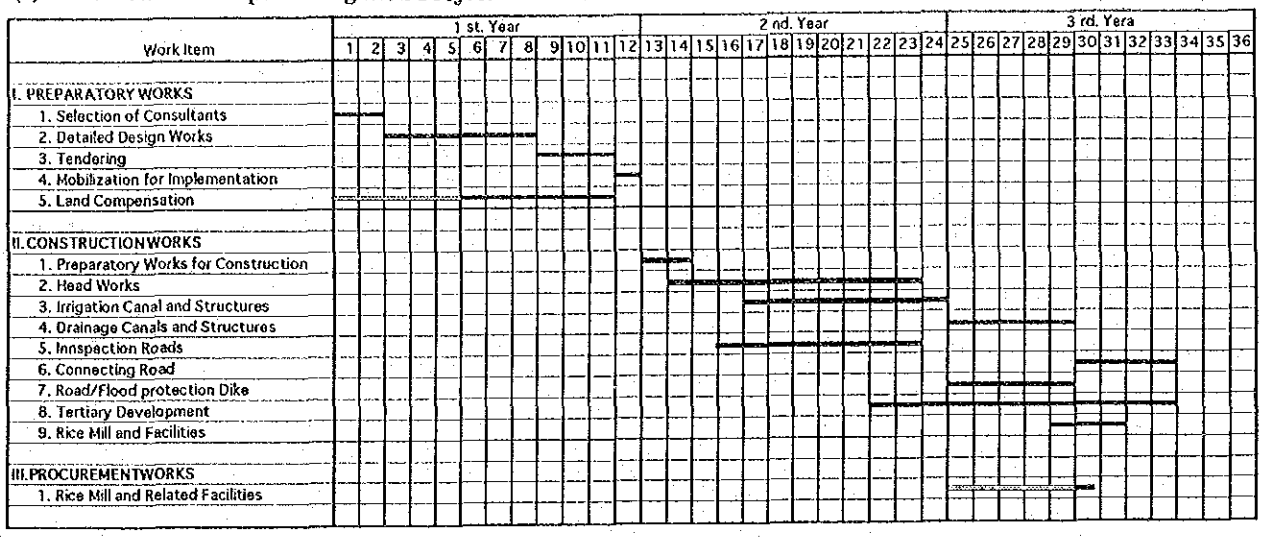


	Rehabilitation (km)	New Construction (km)	River Crossing
A	6.5	2.5	One (1) Nadzipulu
B	13.0	0.0	
C	12.0	1.5	One (1) Namikokwe
D	9.0	0.0	
E	0.0	10.0	Two (2) Namikokwe & Livulezi
Total	40.5	14.0	Four (4)

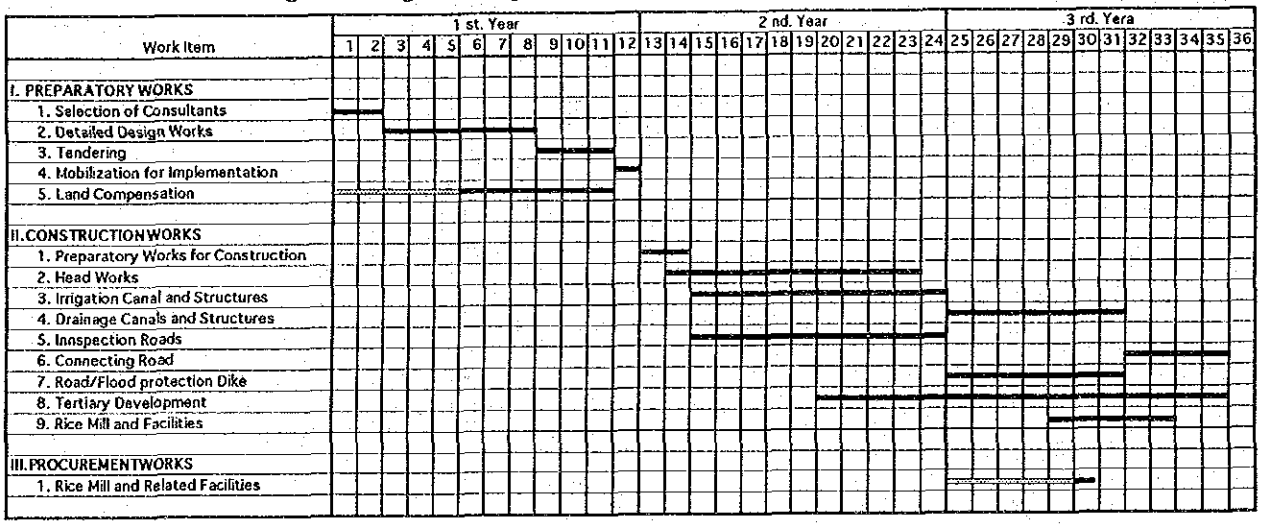
FIGURE 5.4.1 PROPOSED PLAN FOR IMPROVEMENT OF RURAL ROAD NETWORK

FIGURE 6.1.1 IMPLEMENTATION SCHEDULE OF THE PROPOSED IRRIGATION PROJECTS

(1) The Lower Nadzipulu Irrigation Project



(2) The Namikokwe Integrated Irrigation Project



(3) The Lower Livulezi Irrigation Project

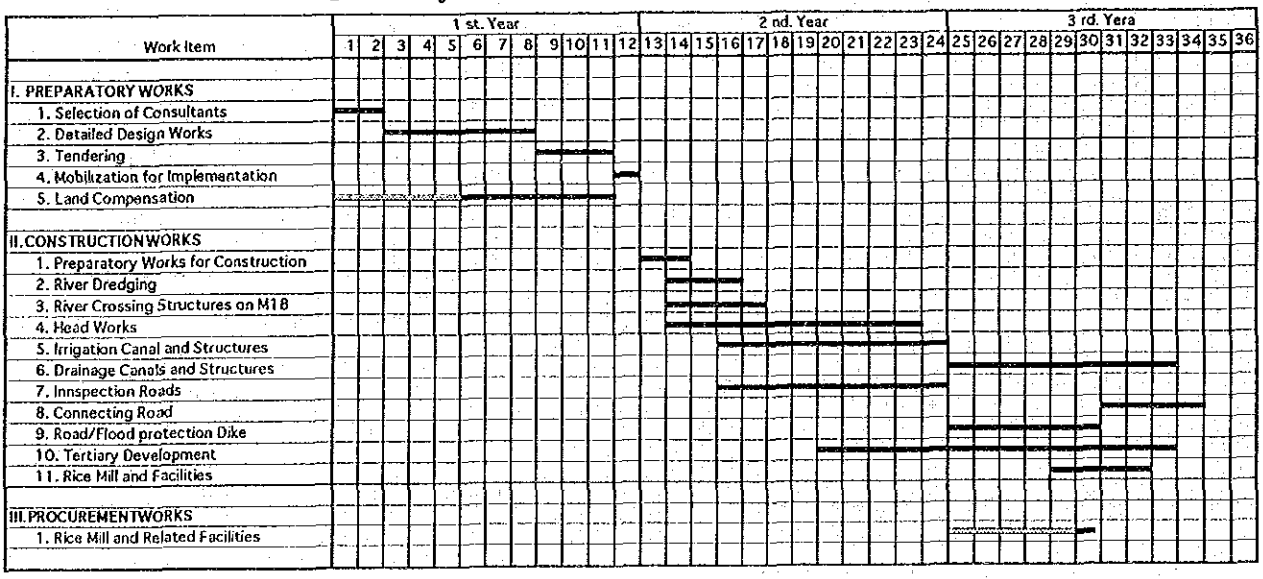
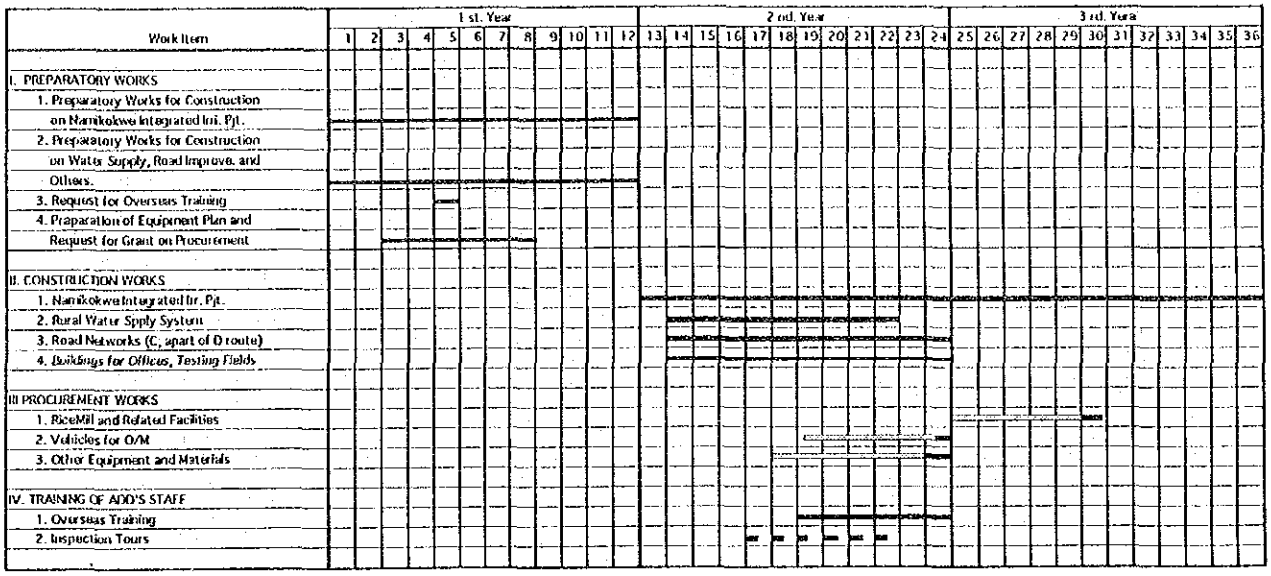
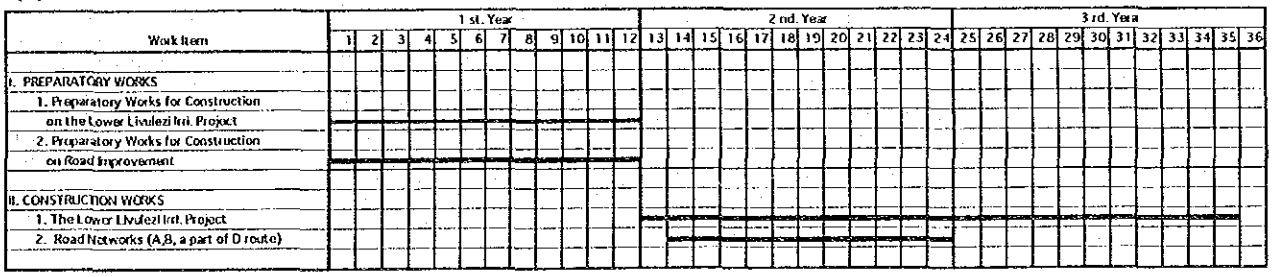


FIGURE 6.1.2 IMPLEMENTATION SCHEDULE OF DEVELOPMENT PACKAGES

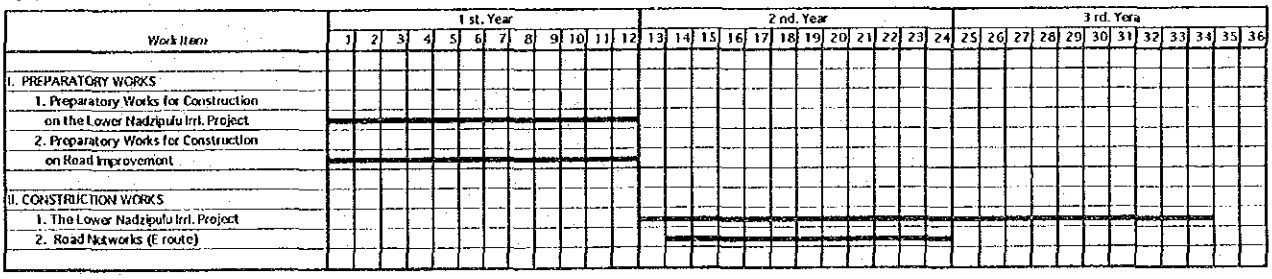
(1) PACKAGE 1



(2) PACKAGE 2



(3) PACKAGE 3



(4) PACKAGE 4

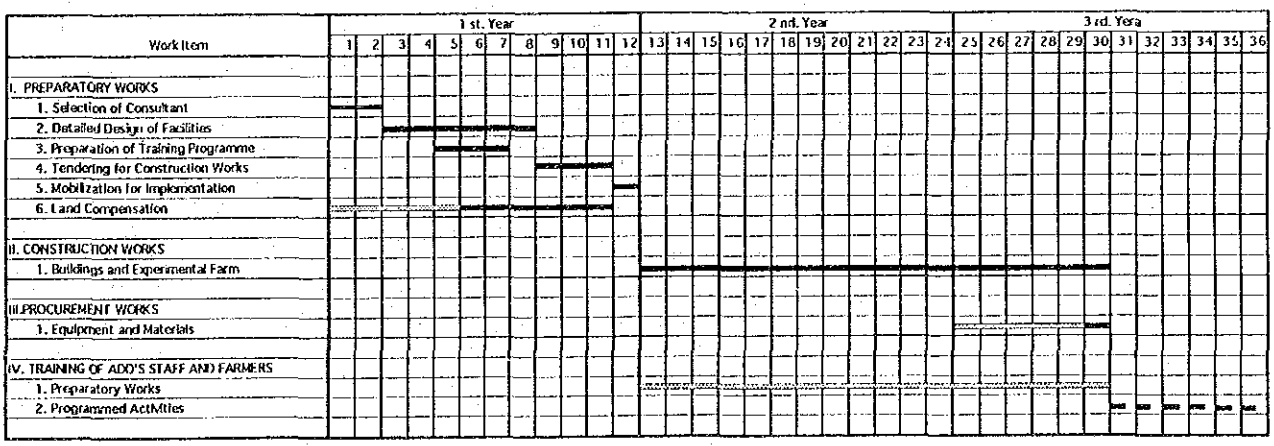


FIGURE 6.1.3 FLOW CHART OF IMPLEMENTATION OF WHOLE DEVELOPMENT WORKS

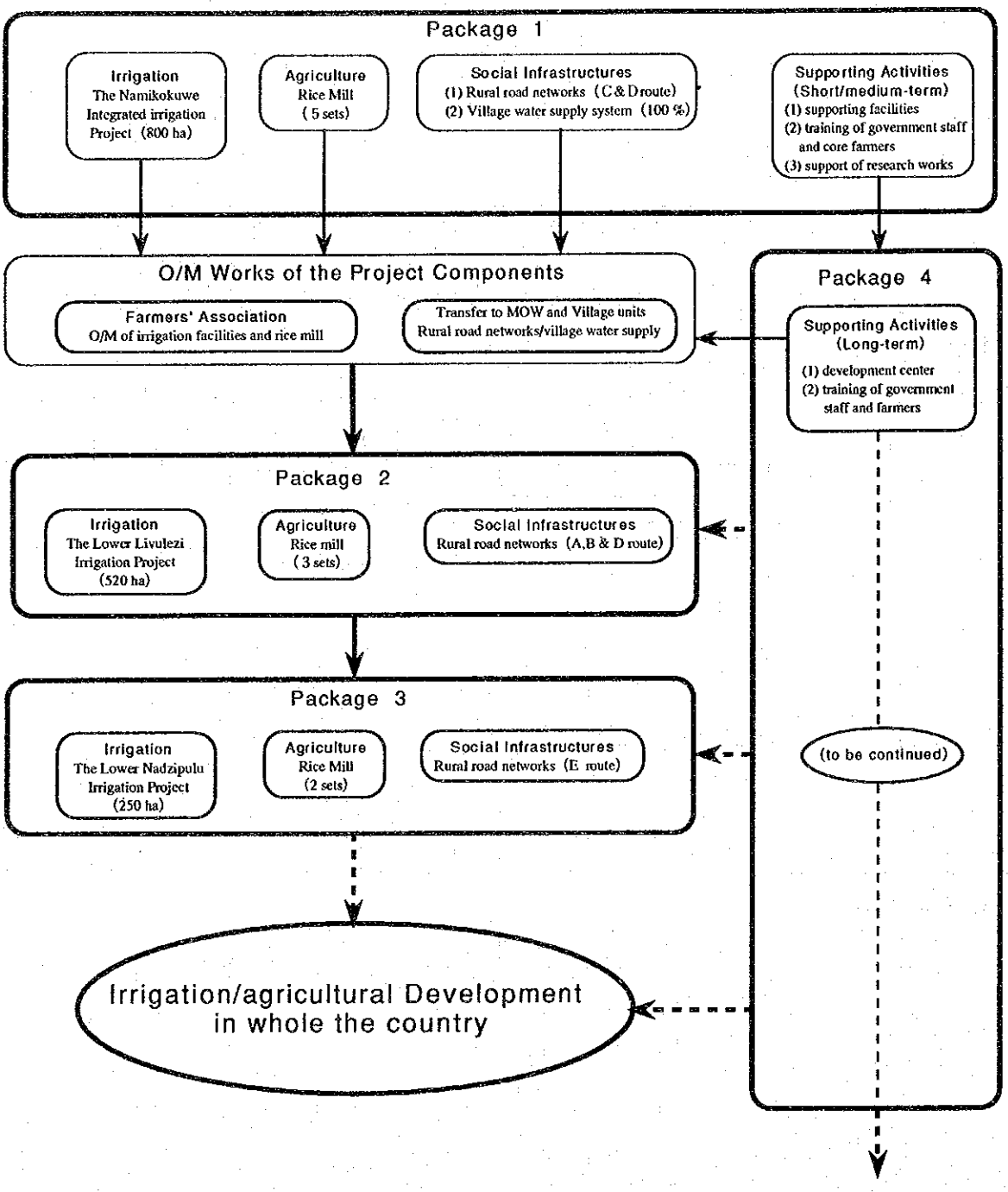


FIGURE 6.2.1 ORGANIZATION CHART FOR CONSTRUCTION STAGE