BASIC DESIGN STUDY REPORT ON THE CONSTRUCTION OF MEDIUM SIZE DAMS IN MASVINGO PROVINCE IN THE REPUBLIC OF ZIMBABWE

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PREFACE

In response to the request of the Government of the Republic of Zimbabwe, the Government of Japan has decided to conduct a Basic Design Study on the Project for Construction of Medium Size Dams in Masvingo Province and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to Zimbabwe a survey team headed by Mr. Takashi Tachibana, Deputy Director of Construction Department, Hokuriku Regional Agricultural Administration Office, Ministry of Agriculture, Forestry and Fisheries from 6 December, 1988 to 19 January, 1989.

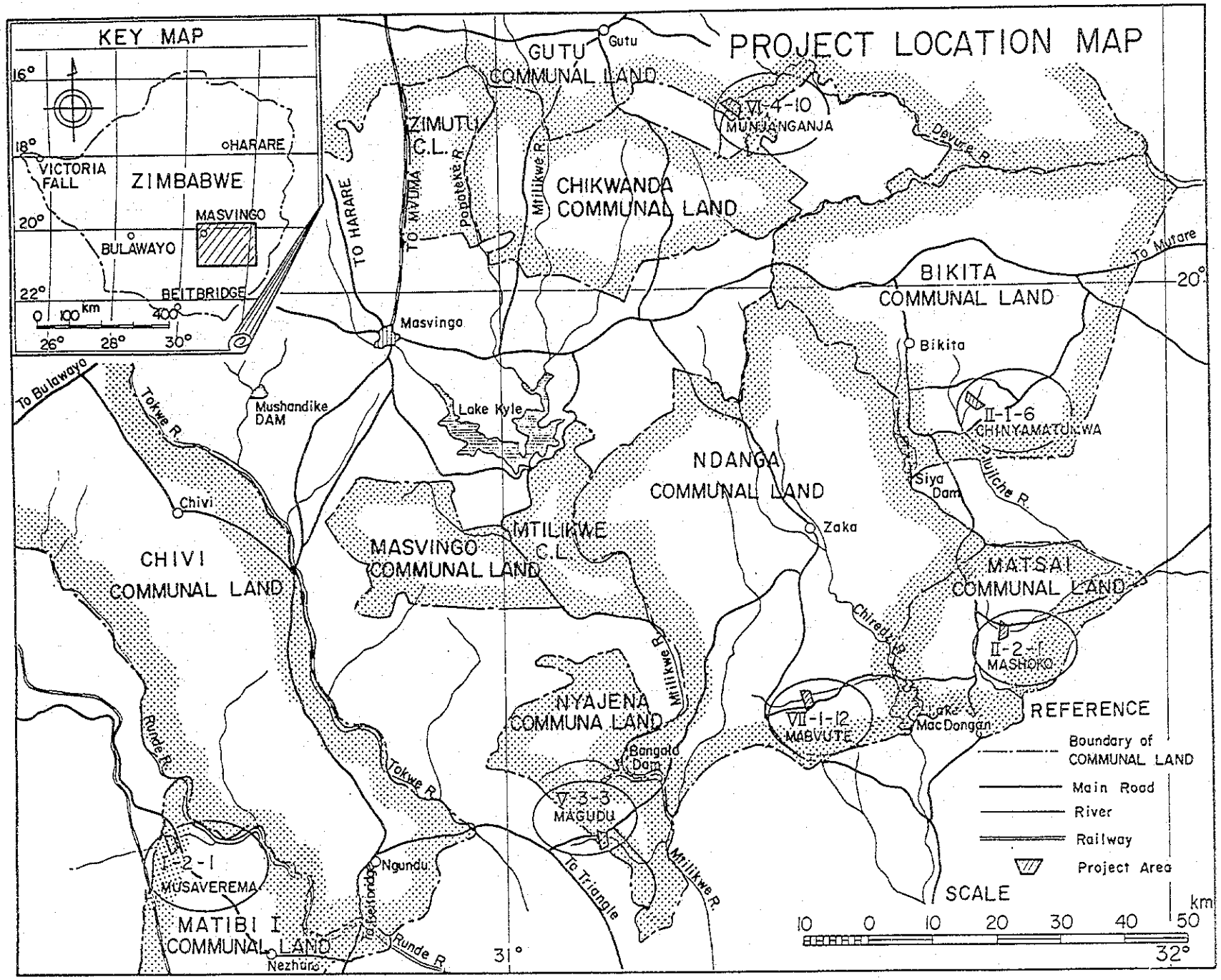
The team exchanged views with the officials concerned of the Government of Zimbabwe and conducted a field survey in the Project area. After the team returned to Japan, further studies were made. Then, a mission was sent to Zimbabwe in order to discuss the draft report and the present report has been prepared.

I hope that this report will serve for the developmet of the Project and contribute to the promotion of friendly relations between our two countries.

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

May, 1989

Kensuke Yanagiya
President
Japan International Cooperation Agency


KEY MAP
16°
18°
20°
22°
VICTORIA FALL
ZIMBABWE
HARARE
MASVINGO
BULAWAYO
BEITBRIDGE
0 100 km 400
26°
28°
30°
PROJECT LOCATION MAP
GUTU COMMUNAL LAND
Gutu
ZIMUTU C.L.
VI-4-10 MUNJANGANJA
Delure R.
CHIKWANDA COMMUNAL LAND
Popoteke R.
Mtilikwe R.
TO HARARE
TO MVUMA
BIKITA COMMUNAL LAND
To Mutare
20°
Masvingo
Bikita
To Bulawayo
Tokwe R.
Mushandike DAM
Lake Kyle
II-1-6 CHINYAMATUKWA
NDANGA COMMUNAL LAND
Siya Dam
Sujiche R.
Chivi
Zaka
CHIVI COMMUNAL LAND
MTILIKWE C.L.
MASVINGO COMMUNAL LAND
MATSAI COMMUNAL LAND
Chiredzi R.
II-2-1 MASHOKO
Mtilikwe R.
NYAJENA COMMUNA LAND
VII-1-12 MABVUTE
Lake MacDongan
Bangala Dam
V-3-3 MAGUDU
Runde R.
Tokwe R.
II-2-1 MUSAVEREMA
Ngundu
To Beitbridge
To Triangle
Mtilikwe R.
MATIBI I COMMUNAL LAND
Nezhuro
Runde R.
31°
32°
REFERENCE
Boundary of COMMUNAL LAND
Main Road
River
Railway
Project Area
SCALE
10 0 10 20 30 40 50 km

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SUMMARY

The Republic of Zimbabwe became independent in 1980 by transition from the South Rhodesian Government to the present Government. The total population is about 7.5 million in 1982, and the average growth rate is about 3.1 percent per annum.

The national land area has about 390,750 square kilometers, one fourth of which extends in high land at the elevation of more than 1,000 m, and the major municipalities and arable land are located concentratedly in the high land. The average annual rainfall is about 700 mm, and some parts of the eastern area have recorded a rainfall of about 2000 mm per annum, about 600 mm in the west, and 400 mm in the south. The annual maximum temperature rarely exceeds 30°C even in the hottest month of October, and the climate is mild and suitable to the inhabitants.

The Five-Year Development Plan of Zimbabwe has also given agriculture a core role in the national economy in future. In 1985, the agricultural production occupied about 16 percent in the Gross Domestic Products (GPD). At present, about 70 percent of the local inhabitants is engaged in agriculture to provide more than 25 percent of the national labour opportunity. About 40 percent of farm products have been exported.

The communal land, in particular, is lagged behind the development, as compared to that in the urban area, and there are no industries to be expected other than agriculture. Agriculture products are subject to considerable fluctuation in rainy season due to insufficient and erratic rainfall. There is no opportunity to cultivate during the dry season because of the lack of irrigation. Large areas remain without reliable water sources. In many remote areas, water sources are insufficient to meet the minimum requirement of water supply for domestic use and animals.

The annual rainfall in Masvingo province is recorded as much as 800 mm to 1,000 mm in the central part while as little as 500 mm to 700 mm in the communal land surrounding the commercial farm areas. Most of rainfall is concentrated in the rainy season from November to February, whereas little rainfall is observed in the dry season.

In the communal land, maize, sorghum, some drought-resistant crops as staple cereals are fully cultivated relying only upon the rain water available in the rainy season. Even in the rainy season, the rainfall is not only insufficient, but has heavy fluctuation in its amount, and only 300 mm to 400 mm can be observed in the drought years. Such a little and unstable rainfall has remarkably reduced the farm production and there has been no harvest observed in some areas. Under the circumstances, the people in the communal land have suffered difficulties in the drought years that they are forced to live on the Government drought relief against serious food shortage.

Furthermore, the local farmers are commonly keeping several number of domestic animals like cattle, donkey, sheep, etc., and they suffer in the drought years from not only feed shortage but water shortage for animals. The farmers have to migrate with animals to seek for their drinking water sources, and the most harsh drought sometimes compels the farmers slaughter some of their animals to save drinking water for animals.

The purpose of the Project is to ensure the water for irrigation and animal breeding through potential surface water resources development by constructing medium size dams across the medium rivers running through the communal land in Masvingo province, where the local inhabitants have been suffering from frequent serious drought damages.

Introduction of modern irrigation practices aims to secure stable crop production with high yield and stable supply of fresh vegetables with local people throughout the year so as to improve the nutrition balance for health improvement.

The following facilities will be constructed in the Project.

	Musa-verema	Magudu	Munjan-ganja	Chinya-matumwa	Mashoko	Mabvute
1 Dam and Reservoir						
Capacity (MCM)	6.65	5.67	1.83	2.25	1.45	3.13
Dam Height (m)	12.7	18.8	18.7	18.8	18.4	19.3
Dam Length (m)	1,700	460	920	580	700	625
2 Conveyance Canal						
Method	Gravity	Gravity	Gravity	Pump	Gravity	Pump
Discharge (l/s)	54	76	49	74	23	151
Length (m)	5,600	7,940	4,720	870	800	860
3 Night Storage Reservoir (m^3)	4,600	6,500	4,300	4,300	1,400	8,700
4 Beneficial Area (ha)	44	70	51	50	21	100

The Implementing Body for dams, conveyance canals and night storage reservoirs will be the MEWRD and AGRITEX for in-field facilities. The construction works of medium size dams, conveyance canals and night storage reservoirs in six (6) sites will be undertaken by Japanese contractors under the grant aid programme, whereas the construction of in-field facilities in six (6) sites will be undertaken by AGRITEX on force account basis.

The major construction machines and equipment necessary for the construction of medium size dams, conveyance canals, night storage reservoirs and in-field facilities in six (6) sites will be supplied under the grant aid programme. The construction machines and equipment to be procured under the grant aid programme shall be delivered to both the agencies according to their responsibilities for the implementation.

The outline of machines and equipment to be procured are as follows:

Machines and Equipment for MEWRD

(a) Earth Work Machine

- Bulldozer
- Wheel Loader
- Motor Scraper
- Motor Grader
- Roller
- Hydraulic Excavator

(b) Transportation Vehicle

- Dump Truck
- Flat Bed Truck
- Water Tank Lorry
- Tractor and Trailer
- Pick-up Truck
- Station Wagon

(c) Grouting Machine

- Crawler Drill
- Grout Pump
- Grout Mixer

(d) Others

- Air Compressor
- Pump
- Generator
- Concrete Mixer
- Caravan

Machines and Equipment for AGRITEX

(a) Earth Work Machine

- Bulldozer
- Wheel Loader
- Motor Grader
- Land Grader
- Land Leveller

(b) Ploughing Machine

- Tractor
- Disk Plough
- Disk Harrow
- Ripper

(c) Transportation Vehicle

- Dump Truck
- Tipper Trailer
- Flat Bed Truck
- Pick-up Truck
- Fuel Bouser
- Water Bouser

(d) Others

- Pump
- Generator
- Concrete Mixer
- Plate Compactor
- Caravan

The whole project is divided into four phases as follows:

Phase 1: Procurement of construction machines and equipment

Phase 2: Construction of two projects, Musaverema and Magudu

Phase 3: Construction of two projects, Munjanganja and Chinyamatumwa

Phase 4: Construction of two projects, Mashoko and Mabvute

The required implementation period for the Phase 1 "Procurement of construction machines and equipment" is estimated to be 14 months from the commencement of the detailed design following the Exchange of Notes between the two governments up to the hand-over of the construction machines and equipment, while the required construction periods for Phase 2, Phase 3 and Phase 4 of "Construction of two dams and related irrigation facilities" are estimated to be 19 months each from the detailed design up to the completion of the construction work, including the tender and contracting procedure.

The estimated project cost for the Zimbabwe side (construction of in-field facilities) is approximately Z$1.68 million.

The operation and maintenance (O & M) services in the Project include the services to be rendered for the dams, pumping facilities, canals, night storage reservoirs and in-field facilities for agricultural production, as well for equipment and machinery provided under the grant aid programme. The provincial office of MEWRD shall carry out the O & M services for dams, pumping facilities, canals, and night storage reservoirs, while the AGRITEX for the in-field facilities.

The irrigated farm land of 0.1 ha will be allocated to 2,400 farm households in the Project. The increase of crop production is estimated at 2,500 tonnes per year, which will contribute food security in the communal lands in Masvingo province. The increase of farm income per household by the increase of the crop production is estimated at Z$240 which corresponds to 60% of the present farm income.

The cultivation of fresh vegetable is planned in 20% of the total irrigable area. The number of beneficial population to be supplied with fresh vegetable by the project is estimated at 96,200 inhabitants. The number of domestic animals to be supplied with drinking water from the proposed reservoirs is estimated at 11,500 Livestock Unit.

The medium size dams project in Masvingo province will play a vital role in promoting agricultural development in the communal land in the province, which coincides the policy of the Zimbabwe government with a philosophy of "Growth with Equity". Based on the management of the existing irrigation schemes, the facilities to be constructed in the project will be effectively operated and maintained by MEWRD and AGRITEX. Therefore, it is deemed quite justifiable and appropriate that the government of Japan extend grant aid cooperation to the medium size dams project in Masvingo province.

The number of civil engineers for dam construction and operators for construction machines are in shortage. Transfer of technology to the Zimbabwean counterparts through the on-job-training in the implementation of the project is essential. It is recommended that MEWRD positively allocate the counterpart staff to participate in the implementation of the construction work of the medium size dams and the related irrigation facilities in order that MEWRD can continue the similar natured medium size dams project after the completion of six projects under the Japanese grant aid programme.

CHAPTER 1. INTRODUCTION

The agriculture has played a dominant role in the national economy of Zimbabwe and for its development. In the First Five-Year National Development Plan, the land (utilization) reform for effective use of national land and enhancement of living standard of people, especially in the agricultural labours class have been set up as the national targets. The communal land, in particular, is considerably behind the development, as compared to that in the urban area, and there are no industries to be expected other than agriculture.

Agriculture products are subject to considerable fluctuation in rainy season due to insufficient and erratic rainfall. There is no opportunity to cultivate during the dry season and because of the lack of irrigation. Large areas remain without reliable water sources. In many remote areas, water sources are insufficient to meet the minimum requirement of water supply for domestic use and animals.

The population growth rate per annum in the communal lands is estimated to be more than 3 percent. The communal lands seem to be over populated and the population movement is caused by the surplus manpower within agriculture, mainly by youths seeking for cash income sources in the non-agricultural sectors.

Under the circumstances, the Zimbabwe Government has placed emphasis on the development of the communal lands since its Independence. The scheme of the Medium Size Dams Project has been induced by the needs for water resources development in communal land.

The government of Zimbabwe requested the government of Japan to extend technical cooperation for the formulation of the development plan of the Medium Size Dams Project in the communal lands in Masvingo Province.

In response to the request of the Government of the Republic of Zimbabwe, the Government of Japan decided to conduct the feasibility study and Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched the study team to Zimbabwe. The study team conducted a series of survey from September 1986 and submitted the feasibility study report in March 1988.

Based on the above study, the Government of Zimbabwe has requested the construction of six (6) dams and the related irrigation facilities together with the procurement of construction machines and equipment to the Government of Japan under the grant aid programme. The Government of Japan decided to conduct the basic design study for the project. In accordance with the decision, JICA sent to the Republic of Zimbabwe the study team headed by Mr. Takashi Tachibana, Deputy Director of Construction Department, Hokuriku Regional Agricultural Administration Office, Ministry of Agriculture, Forestry and Fishery from 6 December 1988 to 19 January 1989.

The study team made a series of discussions with the officials concerned of the Ministry of Energy and Water Resources and Development (hereinafter referred to as "MEWRD") and Department of Agricultural, Technical and Extension Services of the Ministry of Lands, Agriculture and Rural Resettlement (hereinafter referred to as AGRITEX), the executing agencies of the Government of Zimbabwe, and conducted a field survey in the Project Area.

The results of the discussions between MEWRD, AGRITEX and the study team were reported to and were agreed by the Ministry of Finance, Economic Planning and Development (hereinafter referred to as "MFEPD"). The Minutes of Discussion was compiled and signed by the representatives of MEWRD, MFEPD and the study team on 16 December 1988.

The member list of the study team, its field survey itinerary, a list of related officials contacted by the team, a copy of the Minutes of Discussion, and the list of reference documents are herein attached as appendices.

Based upon the said survey, the study team has carried out, since their return to Japan, an examination of the effectiveness of the Project, design of the dams and irrigation facilities, the selection of the construction machines and equipment necessary for implementation of the project, a rough estimate of the Project cost, planning for operation and maintenance of the facilities and so forth.

This report describes the most effective plan for the Project implementation.

CHAPTER 2. BACKGROUND OF THE PROJECT

2.1. General Situation of the Country

The Republic of Zimbabwe became independent in 1980 by transition from the South Rhodesian Government to the present Government. The total population was about 7.5 million in 1982, and the growth rate is about 3.1 percent per annum on an average. The demographic composition by races is shown as follows;

Africans	abt. 7.30 million
Europeans	abt. 0.15 million
Others	abt. 0.03 million

Source: STATISTICAL YEARBOOK 1987

More than 80 percent of the population is the Mashonas dwelling mainly in the high land of the northeastern and central parts of the country, while the Matabeles in the southern part.

The national land area has about 390,750 square kilometers in total, one fourth of which extends in high land at the elevation more than 1,000 m, and the major municipalities and arable land are concentratedly located in the high land. The annual rainfall is about 700 mm on the national average. And some parts in the eastern area has recorded the rainfall of about 2000 mm per annum, while about 600 mm in the west and 400 mm in the south.

The annual maximum temperature rarely exceeds 30°C even in the hottest month of October, and the climate is mild and agreeable to the inhabitants.

The Country is blessed with abundant mineral resources of gold, nickel, tangsten, etc. together with high caloried quality coal. Zimbabwe, as being an inland country, has not provided the suitable transportation facilities for its export goods even if developed for the purpose, nor has been industrialized yet. Under the circumstances, agriculture is the main industry of Zimbabwe, and the Gross National Products (GNP) in 1985 was 960 Z$ (570 US$) per capita.

The agriculture in Zimbabwe can be classified into large-scale commercial farming, small-scale farming in the resettlement areas, and subsistent farming in communal land. The major products are cotton, maize, soybean, groundnuts, sorghum, and sunflower seeds. The country, however, has to import a bulk of food (84 million Z$) due to considerable serious decrease in production by harsh droughty damages in 1980-1984.

2.2. General Situation of Agriculture

(1) Role of Agriculture in National Economy

The Five-Year Development Plan of Zimbabwe has also given the agriculture a core role played in the national economy in future. In 1985, the agricultural production occupied about 16 percent in the Gross Domestic Products (GPD).

At present, about 70 percent of the local inhabitants is engaged in agriculture to provide more than 25 percent of the national labour opportunity. About 40% of the total farm products have been exported.

Positive investment to the commercial farms was made in the period of 1960s through 1970s to keep the irrigation area rate by more than 16 percent. Those farms had mainly grown as export-oriented crops, and/or those industrial crops as raw materials for domestic industries as well as cereal crops for export business. Contrarily, the communal land farms grow the limited crops for the local marketing. Such small scale farms are expected to play an important role in the local supply of the agricultural products.

(2) Agri-economic Structure

(a) General Structure of Agricultural Economy

Food self-sufficiency has been met in the country. As a whole, however, occasional deficiency arises in communal lands especially during continuous drought. Drought relief measures have been taken since 1982 by distributing free foods. Zimbabwe is one of the self-sufficient countries in food. This is partly because the crop yield has fairly been stable under a considerable rate of irrigation coverage in commercial areas, and partly because the Government has taken due measures necessary for the food security. Consolidation of road networks and storage capacities of G.M.B. have been intensified since the Independence, thereby contributing much to this stabilization. Commercial lands with their advantages in agricultural production in various aspects like climate, land productivity or water supply have played a functional role in both food security and exports, thus contributing much to the State in terms of acquiring and saving foreign exchange.

On the other hand, communal lands have in many cases carried their population beyond their capacities on account of their original infertility of the land as well as poor resources, followed by the recent rapid population growth at the rate of over three percent per annum. Under the conditions of chronic and critical hardship in sustaining daily life, local potential purchasing power has never been materialized and the radius of marketing sphere for local produce is seldom extended beyond their living circles. This is why communal people is often referred to as living on the border of monetary economy bloc. The arable land is estimated to be 25 percent of the communal lands in view of the natural region classification. Land degradation and erosion resulted from overgrazing are taking place, and the deterioration of land productivity is further accelerated by exploitable cultivation on unsuitable lands.

(b) Double Structure of Agro-Economy

The national economy of Zimbabwe is well-balanced with diversity, having a distinguished double structure with agriculture, mining and manufacturing as core industries. Every field and sector of the country have the two groups of the modern and the traditional, or the rich and the poor. An effort, however, has been made to abolish the institutional double structure through the education system and vocational training programme.

In 1985, GDP was marked by Z$7,000 million (US$4,200 million) and the percapita GDP was Z$860 (US$510). Since the income distribution has been made unfair due to the double structure of the society.

GDP of Zimbabwe consists of the following:

Gross Domestic Products

	GDP (million Z$)	(%)
Agriculture & Forestry	1,115	16
Mining and Quarrying	381	5
Manufacturing	1,883	27
Electricity and water	189	3
Construction	262	4
Distribution and Hotel	994	14
Transportation and Communication	439	6
Others	1,738	25
Total	7,001	100

Source: SOCIO ECONOMIC REVIEW 1986

The double structure of the agricultural sector is represented by the presence of the large-scale commercial farms and the communal land farms for subsistent agriculture. In details on the farming acreages, the former has a farm land of about 2,200 ha per farm, whereas the latter only 2.3 ha on an average, and the unit yield of maize is about 6.0 tons/ha in the large-scale commercial farms, whereas about only 1.0 ton/ha in the communal land farms. In other respect, the comparison of the cash farm income reveals that the former gains Z$805 per annum, while the latter Z$482 which accounts for about 60 percent of the farmer earnings.

(3) Economy and Agricultural Production in Communal Land

(a) Economy in Communal Land

The economic activity in the communal land is dull except agriculture, animal husbandry, and other related works. Those people depending upon the communal land form about 700,000 households (6.3 persons per family on an average) and two members of the family are engaged in agriculture or animal husbandry, and furthermore, 1 to 1.5 members are working in other jobs than the above to gain income.

The annual per capita income of the people in the related areas is estimated at Z$80, and the annual income per family is only about Z$480. Since the Government has proposed a monthly labour wage per worker (public works) of Z$153, farmers in the communal land are about 30 percent or below the labour wage.

Under the circumstances the farmers have been living on the border of the monetary economy and barter economy, and the shortage in income for living has been covered by remittance from family members working outside the areas, livelihood subsidy, drought relief, earning from public works labour, etc.

In line with the situation, the Government has stipulated in the current Five-year Development Plan that the rural areas comprehensive development should be encouraged, and the social capitals should be fully provided through public infrastructure investment.

Besides the promotion of the primary industry, the Government puts emphasis on agro-industries like marketing, processing and storage which will create employment opportunities. The Government also intends to mitigate expense presently required for price support on agricultural products and subsidies, which is now a burden on fiscal budgets.

(b) Agricultural Production in Communal Land

The farming in the communal land can be characterized by the fact that the agri-productivity is remarkably low as compared with that of the large-scale commercial farms, because of such poor conditions prevailing as topography, soils, rainfall, availability of water resources, etc., together with very little dosing of agri-inputs of fertilizers and chemicals, and poor farming technology.

The average yield of maize as main crop in the communal land ranges only from 1/6 to 1/10 of that of the commercial farms. The low productivity in the communal land is due to absence of irrigation facilities besides various physical conditions mentioned above. Introduction of irrigation facilities into the communal land is expected to increase the cropping intensity to 200% or more in order to raise the local people's income by several times.

(4) Role of the Project

The prerequisites to the successful agricultural development of the communal land with poor productivity as mentioned above are water resources development and effective and efficient use of developed water. In this view, construction of medium size dams is indispensable for the inhabitants of the communal land.

2.3. Related Plan and Programme

2.3.1. National Development Plan

(1) Outline of the First Five-year Development Plan

The Government of Zimbabwe established its first national development plan in 1980 after its independence, known as the First Five-Year Development Plan (1986 - 1990). The national development policies taken up therein can be described briefly as follows:

a) Transformation and control of the economy as well as economic expansion;

b) Land reform and efficient utilization of land;

c) Raising the standards of living of the entire population and, in particular, the peasant population;

d) Enlargement of employment opportunities and manpower development;

e) Development of science and technology; and

f) Maintenance of a correct balance between the environment and development.

The above policies suggest that the Government tries to be liberated from the old colonial economy and socio-economy so as to ensure independence.

(2) Present status of national development

In view of the land use of the national land area, the commercial farm land occupies about 17.1 million hectares, the communal land about 16.4 million hectares and the national parks/water surfaces (including city areas) 5.6 million hectares, respectively. (See following table)

	Area (km^2)	Population (1 000 persons)	Population Density (person/km^2)
Commercial Farm	171,200	1,680	10
Communal Land	163,500	4,300	26
Others	56,200	1,537	27
Total	390,900	7,517	19

Source: Commission and Inquiry into the Agricultural Industry (1982)

Approximately 57 percent of the national population lives in the communal land, while its gross agricultural production can manage to keep some 20 percent level in the national total. And the Government drafted the 1986/1987 national budget including Z$830 million accounting for about 20.6 percent of the total for the investment to the public works of the communal land development.

The aforesaid amount can be converted into about Z$192 per person in the communal land, which can be further increased to Z$540/head by adding the subsidies for relief of drought foods, medical services, education, etc.

The investment to public works development has permitted to provide potable water supply facilities within three kilometers from each village, elementary schools, clinics, rural area development centres, road networks, etc.

The budget for development of the Communal Land has been rapidly increasing year by year, whereas about 35 percent of the development costs is covered by foreign aids.

(3) Development strategy

As mentioned in the previous paragraph 2.2, the development strategy of the Zimbabwe economy points at correcting the double structure and balancing the income disparity. The Government has provided various subsidies and assistance in commodities price control, agricultural crediting, public works projects, etc. for minimizing the income disparity.

The last end of these subsidies assistance exists in people in not being the burden of the Government in future by economical independence of the people in the communal land, although aiming directly at relief from drought damages.

In the communal land areas, conservative investment has created less employment opportunities to result in surplus labour discharge to the urban areas. The employment in the urban areas, however, has been very limited due to being affected by international recession in world economy. Unemployment has been increased in number in the country.

Consolidation of the irrigation facilities is expected to absorb the surplus labour and contribute to development of agriculture which is a labour-intensive industry. The Government has much expectation in agriculture as a sector which will enable people in the communal land to become economically independent in future.

2.3.2. Regional Development Plan

The national development plan reveals that the Government will give a stress on the development of the communal land along with its "Growth with Equity" policy so as to correct the socio-economic disparity between the urban areas and the communal land.

The Provincial Development Committee, established in Masvingo as well, has shown the provincial development plan. The proposed Five-year Provincial Development Plan covers a period from 1986 to 1990, and the development problems considered are as follows:

i) Pressure by rapid population increase
ii) Low productivity of agricultural sector
iii) Delayed development in industrial sector
iv) Little employment opportunity
v) Poor transportation facilities
vi) Poor social infrastructure.

Among the above, the employment problem caused by the increase in number of the college graduates will become the most critical problem in the future. A solution is expected in developing industries related with resources available or materials produced in the Province.

As a matter of fact, however, the industrial development in the Province is limited, and the agricultural sector is expected to play a vitally important role for the provincial development in future.

In respect to the social development, careful attention has been given to maintain the balance of the socio-environmental gap between urban areas and rural areas.

It is necessary to give stress on the consolidation of social infrastructure, raise of agricultural productivity and furthermore, development of agri-industries by farm products available in the Province. Under the circumstances, the proposed Project should be positively executed taking into account the specific features of the province.

As a consequence, the agricultural development in the region should be made so as to meet the local conditions and requirements, and the development of marketing, agri-processing industry, etc., in parallel with the above development. Thus, the Provincial Five-Year Development Plan has proposed the following development components:

i) New irrigation plan

ii) Introduction of food/cash crops suitable to the conditions of each agricultural division.

iii) Plan for technology improvement for animals breeding

iv) Strengthening plan of extension services

v) Improvement plan for agricultural cooperative organization

vi) Improvement plan for marketing system and agricultural credit

2.3.3. Agriculture and Irrigation Development Plan

(1) Agriculture Development Plan

Manufacturing and agriculture are the two major sectors of the national economy, sharing 23 percent and 16 percent, respectively, in the gross national income. The Five-Year Development Plan suggests that these two major sectors will grow 6.5 percent for manufacturing and 5.0 percent for agriculture, respectively, keeping a considerably high growth rate.

Agriculture occupied about 40% (1985) in export contributing to national economy as a large foreign exchange earner. The Five-Year Plan aims not only to keep such high growth but to increase further.

The agriculture development plan has provided the sectoral development schemes as those for commercial farm and communal land, or as cropwise production targets, as the regional disparity can be corrected and the living standards of the rural people can be raised.

In the plan, the growth of agricultural production is proposed by 5 to 6% for commercial farm and 7 to 8% for communal land. The target production by crops is as follows:

(i) Maize, one of the major crops, is expected to be produced in the communal land by about 2.4 million tonnes which are approximately 70% of 3.5 million tonnes, the national total, although about 41% of the national total in the past. (1981-1985)

(ii) Tobacco production as money-making industry of the country, so-called "Golden Leaf", shall be encouraged in the communal land in the small scale under the Governmental support.

(iii) Production of soybean and sunflower as cash crops shall be encouraged in the communal land as well under the Governmental support.

(2) Water Resources Development Plan

The Government has understood the unfavourable water resources conditions of the communal land for agriculture, and formulated the plan to develop irrigation systems in the communal land.

The medium size dams project is proposed for the water resources development in the communal land, because the communal land extends in the complicated topography unsuited to large scale irrigation system with a large size dam.

In the communal land, construction of the medium scale irrigation systems in many districts will enable the farmers in the areas to commute to their own farm land.

The medium size dams are expected to give a quick yield for the Project. Thus, the project is urgently required from the viewpoints of effective land use, increase of the farmers' living standards, and employment opportunity, and alleviation of poverty.

2.4. Outline of the Request

(1) Background

MEWRD had been promoting the medium size dam project in many provinces except Masvingo province with assistance of foreign countries. Under the situation, the government of Zimbabwe requested the government of Japan to carry out the Feasibility Study on Medium Size Dams in Masvingo Province in June 1985.

In response to the request of the Government of Zimbabwe, the preliminary survey team was dispatched and the Scope of Work was agreed between MEWRD and JICA. The study team was dispatched twice to Zimbabwe to carry out the feasibility study during the period from July 1986 to December 1987. The final report has been submitted to the Zimbabwe government. The report includes the inventory study of 98 potential medium size damsites and the feasibility study of the six priority projects.

After examination of the feasibility report, the government of Zimbabwe requested the government of Japan for the implementation of the six medium size dams under the grant aid programme.

(2) Details of the Request

The details of the request can be briefly described as follows.

(a) Purposes

There are two kinds of purposes; namely long-term and medium term.

The long term purposes exist in the economic development of the country in accordance with so-called "Growth with Equity".

On the other hand, the short term purposes exist in the development of the communal land by improvement of the water supply facilities for irrigation use and animal breeding so as to raise the living standards of the local people.

These short-term items will greatly contribute to increasing and stabilizing the local farmers' income as well as ensuring stable supply of the foods through mitigation of drought damages and strengthening animal husbandry.

(b) Executing Body

The Ministry of Energy Water Resources and Development (MEWRD) and the Department of Agricultural Technical Extension Services (AGRITEX) will be the Executing Body.

(c) Proposed major works

The proposed major works include construction of six dams, conveyance canals and night storage reservoirs together with in-field facilities. A construction work can be divided into the following three phases:

Phase 1. Provision of machines, equipment, and construction of Musaverema and Magudu dams and related facilities.

Phase 2. Construction of Munjanganja and Mashoko Dams and related facilities.

Phase 3. Construction of Chinyamatumwa and Mabvute dams and related facilities.

CHAPTER 3. GENERAL DESCRIPTIONS OF PROJECT AREA

3.1. Location and Administrative Division

(1) Location

Masvingo Province, extending in the area by Lat. 19°00'-22°20'S and Long. 30°00-32°20'E, is bounded by the Republic of Mozambique on east and the Republic of South Africa on south, respectively. The province covers a land area of about 57,000 km^2, including 18 communal lands with about 21,300 km^2 in total. The locations and acreages of the communal land are shown in Figure 3-1 and Table 3-1.

Masvingo, the provincial capital, is located about 300 km south of Harare, the national capital. Both cities are linked by highway and air service is available.

The trunk line of railways runs between Harare and Burawayo, and a branch line is bifurcated at Gweru connecting Masvingo.

(2) Population

Masvingo province has population of about 1.029 million in 1988, which accounted for about 12.1% of the national total. It is projected that the population in Masvingo province will become about 1,087 million in 1990.

The population by land use categories is shown below.

	Area (km^2)	Population
Commercial Farm	22,830	11,400
Communal Land	21,263	939,000
Others	12,907	78,600
Total	57,000	1,029,000

Figure 3-1. ADMINISTRATIVE DISTRICT AND COMMUNAL LAND

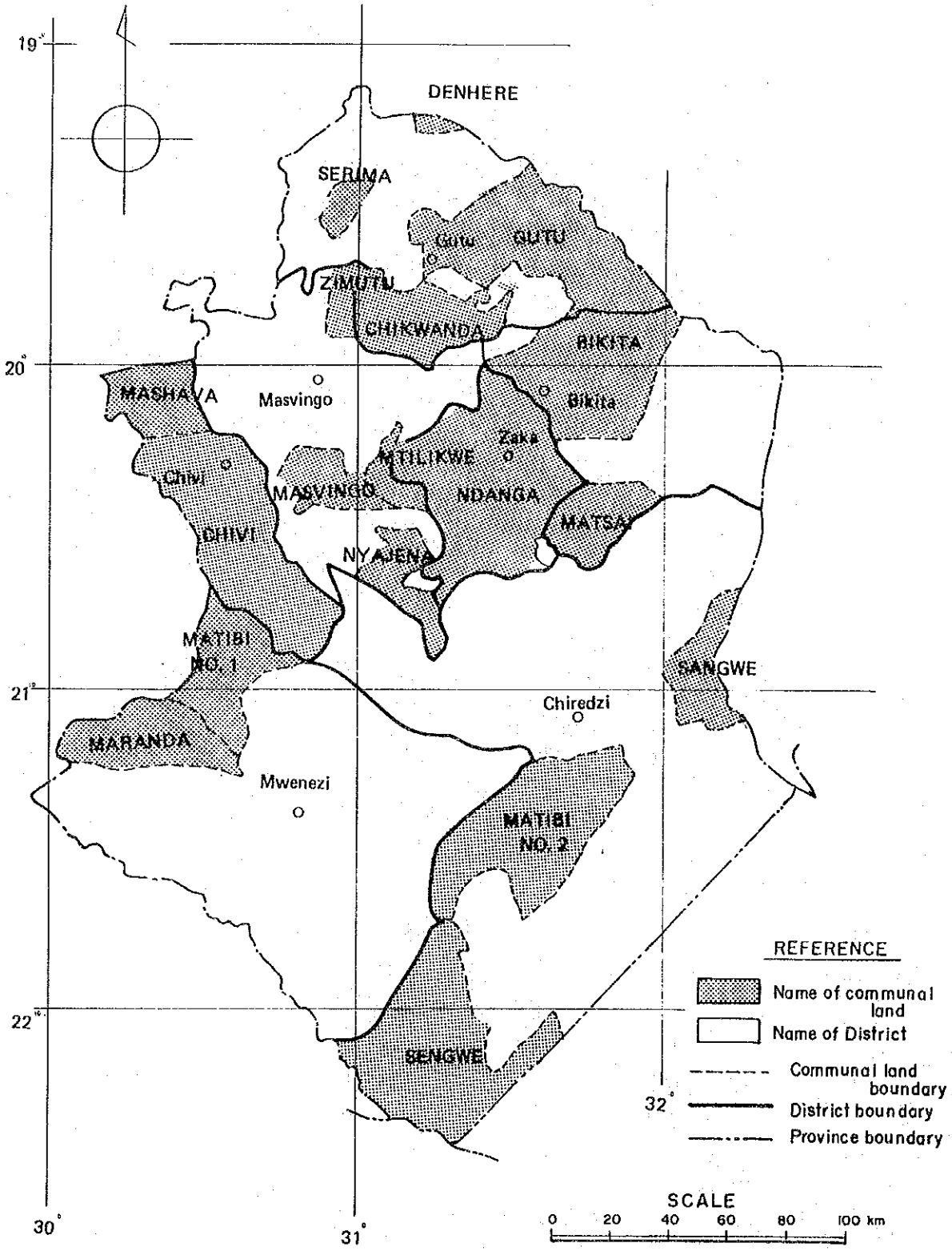


Table 3-1. POPULATION AND HOUSEHOLDS IN COMMUNAL LAND

Communal Land	Population (1988)	No. of Households	Land Area (ha)	Population Density	Cultivated Land (1988) (ha)
I. BATANAI					
1. Maranda	33 490	6 398	102 600	32.6	14 107
2. Matibi No.1	56 417	6 820	103 700	54.4	25 180
II. BIKITA					
1. Bikita	115 800	21 404	193 100	60.0	30 341
2. Matsai	34 000	3 800	43 100	78.9	5 983
III. GAZA KOMANAI					
1. Matibi No.2	31 012	5 000	220 600	14.0	10 169
2. Sangwe	17 400	3 500	63 500	27.4	7 660
3. Sengwe	14 248	3 000	234 500	6.1	7 512
IV. GUTU					
1. Chikuwanda	30 907	11 000	94 500	32.7	37 988
2. Denhere	3 818	1 134	7 500	50.9	7 385
3. Serima	9 019	21 770	20 000	45.1	10 335
4. Gutu	203 470	32 820	277 450	73.3	155 378
V. MASVINGO					
1. Masvingo	34 892	6 944	50 500	69.1	14 977
2. Mtilikwe	16 094	3 203	29 900	53.8	9 198
3. Nyajena	47 959	7 993	59 500	80.6	14 138
4. Zimutu	11 600	4 000	29 000	40.0	6 221
VI. CHIVI					
1. Chivi	83 000	28 000	249 100	41.6	64 468
2. Mashava	21 211	5 723	40 150	52.8	10 000
VII. ZAKA					
1. Ndanga	175 000	27 500	307 600	56.9	70 903
Total	939 337	200 009	2 126 300	38.3	501 943

Source: Data of Masivingo Provincial Office of Agritex.

The population density of the Province is estimated at 18.1 persons per square kilometer in comparison with the national average of 19.3 persons/km. The urban areas and the communal land in the northern part are higher in population density than that of the large-scale commercial farm areas and the communal land in the southern part of the province.

The population growth rate was about 3.2 percent per annum on an average according to the census in 1982. The average number of family members is 5.7 persons based on the number of households by about 200,000 in the province.

The land area of the province is about 57,000 square kilometers which occupies about 14.5 percent of the national total.

The land use in the province can be roughly specified as the communal land, large-scale commercial farm land, resettlement area, municipality, and national parks. The large-scale commercial farm land is populated by only one percent of the national total, although accounting for about 40 percent of the national land area, whereas the communal land is populated by 78 percent, while accounting for only 37 percent of the national land area.

(3) Administrative Division

Masvingo province consists of seven districts of Mwenezi, Bikita, Chiredgi, Gutu, Masvingo, Chivi, and Zaka. (Ref. to Figure 3-1)

The communal lands are administered by the district councils which form the basis of local governments. A local government consists of two bodies, namely a deliberative body composed of elected councillors and ex-officio traditional chiefs, and an administrative body headed by Chief Executive Officer who is at the same time, District Administrator (D.A.). D.As are dispatched from the central government, Ministry of Local Government and Town Planning (M.L.G.T.P.).

A local government concerned with communal lands, is organized by four levels: village, ward, district and province. Masvingo Province has 1,186 villages. One village comprises about 100 families with about 1,000 persons, having a village development committee (VIDCO). The Province has 195 wards. One ward consists of five to six villages with a ward development committee (WADCO) and elected councillors. Besides the above areas under the control of the Councils, the Gonarezhou National Park which is not under the control of the Council extends along the boundary with Mozambique.

Recently, however, the resettlement plan has been positively executed in the commercial areas under the jurisdiction of the Rural Council, and the existing council system has been gradually changing.

It is a recent trend that the District Council and the Rural Council, both belonging to the rural area administration, should be unified as one local administration organization.

The Provincial Authority is an autonomous legal body composed of the chairman of all councils and selected chiefs in the Province. Administratively, the Authority falls under the M.L.G.T.P and the Provincial Administrator acts as a Chief Advisor. It is expected that the Provincial Council chaired by the nominated Governor, will represent all local authorities in the Province, not only in communal lands.

3.2. Natural Conditions

(1) Meteorology

Masvingo province is mild in climate and agreeable to the local people living in the northern part because of the lying at the elevation from 900 m to 1,400 m, although extending in the tropical zone.

The mean monthly maximum temperature appears in November at 23°C, while the mean monthly minimum temperature in August at 14°C.

The annual rainfall takes place in concentration in the months from October to March and is recorded at about 800 mm/year.

In the southern part with elevation ranging from 300 m to 900 m, the mean temperature is 3.0 to 4.0°C higher than that of the high lying plateau areas, while the annual rainfall is as little as 300 mm/year.

(2) Topography and Water System

Masvingo province is roughly divided into two: the northern high-lying plateau with the provincial capital of Masvingo included and the southern low-lying area. Most of these areas lie in the catchment area of the Sabe River except some southern most in the catchment of the Limpopo River.

(3) Geology

Granite and gneiss prevail in the province with a variety of penetrations and the quartenary rocks.

3.3. Social Environment

(1) Social Conditions

The major roads in the province have been constructed by Ministry of Transportation and the District Development Funds, and presently about 2,300 km of roads are maintained. The vitally important roads are Harare-Masvingo-Beitbridge Route (No.304-504) which runs through the province from north to south, and the Birchenough bridge-Masvingo-Bulawayo Route (No.409-509) which traverse the province from east to west.

The Ministry of Transportation has been constructing the important linking roads of the District Service Centers and the Growth Points.

The District Development Funds has been keeping maintenance works for about 5,080 km of unpaved road networks throughout the country, as well as constructing many linking roads between business centres. In addition to the above two organizations, the Rural Councils keep maintenance works for about 2,000 km of the roads running in the commercial farm area. Recently, however, the control of these roads in the commercial farm area has tended to be transferred to Ministry of Lands, Agriculture and Rural Resettlement as the development of the resettlement farm land areas has been promoted.

There are six railway lines running in the Country and most of the trains are freighters carrying farm products in the low-belt area, agricultural inputs materials as well as mining products and their necessary input materials.

The water supply systems have been provided mainly in urban areas, while rarely in the rural areas. In those towns of Masvingo, Chiredzi, etc., the municipal water supply networks have been well provided, whereas in the Growth Points of the communal land, and living quarters in the district service centers, the rural water supply development has been promoted.

In the communal land, the domestic water supply depends for its water sources upon borehole wells.

The National Master Plan for Rural Water Supply and Sanitation (1984) reveals that the number of users per borehole or hand dug well in the province is 521 persons per well, which is larger than the national average of 487 persons per well. In other words, the well density is about 0.08 well/km^2 in the province, which is more than the national average of 0.06 well/km^2.

There are telephone relay stations located in Bikita, Chatsworth, Chiredge, Gutu, Mashaba, Masvingo, Mwenezi and Triangle. The post office is located in Masvingo District by 5 offices, Chiredzi by 3, Chibi by 2, and one each in other four districts. And 14 post offices in total were operated in 1985.

In addition to the above main offices, two or three branches are provided in every district and the total 22 post offices are available in the province. Social services such as telephone, telegram, post, electricity, etc. are available only in the thickly populated urban areas of Masvingo, Chiredge, Growth Points, Service Centers, etc.

In the province, there are 632 elementary schools provided (331, 892 pupils) and 134 junior high schools (83,881 pupils) in 1985. The number of pupils per teacher is estimated at 45 pupils for elementary school and 38 pupils for junior high school. Both of these figures are larger than the governmental targets by 40 pupils/teacher for elementary schools and 30 pupils/teacher for junior high schools, respectively.

The education system, however, has been greatly improved since the independence. Although the education materials are not sufficient to meet the requirements, the number of elementary schools and their distribution in the province are appropriate.

Each district established junior high schools, but both the number of schools and education materials are still insufficient and further construction of the junior high schools is required.

There are 138 clinics in the province, most of which are provided in densely populated urban area, but some inhabitants of the communal land must go to see a doctor at clinic about 15 km far from their residence.

Under the situation, provision of new clinics with appropriate staffs and equipment are expected to meet the requirements of the rural people.

(2) Major Industry

(a) Agriculture

The major industry of Masvingo province is agriculture with maize, cotton, sorghum as main crops.

(b) Mining

Mining is the second largest industry to agriculture in Masvingo, and ensures to keep about 8,000 persons employment. Renco and Mashava are the main mining sites producing gold, lithium, cesium, and asbestos. There are many small scale mining industries scattered in the province in producing a variety of minerals.

(c) Manufacture

A few industries are effective to absorb the labour force. The most industrialized areas in the province are Chiredzi and Triangle in the lowveld. In Triangle, a large-scale sugar mill has been operated to process sugarcanes produced in the area, which provides employment opportunities for about 28,000 people both in the agriculture and industrial sectors. The production

of the manufacturers of Masvingo province occupies only one to three percent of the national total.

(d) Tourism

Tourism is one of the characteristic industries in the province economy and promising in development in future. The Great Zimbabwe Ruin, the Kyle Lake, the Gonarezhou National Park, etc. are well-known.

3.4. Land Use and Agriculture

(1) Land Use

The farm land area in Masvingo province accounts for about 77 percent of the provincial total land area, including about 40 percent for the commercial farm areas and about 37 percent for the communal land. Recently, however, the land use as cropped area has been found to be 6.3 percent (363,000 ha) only of the total provincial land area.

The cropping acreages in the province depend largely upon meteorological conditions, and in the cropping year of 1982/83, the droughty year, the cropped area was only 3.9 percent (14,000 ha).

(2) Agriculture

(a) Natural Region

The land of Zimbabwe on the basis of soil, rainfall and other climatic factors is divided into the following five Natural Regions.

Region I; region for specialized diversified farming
Region II; region for intensive farming
Region III; region for semi-intensive farming
Region IV; region for semi-extensive farming
Region V; region for extensive farming or grazing

Figure 3-2. MAP OF NATURAL REGION

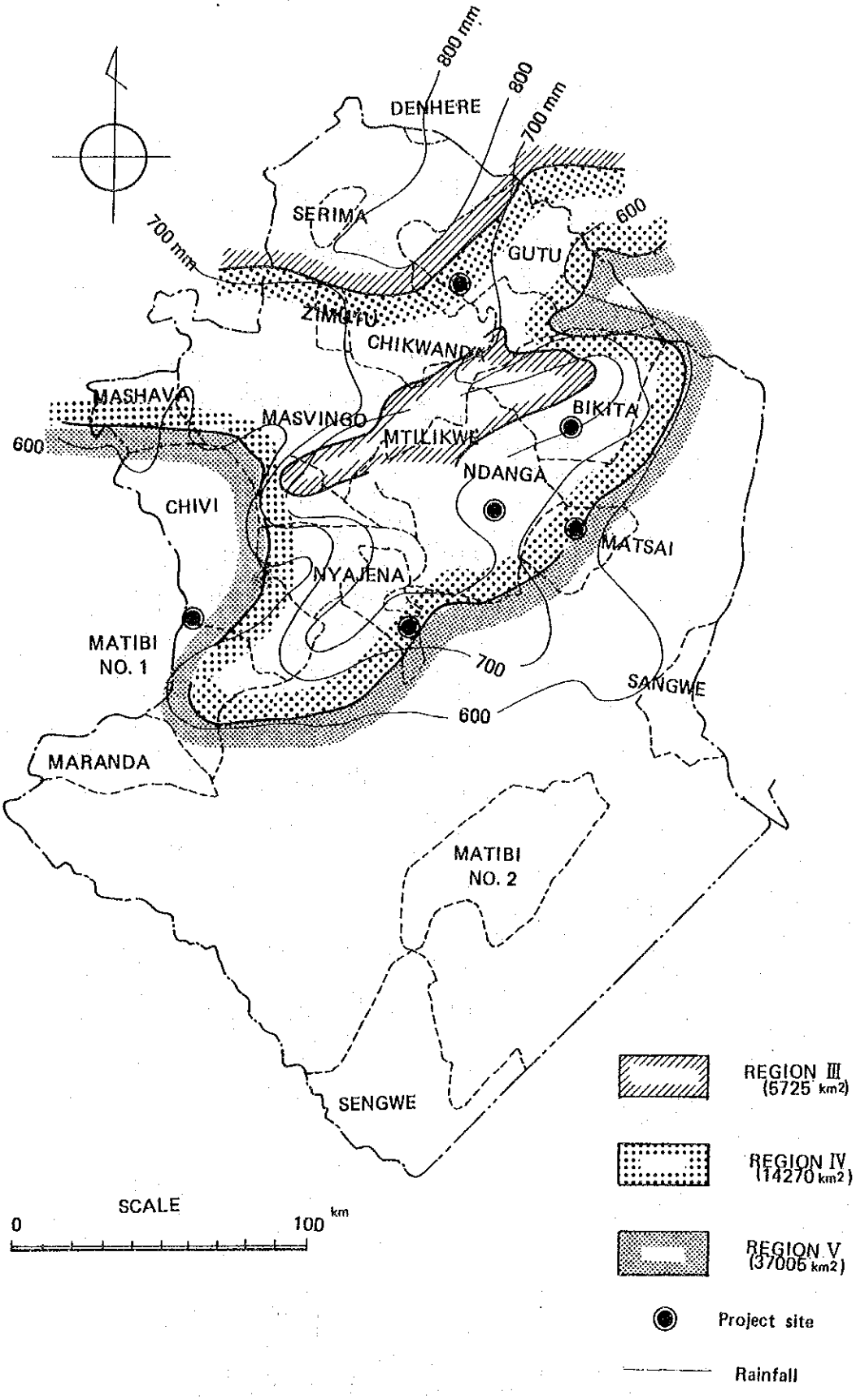


Table 3-2. NATURAL REGION AND AGRICULTURE SEGMENTS IN MASVINGO PROVINCES

(unit: km^2)

Region	Large Scale Commercial Land	Small Scale Commercial Land	Communal Land	Resettlement Area	Town and Rivers	Others (Park, etc.)	Total
Region 3	2 867	3 900	157 520	47 100	59 600	17 700	572 520
Region 4	1 634	170 100	801 780	176 000	99 200	16 500	1 426 980
Region 5	1 626 000	32 900	1 167 000	121 300	238 100	515 200	3 700 500
Total	2 076 100	206 900	2 126 300	344 400	396 900	549 400	5 700 000

Source: Data of Masivingo Provincial Office of Agritex.

The land in Masvingo Province falls into three Natural Regions of III, IV and V. Especially latter two regions are predominant. Relative shares of these regions are 11%, 27% and 62% respectively.

Region III is characterized by rainfall ranging 650 - 800 mm per annum and fairly severe mid season dry spells. Region IV has rainfall of 450 - 650 mm per annum and periodic seasonal drought and severe dry spells during the rainy season. In the last Region V, rainfall is too low and erratic for even drought resistant fodder and grain crops.

Nevertheless, in communal lands, most farmers try to grow grain crops such as maize, sorghum or millets, even in Region V, although sometimes suffering from drought.

(b) Crop production

Masvingo province produces maize, tobacco, wheat, groundnut and pulses as major farm products with annual production of 99,000 tonnes, which are equivalent to only about 7.0% of the national total production. These figures are deemed quite low in comparison with the farm land acreage ratio and population ratio of 14% to the national total.

(c) Communal Land Farming

In the communal land areas, the subsistent farming has been carried out in cultivating 2 to 3 ha of farm land per household. In the communal land, such staple cereals as maize, mhunga, ropoco, etc. are mainly produced. The surplus products are supplied to the local markets through G.M.B.

The rainfed farming currently practised in the areas has resulted in unstable crop production with a considerable large fluctuation by year. Under the situation, several small scale irrigation schemes have been contemplated to ensure stable farming and increase cash income in the areas.

(d) Commercial Farming

The representative large-scale commercial farming in the province are the intensive sugar cane farming in Triangle and Hippo Valley, where the irrigation water is secured by those large dams, Kyle, Bangala, Manjirenji, etc.

3.5 General Descriptions of the Project Area

(1) Location and Natural Condition

(a) Musaverema

The Project Area is located closely to the provincial boundary in Matabeleland at the western edge of Masvingo province. It takes about two hours by car from Masvingo town to the Project Area with 100 km (southward via paved Beitbridge road) for one hour ride and further 70 km unpaved road for another hour ride.

The annual rainfall is about 600 mm on an average although having heavy annual fluctuation to result in frequent serious drought damages which have made the Area famous in the country for its vulnerability to drought. Miserable scenes due to drought in 1984 were reported in the country through a variety of mass media.

(b) Magudu

The Area is in the southern limit of the crop cultivation and the animal husbandry is mainly practised in the further south of the country. The annual rainfall is about 700 mm on an average and there are river discharges observed for two or three months only a year. In other months, the inhabitants are supplied with underground water by digging the riverbed. The approach to the Area from Masvingo town is about 130 km via Ngundu and about 20 km via unpaved road.

(c) Munjanganja

The Area extends about 70 km north-east of Masvingo town at the elevation of about 1,100 m, which is highest in elevation of all six proposed sites. The Area will be most advantageous taking into account river runoff discharges available throughout the year.

(d) Chinyamatumwa

The Area, located about 15 km south-east of Bikita, has the beneficial area extending around the Garange primary school. The annual rainfall is about 800 mm which is more than the others, but the local people obtain their potable water by shallow wells by some springing water because of little direct runoff discharges due to well-developed cracks in the granite layers.

The paved road upto Bikita is about 110 km from Masvingo town, and another 20 km of unpaved road is necessary to reach the proposed site.

(e) Mashoko

The Area is located almost in the center of the Matsai Communal Land, in the upstream of which there is the Mashoko Mission.

The Matsai Communal Land, so-called Middle Veld with elevation 1200 m to 600 m, is arid area with annual average rainfall of about 600 mm. The river runoff discharges take place only after heavy rainfall.

The access to the Area from Masvingo town is about 110 km of paved road and another about 50 km of unpaved road.

(f) Mabvute

The Area is located about 25 km south of Zaka, and the most humid area of the Province with the annual average rainfall of about 800 mm. The runoff ratio shows the highest of all the proposed areas.

The catchment area is about 31.1 km^2, which can hold water resources of about 3.1 MCM per year, about 1.3 MCM of which is expected to be utilized.

Access to the proposed site is about 120 km paved road to Zaka and another 30 km of unpaved road which is now under paving works. The project indices are listed in Table 3-3.

(2) Agriculture and Socio-economy

(a) Musaverema

The Area carries out cereal cropping and animal husbandry in combination, and the latter is the money earner by about 20 percent of the total income of the Area. As major crops, sunflower has been introduced besides maize. Since there are no large towns and factories in and around the Area, the inhabitants do not have good employment opportunities.

(b) Magudu

The Area is relatively low in farm productivity in spite of being blessed with favourable soil conditions. This was due to serious drought which hit the Area several times.

The population density of the Area is comparatively high and the local farmers cannot obtain sufficient income from farming due to small land holding by 1.8 ha/farmer. Consequently, the farmers have to go out working in Renco mine, Chiredzi commercial farm.

(c) Munjanganja

The farmers in the Area have been mainly engaged in crop cultivation with animal husbandry occupying a very small portion in the farm income, and maize production accounts for about 80 percent of the total farm production in the Area. The land holding per farmer is the largest in the six proposed areas.

(d) Chinyamatumwa

In the past, the Area was a typical maize production area, but recently, the local farmers have been trying to introduce diversified cash crops like groundnuts. The farming land area, however, is not so large that the farmers can earn their farm income as small as about 25 percent of total income from non-farm income sources.

(e) Mashoko

The farmers of the Area have been mainly depending upon animal husbandry rather than crop husbandry. Maize cropped in the Area is for individual family consumption. Different from crop husbandry, animal husbandry is not limited by land acreage factor, and animal husbandry can be practised more freely than crop husbandry.

(f) Mabvute

Crop cultivation is the main agriculture in the Area with the most rainfall of the six proposed sites together with very favorable soil conditions prevailing. The farm productivity, therefore, is more stable than the other areas.

A paved road is now under construction between Zaka and Chiredzi. And since this road will run about 8.0 km west of the Area, the Area will be benefited by cultivating cotton and other cash crops.

Table 3-3 Location Indices of Project Area

	Musaverema	Magudu	Munjangania	Chinyamatumwa	Mashoko	Mabvute
1. Administrative Division						
District	Mwenezi	Masvingo	Gutu	Bikita	Bikita	Zaka
Communal Land	Matibi I	Nyajena	Gutu	Bikita	Matsai	Ndanga
2. Damsite Location						
Map Reference	2030D3	2031C3	1931C4	2031B1	2031B4	2031C2
Coordinates	TN397011	UN143006	UP278155	UN654702	UN709346	UN388234
Altitude (m)	672	514	1134	736	664	630
3. River						
Name of River	Musaverema	Mwedzi	Mutore	Chinyamatumwa	Chenyere	Mushuche
Catchment Area (sqkm)	131.0	41.9	52.8	16.4	27.2	31.1
4. Common Utility (Distance)						
Business Center	Neshuro (26)	Nyamande (4)	Mutanbara (6)	Mujiche (4)	Magocha (3)	Mabvute (0.5)
School (Km)	Shazhaume (10)	Magudu (5)	Munjanganja (0.5)	Garange (1)	Zindove (4.5)	Chipfunde (1)
Mission (Km)	Matibi (3.5)	—	—	—	Mashoko (2)	—

Table 3-4 General Situation of Communal Land

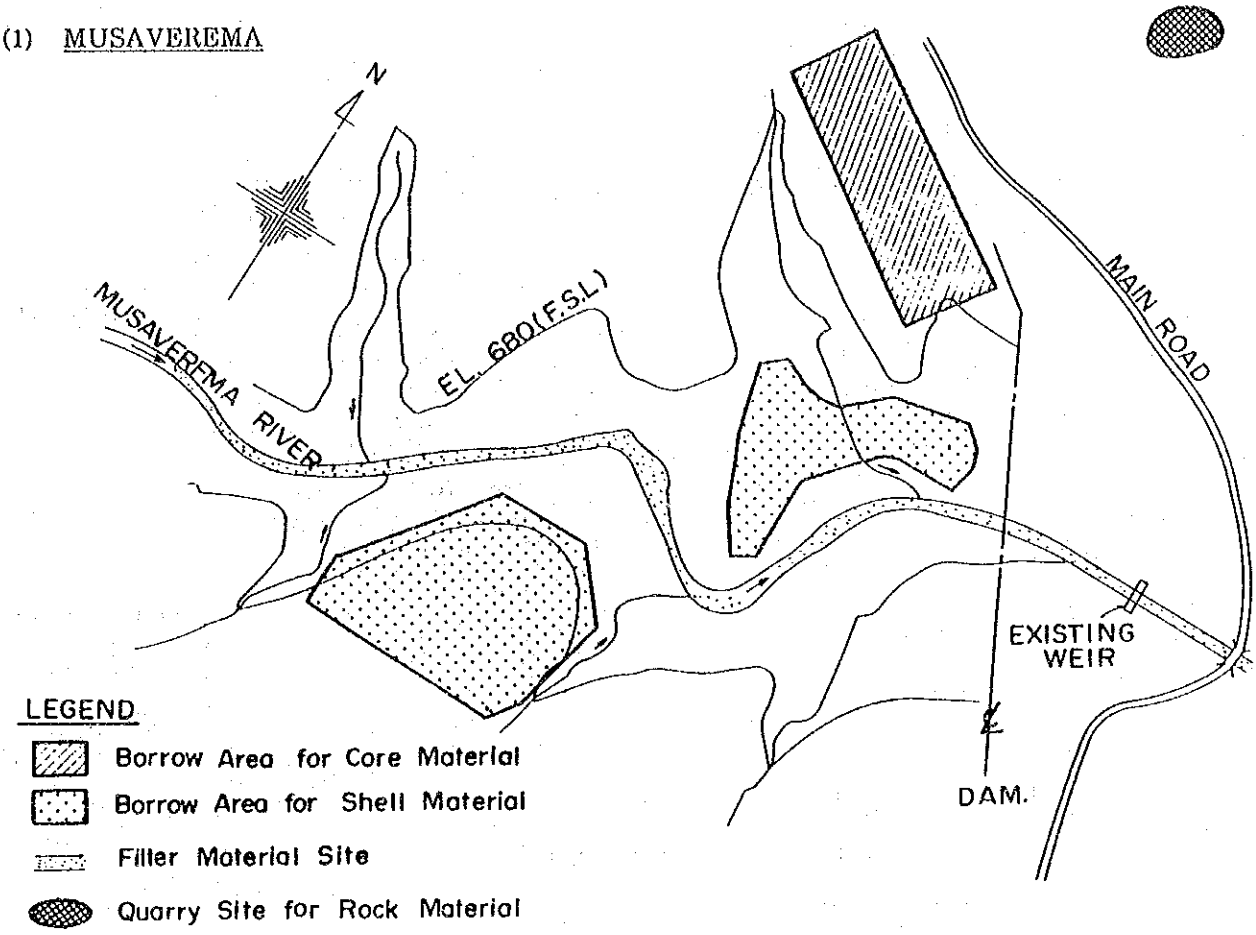
	Musaverema	Magudu	Munjanganja	Chinyamatumwa	Mashoko	Mabvute
Name of Communal Land	Matibi I	Nyajena	Gutu	Bikita	Matsai	Ndanga
Area (km^2)	1,037	595	2,775	1,931	431	3,076
Population	56,400	47,900	203,500	115,800	34,000	175,000
Farm Households	6,800	8,000	32,800	21,400	3,800	27,500
Cultivated Land (ha)	25,200	14,100	155,400	30,300	6,000	70,900
Population Density (persons / km^2)	54.4	80.5	73.3	60.0	78.9	56.9
Average Holding Size (ha)	3.7	1.8	4.7	1.4	1.6	2.6
Production of Maize (tonne)	10,200	6,800	30,800	23,100	3,300	34,200
Yield per Hectare (tonne/ha)	0.4	0.5	0.2	0.8	0.6	0.5

Source : Provincial Agricultural Extention Office

3.6. Borrow Area

Embankment materials for dams, such as impervious core soils, semi-pervious shell soils, rip-rap rocks, filter sands, etc. are mostly obtained in the vicinity of dam sites. Based on the field reconnaisance survey and the studies of the survey results performed last year, the borrow area and the materials for each dam site are selected as illustrated and described briefly as follows:-

(1) MUSAVEREMA



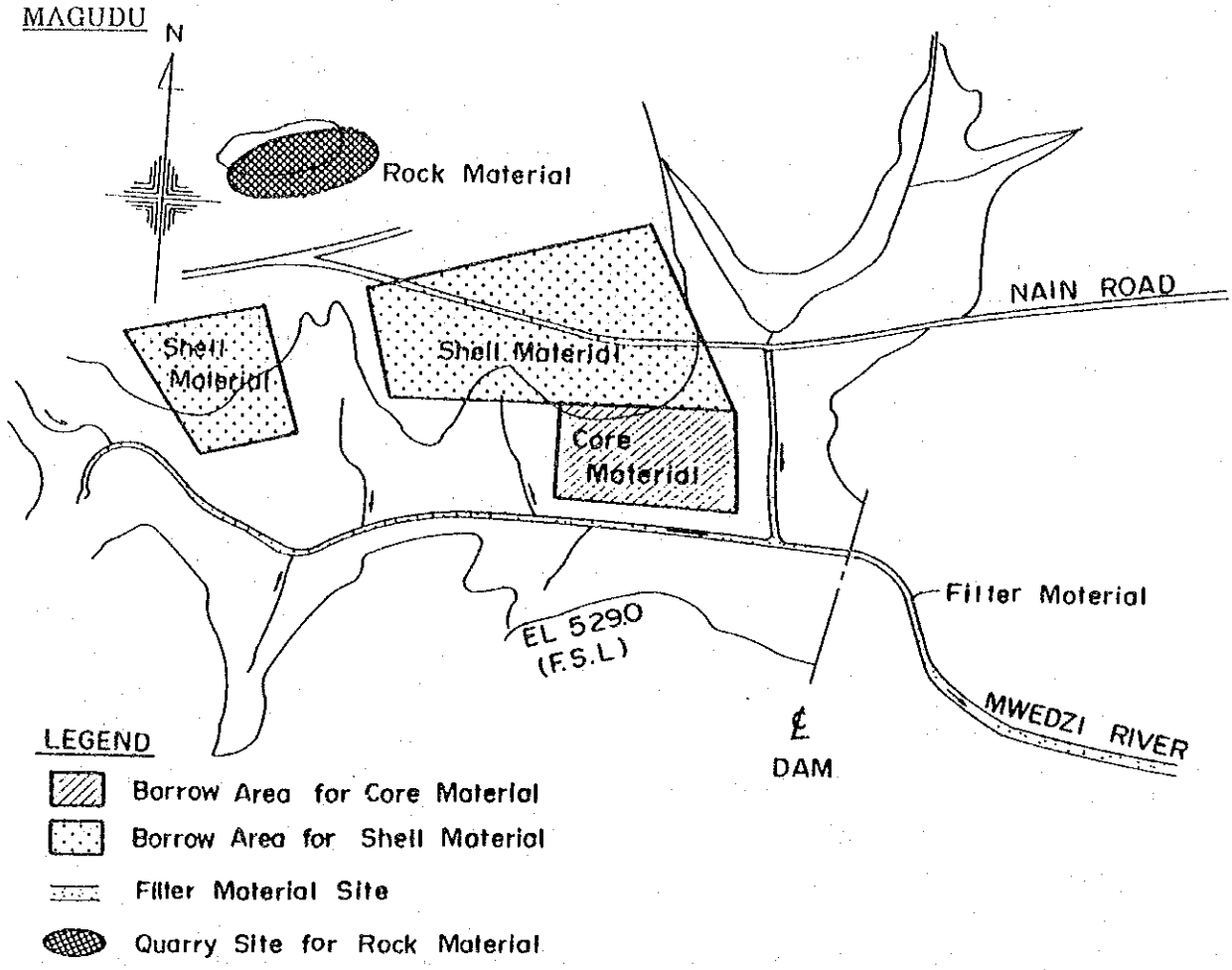
CORE MATERIAL; Impervious soil. Reddish clay to sandy clay with high to moderate plasticity (CL to SC). Obtained from the gentle slope of upstream left abutment. Approximate hauling distance (d=) is 1.0km from the center of dam site. Expecting volume (V=) is about 150,000m^3.

SHELL MATERAIL; Semi-pervious to impervious soil. Sandy clay (SC) from the up-stream gentle slopes of both abutment (but mainly right abutment). d=1.7km. V=360,000m^3.

FILTER MATERIAL; Sand from the river bed nearby dam site which has sufficient deposit because of downstream existing weir. d=0.5km. V=40,000m^3.

ROCK MATERIAL; Rock for rip-rap, pervious embankment and stone masoning are of blusting at quarry site (hill of moderate size on the left abutment), Hard gneiss. d=1.5km. Location; TN401026.

(2) MAGUDU



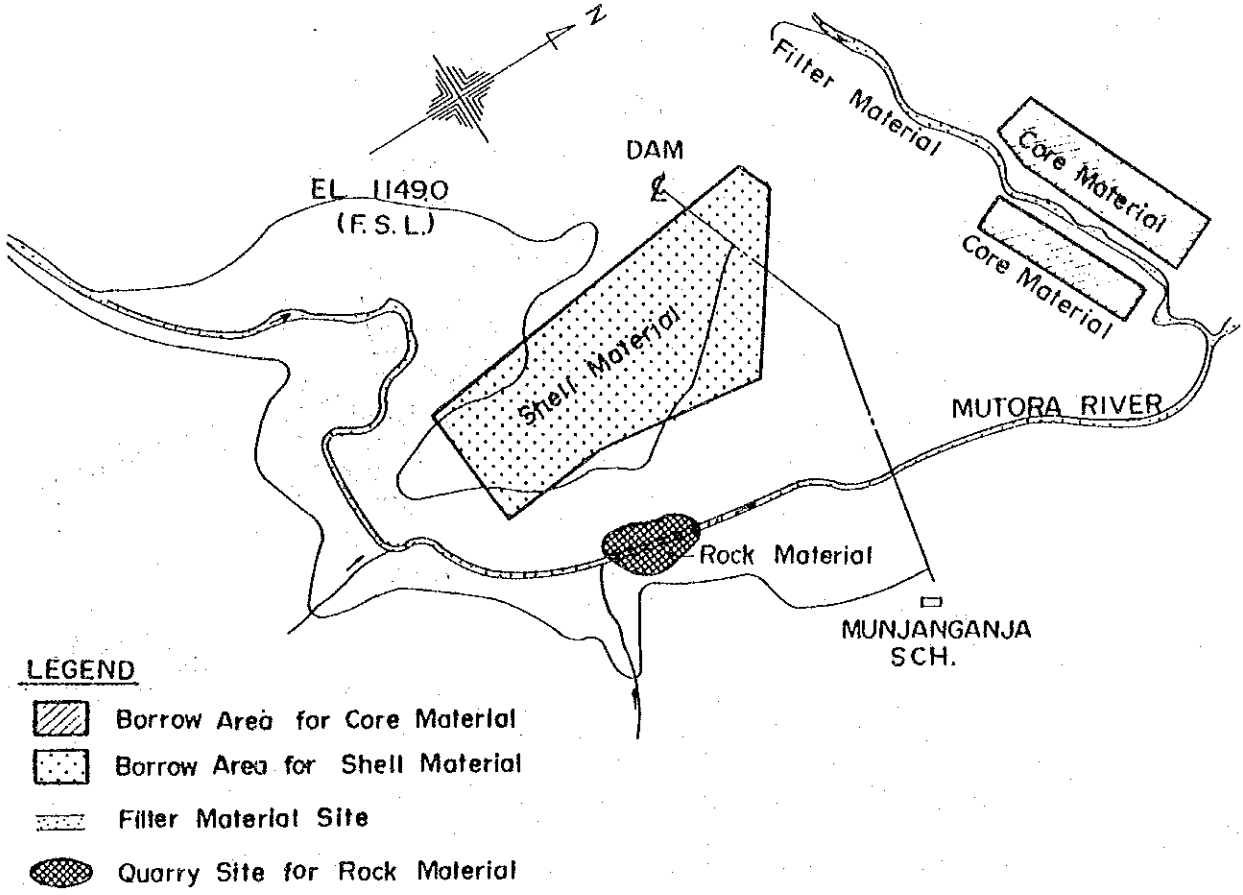
CORE MATERIAL; Reddish brown, silty to sandy clay with moderate plasticity (CH to SC) from the very gentle slope of upstream left abutment nearby dam site. d=0.7km. V=180,000m^3.

SHELL MATERIAL; Grey to reddish, sandy clay (SC) from the very gentle slopes of upstream left abutment. d=1.5km. V=495,000m^3.

FILTER MATERIAL; Sand deposit on the downstream of Muwedzi River (d=2.0km. V=10,000m^3). But not adequate. Additional sands are from Matize River (d=17km). V>10,000m^3. Location; UM145922.

ROCK MATERIAL; Hard gneiss from the hill of moderate size on the upstream of left abutment. d=1.5km. Location; UN078028.

(3) MUNJANGANJA



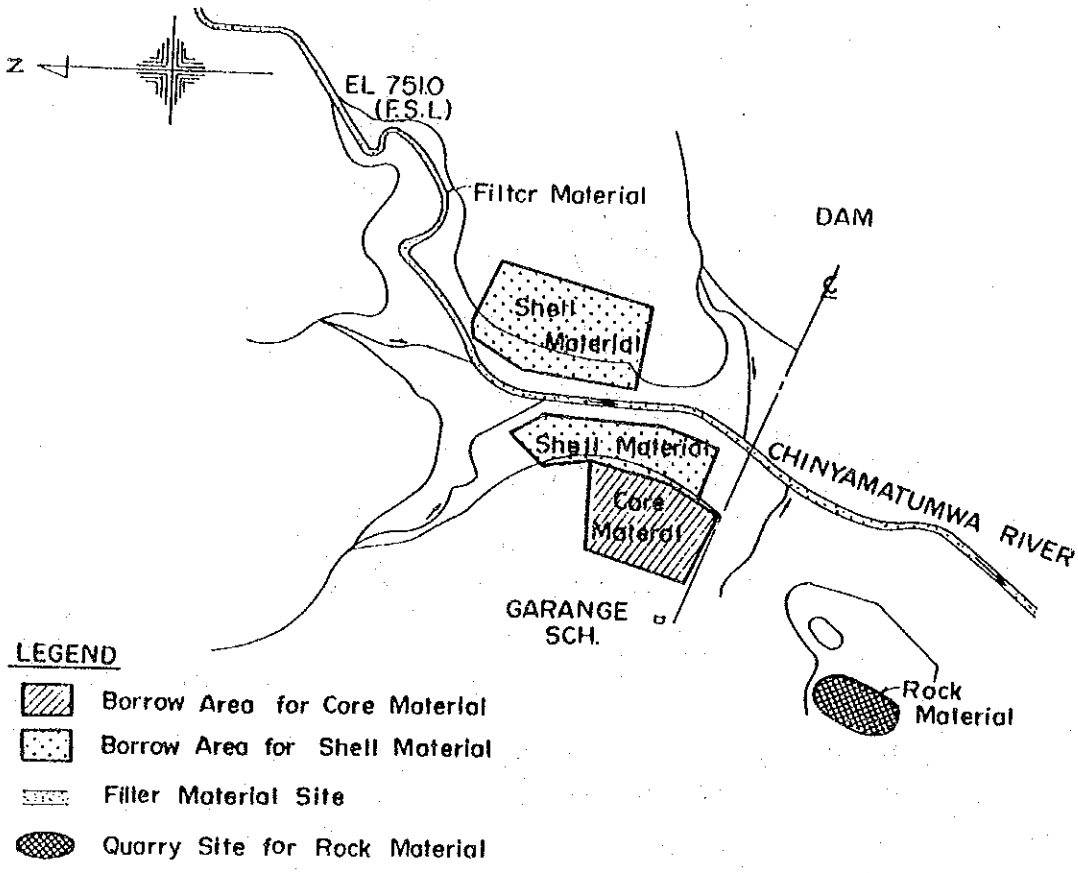
CORE MATERIAL; Reddish, sandy clay with high plasticity (SC) from the dowmstream area on the gentle slopes along the tributary river. Contains some amount of small gravels. d=1.7km. V=90,000m^3.

SHELL MATERIAL: Light brown, sandy clay (SC) from the gentle hill on the left abutment (mostly upstream). d=1.7km. V=400,000m^3.

FILTER MATERIAL: Sand deposit on the downstream tributary, but inadequate. Main sand pit is river bed of DEVURE River. d=12km. V>10,000m^3. Location: UP290243.

ROCK MATERIAL; Hard granite from the upstream steep slopes along the main stream. d=1.0km. Location: UP277152.

(4) CHINYAMATUMWA



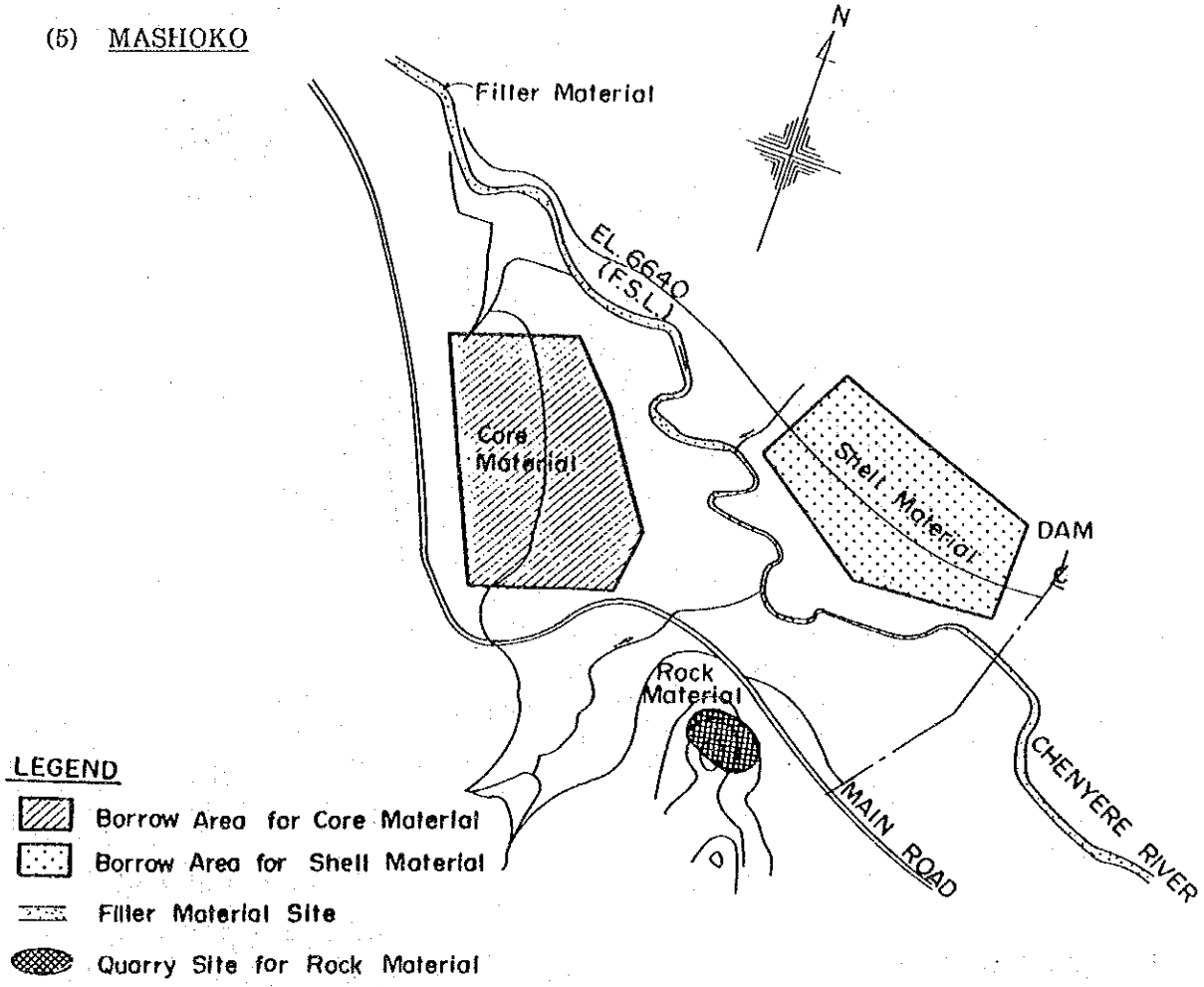
CORE MATERIAL; Reddish, clay to sandy clay with high to moderate plasticity (CH to SC) from the gentle slope of the upstream right abutment nearby dam site. d=0.7km. V=120,000m^3.

SHELL MATERIAL; Sandy clay (SC to SM) from the slopes on the upstream of both abutment. Materials from the left abutment contains some amount of small gravels. d=1.2km. V=280,000m^3.

FILTER MATERIAL; Sand deposit on the upstream of Chinyamatumwa River (d=0.7km. V=7,500m^3) But not sufficient enough to cover all demand. Additional sand pit are river bed of Muziche River (d=6km). V>10,000m. Location: UN643643.

ROCK MATERIAL; Pegmatite from the hill of the downstream right abutment nearby dam site. Rock is somewhat weathered and crackery. d=1.0km. Location: UN651697.

(5) MASHOKO



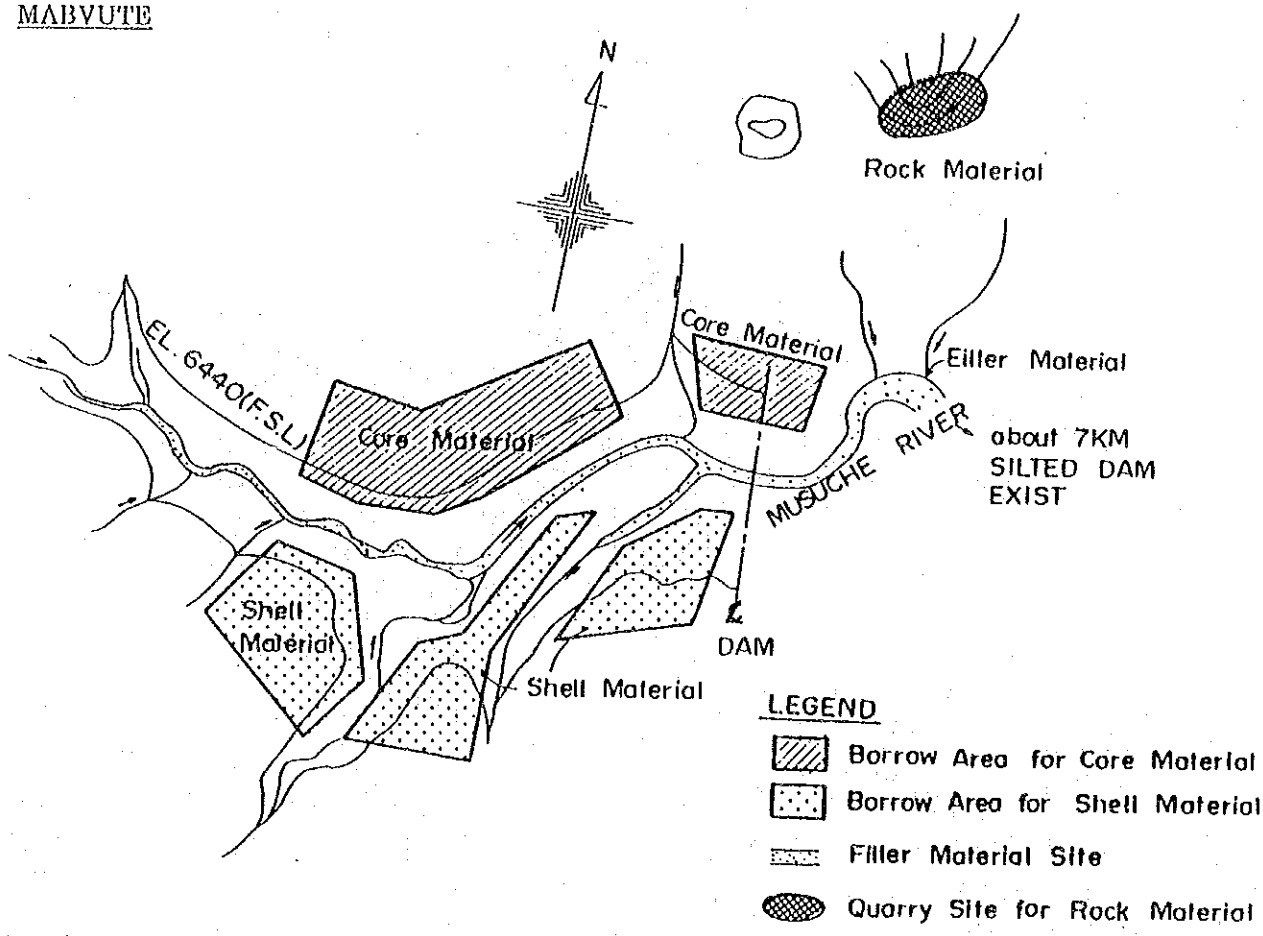
CORE MATERIAL; Reddish, sandy clay with moderate to high plasticity (CH, SC to GC) from very gentle slope on the upstream right abutment. d=1.6km, V=188,000m^3.

SHELL MATERIAL; Grey, sandy clay (SC to GC) from the gentle slope of upstream left abutment nearby dam site. d=0.7km. V=360,000m^3.

FILTER MATERIAL; Sand deposit from river bed of Chenyere River, mainly obtained upstream side upto the wrecked dam (d=2.0km. V=8,000m^3) And supplementary sand pit is expected at the river bed of the large Turwi River (d=24km). V>10,000m^3. Location: UN651494.

ROCK MATERIAL; Metabasite from the hill on the right abutment nearby dam site. Somewhat weathered and very cracky but hard quality. d=1.0km. Location: UN706341.

(6) MABVUTE



CORE MATERIAL; Reddish, clay to sandy clay with moderate to high plasticity (CH, CL to SC) from the gentle slopes to the left abutment (mainly upstream side). d=1.6km, V=160,000m^3.

SHELL MATERIAL; Grey to reddish, sandy clay (SC) from the gentle slopes of the upstream right abutment. d=1.3km. v=330,000m^3.

FILTER MATERIAL; Sand deposit from the river bed of Musuche River (d=2.0km. V=8,000m^3) nearby dam site. But not enough to cover all demand and additional sand deposit is found on the far downstream of Musuche River where existing but silted dam exists. (d=8km). V>710,000m^3. Location: UN443246.

ROCK MATERIAL; Granite from the hill of moderate size on the left abutment. Very hard and messive. d=1.0km. Location; UN387243.

CHAPTER 4. OUTLINE OF THE PROJECT

4.1. Objective

The annual rainfall in Masvingo province is recorded as much as 800 mm to 1,000 mm in the central part while as little as 500 mm to 700 mm in the communal land surrounding the commercial farm areas. Most of rainfall is concentrated in the rainy season from November to February, whereas little rainfall is observed in the dry season.

In the communal land, maize, sorghum, some drought-resistant crops as staple cereals are fully cultivated relying only upon the rainwater available in the rainy season. Even in the rainy season, the rainfall is not only insufficient, but has heavy fluctuation in its amount, and only 300 mm to 400 mm can be observed in the drought years. Such a little and unstable rainfall has remarkably lowered the farm production and there has been no harvest observed in some areas. Under the circumstances, the people in the communal land have been often driven into such difficulties in the drought years that they are forced to live on the Government drought relief against serious food shortage.

Furthermore, the local farmers are commonly keeping several head of domestic animals like cattle, donkey, sheep, etc., and they suffer in the drought years from not only feed shortage but water shortage for animals.

The farmers have to migrate with animals to seek for their drinking water sources, and the most harsh drought sometimes compels the farmers slaughter some of their animals to decrease them in head for management of the animal water.

The objective of the Project is to ensure the water for irrigation and animal breeding through potential surface water resources development by constructing medium size dams across the medium rivers running through the communal land in Masvingo province, where the local inhabitants have been suffering from frequent serious drought damages.

Introduction of modern irrigation practices aims to secure stable crop production with high yield and stable supply of fresh vegetables to local people throughout the year so as to improve the nutrition balance for health improvement.

Further to the above, the Project will enable to transfer the technology of construction of the proposed dams and their related structures to the engineers of Zimbabwe as well as to give training to the local farmers on operation and maintenance of the new facilities for modern irrigation.

4.2. Study of the Project

4.2.1. The Requests

MEWRD and AGRITEX of Zimbabwe have requested the Government of Japan to give grant aid for construction of six medium size dams, conveyance canals, and night storage reservoirs in Masvingo province together with provision of construction machineries and equipment for the works. And the requests were carefully studied below.

4.2.2. Feasibility and Necessity of the Project

(1) National Water Resources Development Plan

The mean annual runoff in the whole area of Zimbabwe is estimated at 19,910 x 10^6 m^3 and the assessed total water resources and the figures of present utilization are summarized as follows.

Item	Storage	Yield
Potential (MCM)	39,820	11,260
Present (MCM)	5,831	2,476
Ratio (%)	15	22

MEWRD had made a plan to construct reservoirs with the total storage capacity of 1,500 MCM within five years from 1986 to 1990. Presently, 800 MCM reservoirs have been completed. In next five years from 1991 to 1995, another 1,500 x 10^6 m^3 reservoirs are planned to be constructed.

(2) Medium Size Dams in Zimbabwe

Before the independence in 1980, the Country had developed farm land of about 155,000 ha centering about the large scale commercial farm areas with 1,320 MCM of irrigation water secured.

On the other hand, the irrigated areas in the communal land are only 3,075 ha throughout the country as shown in the following table.

Province	Nos. of projects	Irrigation areas	Nos. of farm households
Manicaland	10	1,980	2,382
Mashonaland	1	2	6
Masvingo	8	208	1,614
Matabele Land North	7	42	176
Matabele Land South	12	343	1,819
Midland	15	300	1,244
Total	53	3,075	7,241

The Government of Zimbabwe has been advocating "the Growth with Equity" to positively promote the development of the communal land areas, and has requested advanced countries and various international organizations to extend cooperation and aids for development of the medium size dams in the respective provinces concerned.

The aforesaid countries and organizations have tried to formulate the medium size dams projects in five provinces in their charge, while necessary study is on-going in three provinces.

Japan takes charge for Masvingo province and submitted the final study report to the Zimbabwe government in March, 1988.

According to the results of the medium size dams in the country, there have been about 80 to 150 potential sites found in each province, 30 to 40 among which are the priority projects in view of urgency and economy. These priority projects, however, have not made good progress in realization due to financial difficulty and shortage in qualified engineers and experts.

(3) Construction Machines of MEWRD

The construction machines used for works in force account basis have been borrowed from CMD of Ministry of Transportation and private plant hire companies. The number of construction machines borrowed for the construction works of earth fill dams in force account basis are summarized as follows.

Machines	1985	1986	1987	1988	1989	Average
Dozer	6	2	2	6	8	4.8
Scraper	9	3	3	9	12	7.2
Front-end loader	3	1	1	3	4	2.4
Grader	3	1	1	3	4	2.4
Grout pump	3	1	1	3	4	2.4
Compressor	6	2	2	6	8	4.8
Bowser	6	2	2	6	8	4.8
Excavator	3	1	1	3	4	2.4
Roller	3	1	1	3	4	2.4
Tipper	6	2	2	6	8	4.8
Total Cost (million Z$)	2.5	2.8	1.8	11.2	11.1	5.9

(4) Medium Size Dams Project in Masvingo Province

The study of medium size dams projects in Masvingo province was requested by Government of Zimbabwe to Japan, and the feasibility study team was dispatched to the field in September, 1986, and the development plan was formulated into the feasibility study report which was submitted to the Government of Zimbabwe in March, 1988.

In the study, 98 potential damsites were proposed and examined and as a result of the study, 37 sites were selected taking into account the irrigable areas, head of animals feedable with water, construction costs, storage capacity of dams, etc.

(5) Alternative Water Source

Groundwater in this region is not affluent and very precious for the drinking water for the inhabitants and it cannot be used for irrigation. Only the surface water in tributary rivers can be utilized for irrigation in the communal land.

(6) Selection of Proposed Project Sites

For the proposed dam construction, however, the transfer of technology shall be made to the Zimbabwean engineers and experts assigned to each district, and, consequently, the transfer of the technology on construction and O & M of facilities will be made smoothly in a wide range, if one dam can be constructed in each district.

The transfer and extension of the technology for irrigated agriculture to the local farmers shall be made as well through practices in the farm plots prepared and allotted by the project. In such case, the farm plots newly provided should be located within 5.0 km from the farmers' houses for easy commuting. Furthermore, the successful expansion of irrigated farming in future requires to provide some model farms to demonstrate the irrigated farming to the local farmers.

Therefore, the implementation of the proposed six dam projects illustrated in the Location Map are deemed justifiable along with the reasons given above.

(7) Effectiveness of the Project

The irrigable areas by the proposed six medium size dams are as small as 20 ha to 100 ha in scale. The expected crop production increase can be studied in comparison with the result obtained by the existing Mapanzure irrigation scheme in Masvingo province.

(a) General Descriptions of Mapanzure Irrigation Scheme

(i) Summary of project history

The project aimed to irrigate the wet season crops only for the first time in 1968 when the intake weir was completed. Since the said weir has been buried with the sediments, a medium size dam was constructed upstream of the weir in 1975.

(ii) Scale of the project

Catchment Area	42.8 km^2
Storage Volume	1.23 MCM
Dam Height	17.0 m
Dam Length	320 m
Irrigable Area	48 ha

(iii) Farm plots distribution and management

- 0.26 ha/farmer was distributed to 180 farmers.
- Water charges Z$4.5/0.1 ha
- Beneficiary farmers 180 farmers

  An Irrigation Committee is established with one Committee Chief, who can make decision of cropping pattern, water distribution, etc. for the farmers.

. The extension workers dispatched by AGRITEX are rendering guidance and extension services for farming.
. An agricultural cooperatives organized under the Irrigation Committee is engaged in the procurement of fertilizers, agri-chemicals, etc. and in marketing of the farm products.

(iv) Agricultural production

At present, the major farm products in the areas are maize and groundnuts, the respective productions of which can be shown as follows together with the yields from rainfed farming.

Unit: tonnes/ha

Crops	Mapanzure Irrigation Scheme			Rainfed Ave.
	Mini.	Max.	Ave.	
Maize	2.5	10.5	6.9	0.8
Groundnuts	2.5	5.0	3.9	0.4

Demand increase of tomato and other vegetables and transportation improvement have permitted to have expectation to introduce vegetable cropping in future.

(b) Effectiveness of the Project

The direct benefits expected from the project are the following three items.

. Production increase of maize, etc.
. Year-round supply of fresh vegetables
. Sufficient water supply for domestic animals

Following are the discussion on the project benefit and impacts expected.

(i) Cereal Crops Production Increase

As clearly known from the Mapanzure Irrigation Scheme, the cereal crops production has been remarkably increased by effective irrigation practices.

Taking maize as an example, successful irrigation practices can allow the double cropping of cereals to produce 6.9 tonnes/ha of maize per single cropping, which is about 8.5 times of the present yield of 0.8 tonnes/ha and is equivalent to 17 times taking the effect of double cropping into consideration.

From such increased production, the proposed irrigation area of 50 ha on an average can have almost same productivity of maize as the present rainfed fields of 850 ha.

Under the conditions, the planned land allocated to the farmers by 0.1 ha to 0.2 ha per farmer can stand for 1.7 ha and 3.4 ha of the rainfed farm land in their productivity, although deemed small in acreages.

(ii) Year-Round Supply of Fresh Vegetables

The per capita consumption of vegetables in Zimbabwe is as little as 16.5 kg/year in comparison with those other countries of Kenya by 22 kg, Tanzania by 46 kg, etc.

This fact suggests that a quantity of fresh vegetable supply throughout the year is very difficult unless stable production is assured by irrigation in the dry season. As a matter of fact, vegetables farming in the communal land in the dry season is practised in a small garden type plots

(about 100 m^2) with water available by bucket-carrying from the nearby, where the people can dig the subsurface water out of the dried riverbed. As a result, the dry season vegetable production is quite small in quantity.

When the farm land of about 10 ha, equivalent to 20 percent of the proposed total acreage of 50 ha, could be cropped with vegetables under irrigation, two harvests per year would be possible in view of climatical conditions, and the expected harvest, as follows;

10 ha x 20 tonnes/ha x 2 times = 40 tonnes

Based on the above, above 20,000 people will be supplied with about 20 kg of vegetables per year.

Such increase in vegetable consumption will serve for improving nutrition problem of the local people.

(iii) Water Supply for Domestic Animals

At present, the animal drinking water is supplied in the dry season, in the same way as the vegetable irrigation water from the dried river. When the dams, however, are completed under the Project, around 1,000 head to 2,000 head of animals kept within 5.0 km from respective dams will be able to be fed with water of reservoir throughout the year.

If the distance from the dams is extended to 10 km for the animals, 4,000 head to 8,000 head will be able to be fed with water in storage, so that the number of animals would not be decreased even in the drought years.

The number of the households benefited by animal water supply with dams is estimated at 3,000 housholds for one dam.

4.2.3. Executing Body and Management Plan

(1) Executing Body

The two Executing Bodies of the Project are the MEWRD and AGRITEX which will share in carrying out the Project Works.

MEWRD covers most of all the water resources development works in the country by construction of large and medium size dams, borehole drilling for groundwater. The MEWRD will be responsible for the following Project works:

- Construction of medium size dams
- Construction of conveyance facilities
- Construction of night storage reservoirs

On the other hand, AGRITEX will be responsible for agricultural extension works to improve the farming technology and to extend the modernized farming to the local farmers, and will be responsible for the following works:

- Consolidation of farm land
- Construction of in-field facilities
- Various facilities for farm management

The provinical office and district offices of both MEWRD and AGRITEX are located at necessary point for promotion of the similar natured water resources and agricultural development projects.

Figure 4-1 and 4-2 illustrate the organization of the both authorities as executing agencies.

Figure 4-1. ORGANIZATIONAL CHART OF MEWRD

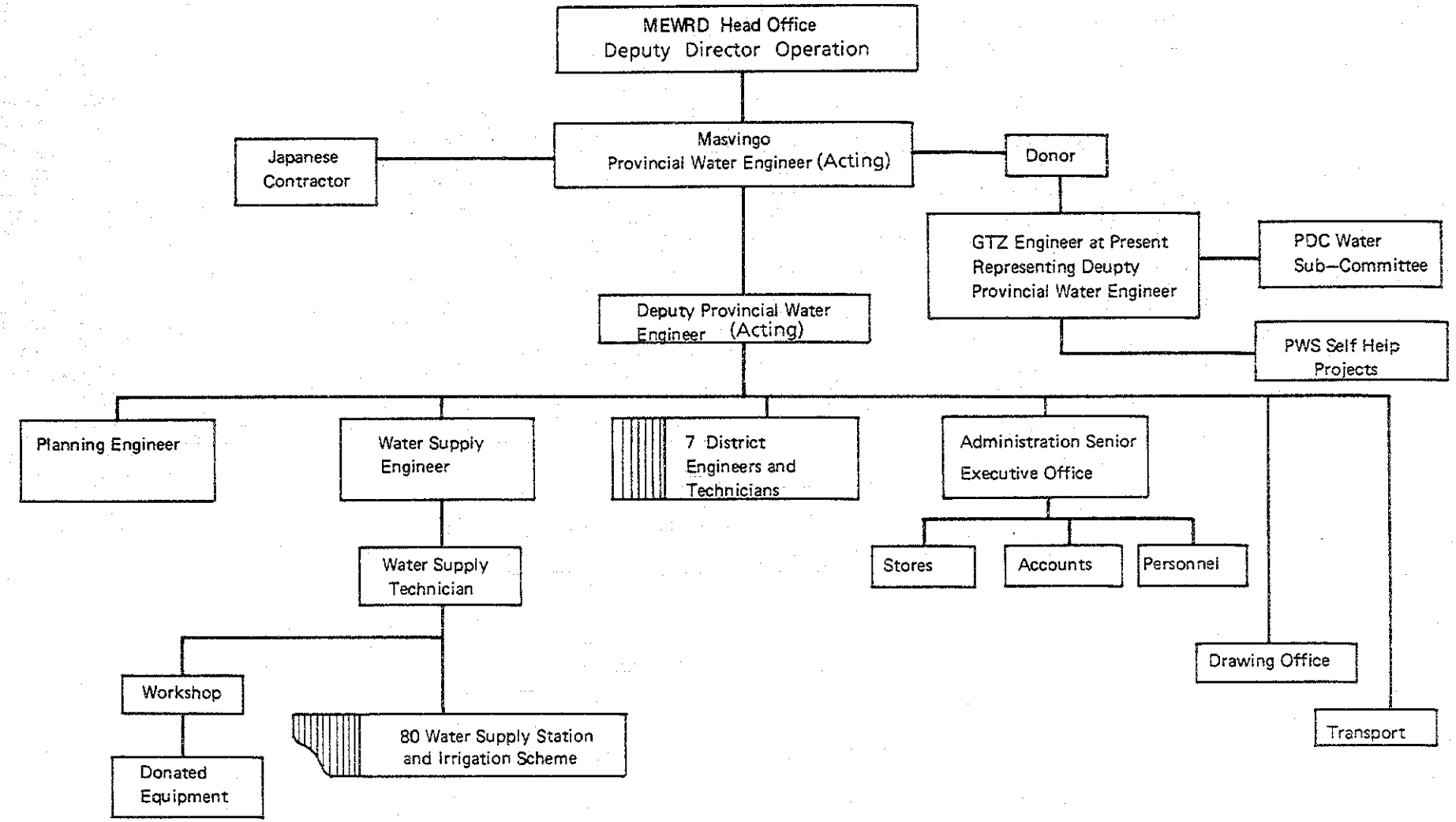
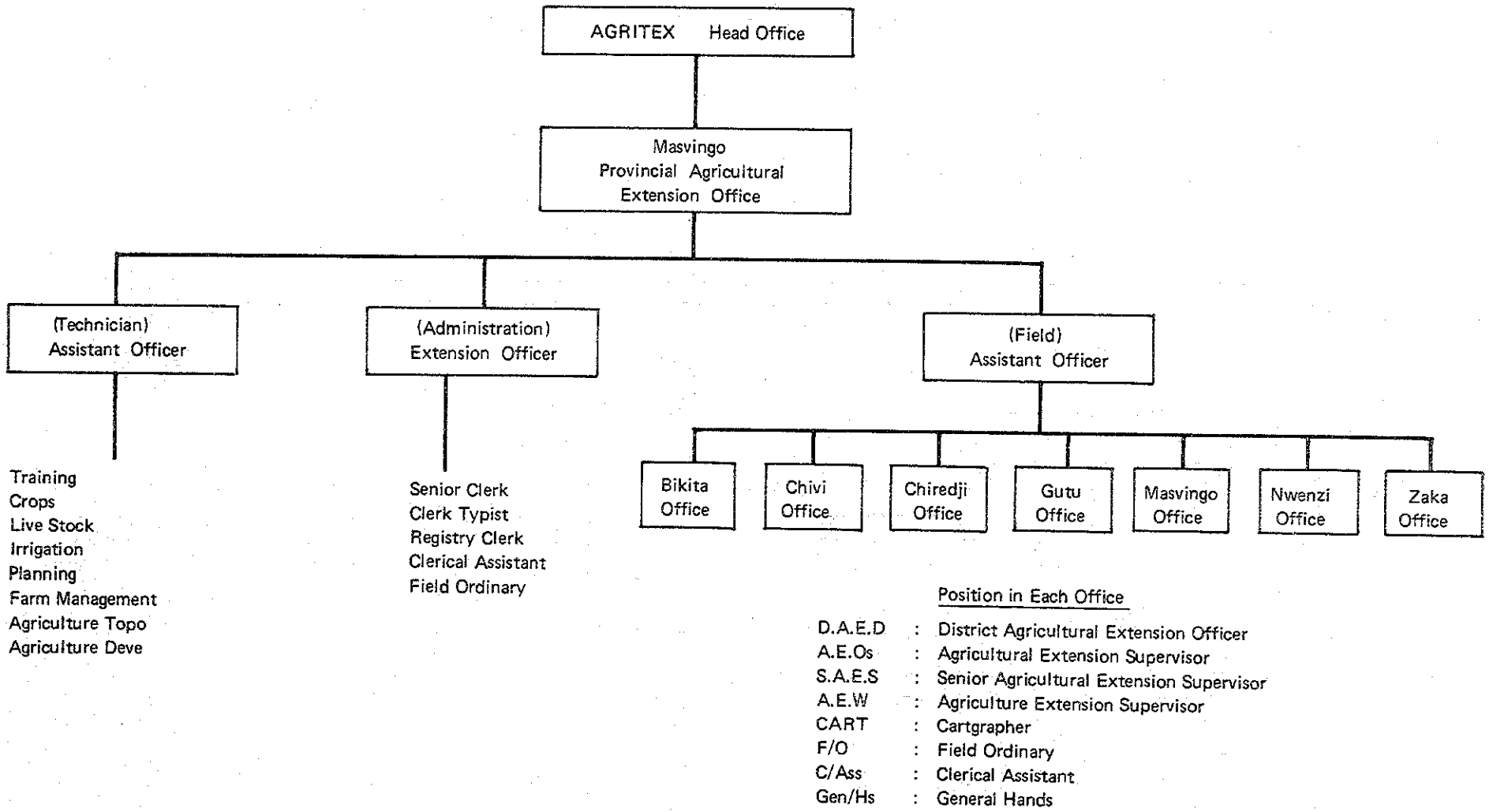


Figure 4-2. ORGANIZATIONAL CHART OF AGRITEX



(2) Implementing Body and Management Plan

MEWRD will be fully responsible for the implementation of the Project. MEWRD will make proper coordination works with MFEPD and AGRITEX and other authorities concerned for smooth execution of the Project.

The provincial offices of MEWRD and AGRITEX will carry out the practical works, however, the budgetary works, staffing, and other necessary works for the Project shall be carried out by their headquarters so as to make smooth progress of the works.

The organization of MEWRD for Project execution is as shown in Figure 4-1; The three offices of planning engineer, water supply engineer, and administration senior executive are organized under the MEWRD provincial office.

The Provincial Water Engineer represents the Ministry, shall administer and supervise the contractors who will be engaged in the construction works on contract basis. The Water Supply Engineer assigned in the provincial office shall be fully responsible for the operation and management of the construction equipment and machinery to be provided.

For the successful implementation of the Project, the staffs of the engineering department and administration department shall be assigned to their respective positions in time for the commencement of the works. The engineering department will be staffed with Civil Engineers (CE) and Civil Engineer Technician (CET), while the administration department will be staffed with Executive Officers (EO) and clerks. The Provincial Office will be staffed with about 20 members for both the engineering and administration departments.

On the other hand, the organization of Provincial Agricultural Extension Office is as shown in Figure 4-2, and the Provincial Agricultural Extension Office will be divided into three: Technical Department, Extension Service Department, and Field Offices.

The field offices shall be responsible for the execution of the works to be made on force-account basis. Each district will be provided with one field office, and about 100 officers will be prepared for the assignments to the field offices, although the assigned staffs will be different in number according to the work volume of each office.

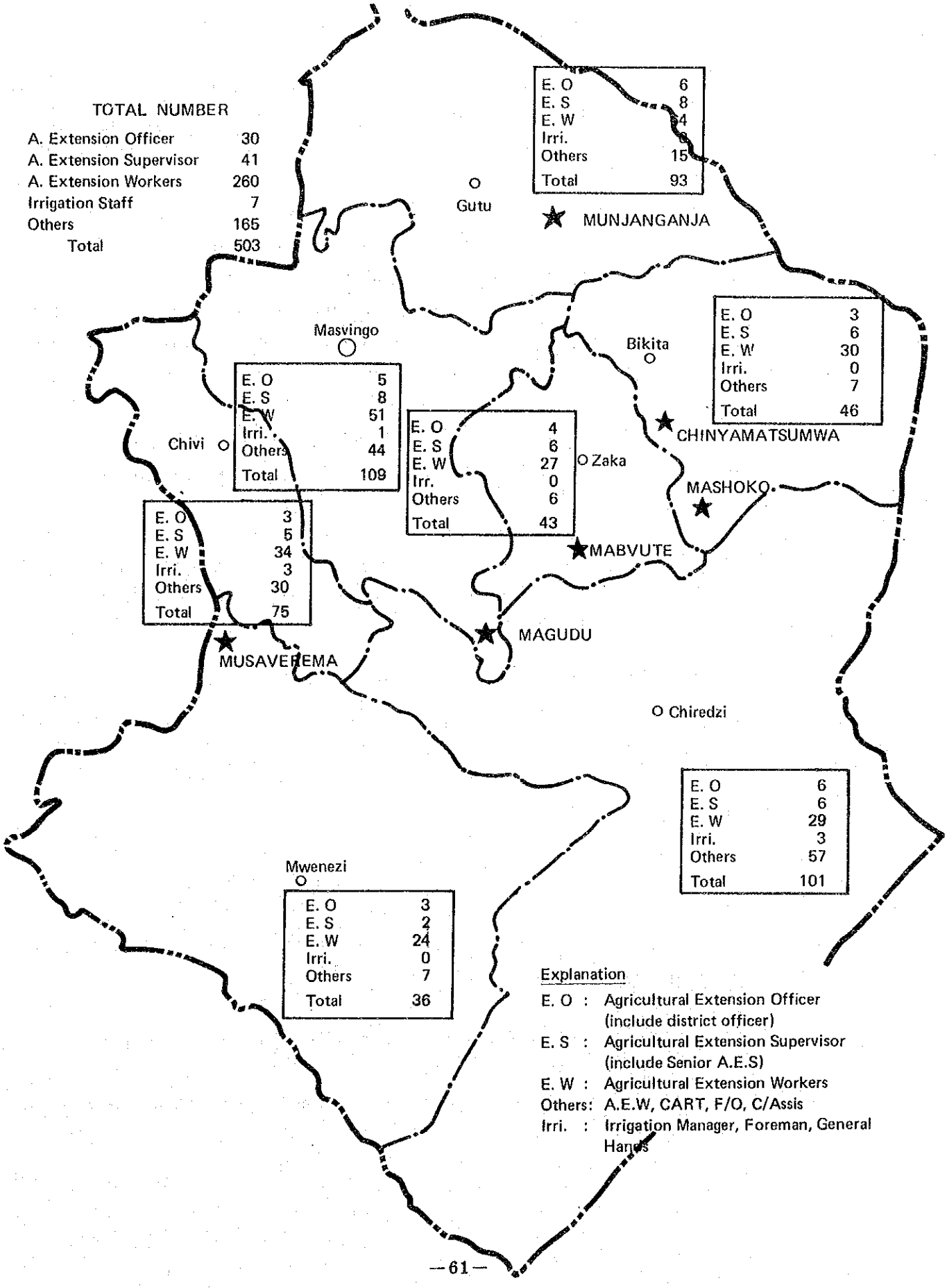
For the in-field works in the Project, the District Agricultural Extension Supervisor, Extension Workers, Irrigation Foremen, and General Workers shall be engaged in the works on force-account basis. (Ref. to Figure 4-3)

Provincial Agricultural Extension Office shall manage the personnel affairs of project level, while the headquarter in Harare shall handle the personnel affairs of the Provincial Office level.

Hence, transfer, new assignments, supplemental staffing shall be handled by both the headquarter and the provincial office at the commencement of the Project.

The equipment and machinery for in-field works shall be held under the control of PAEO. All repair works shall be handled by the Central Mechanical Equipment Department (CMED) excepting minor repairs at the sites.

Figure 4-3. NUMBER OF STAFF IN AGRITEX OF MASVINGO PROVINCE



(3) In-field Construction Works by the Government of Zimbabwe

The in-field construction works for the farm land consolidation shall be made on force account basis by AGRITEX. After the completion of the land consolidation, the cultivation right of the irrigated land will be allotted to the farmers.

The procedures to be followed by AGRITEX for land consolidation is shown in Figure 4-4. Since AGRITEX has much experience in the similar-natured projects and handling of the cultivation right and replotting, the negotiation with farmers shall be started immediately after decision of project implementation.

For allotment of the consolidated farm land, the Government takes a policy to replot the land to farmers by 0.1 or 0.2 ha per farmer.

The present land owners have the priority to acquire the land. AGRITEX shall make negotiation, guidance, and consultation with the farmers along with the aforesaid procedures, while coordinating with the Authorities concerned.

Finally, the members of the resettlers shall be decided by the Local Councillors of the provincial government and the irrigators committee within their power.

(4) Consultants

The consultants will enter into a contract with MEWRD for the following necessary consulting services, immediately after the Exchange Notes between the Government of Japan and the Government of Zimbabwe becomes effective.

a) Detailed design and preparation of the tender documents
b) Evaluation of offered tender
c) Witness and advice on the negotiation between MEWRD and the tenderer

d) Other services required for the successful execution of the works.

(5) Contractors

The Japanese Contractors, who succeeded in the tender, shall follow the necessary procedures for the contract with the Government of Zimbabwe to carry out the works with full responsibility. Furthermore, the Contractors shall dispatch their engineers to the fields so that they can transfer the knowledge and technology to their counterparts on the Project works during their assignment period.

4.2.4. Similar Natured Aid and Related Project

(1) Medium Size Dams Projects in Zimbabwe

MEWRD has planned to construct medium size dams in all provinces in Zimbabwe. The planned and on-going medium size dam projects in seven provinces of the country, except for Masvingo province, are shown below.

Province	Source of Aid	Progress
Mashonaland West	Yugoslavia	Study completed
Mashonaland Central	West Germany	Study to start in 1989
Mashonaland East	Italy	Study completed in June 1989
Manicaland	Italy	Study completed
Midlands	Denmark	Study completed in 1985 3 dams construction is completed funded by Netherlands
Matabeleland North	UNDP	Study completed one dam constructed in 1989 by Netherlands
Matabeleland South	UNDP	Study to start in 1989

Source: Head Office of MEWRD
The construction works have been started in Midland and Matabelaland North provinces.

(2) Similar natured projects in Masvingo province

In Masvingo province, 15 small to medium scale irrigation projects have been constructed or under construction, as shown below.

Name of Scheme	Construction Period	Irrigable Area(ha)	No. of Farmers	Average(ha) Holding Size/Farmer	Note
1) MUSVUVUGWA	1969-1977	60	554	0.11	
2) CHILONGA		144	234	0.61	
3) MANJINJI		33	73	0.45	
4) RUPANGWANA		6.5	44	0.15	
5) St.JOSEPH'S		14.5	112	0.13	
6) GUDO POOL		10	100	0.10	
7) TSUOVANE		400	34	11.8	
8) MAKONESE	1976-1981	60.9	400	0.15	
9) BANGA		5.5	39	0.14	
10) MUTEYO	1979-1979	7	53	0.13	
11) MAPANZURE	1968-1969	48	276	0.17	
12) MUSHANDIKE	1985-upto date	735	430	1.71	Resettlement
13) FUVE PANGANAI	1987 -	280	320	0.88	
14) MADONA	1988-1988	15	19	0.79	Resettlement
15) TANBANA	1988-upto date	19	-	-	
Total		1 838	2 593	0.13	

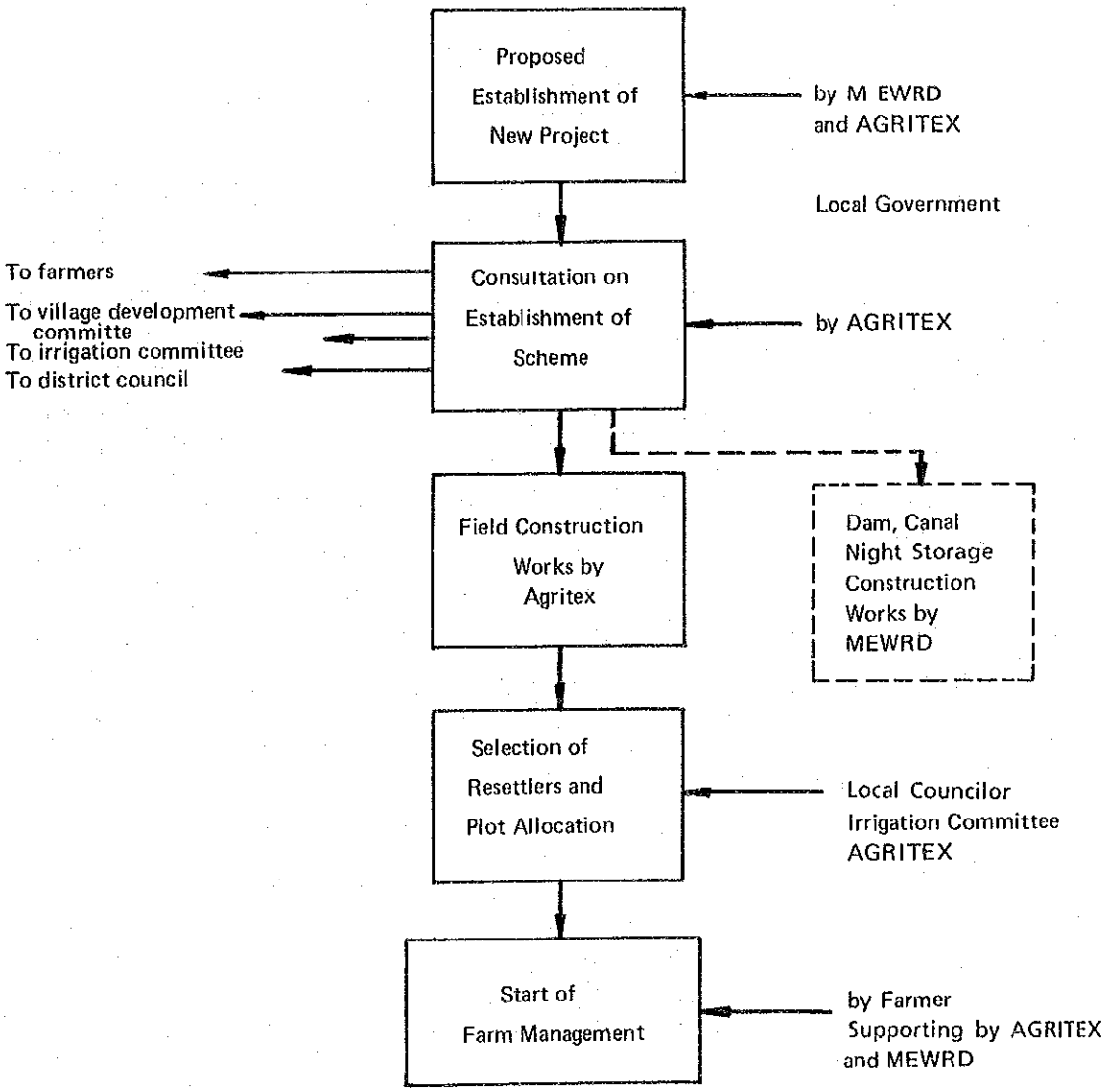
Note: 1) Schemes 12) and 14) are resettlement schemes and other schemes are communal.

2) Scheme 7) is not serviced in full by Agritex except maintenance work; design and construction.

3) Some schemes are not listed in this table as some data were not available.

At present, four construction projects, covering irrigable areas of about 1,050 ha are now on-going. Other existing 11 projects have been rehabilitated after the independence.

Figure 4-4. ESTABLISHMENT PROCESS OF PROJECT



4.3. Outline of the Project

4.3.1. Outline of Project Facilities

The project aims to develop the surface water resources at the six communal lands in the Masvingo Province for the irrigation, domestic and animal uses by constructing medium size reservoirs. The following facilities are incorporated into the project.

i) Dams with storage capacity of one to six MCM

ii) Conveyance facilities from dams to irrigable area and night storage reservoirs

iii) In-field facilities of irrigable area

The construction of dams, conveyance facilities and night storage reservoirs will be undertaken by the government of Japan, whereas the construction of in-field facilities will be undertaken by AGRITEX of the government of Zimbabwe. However, the machines and equipment required not only for the construction of dams, conveyance facilities and night storage reservoirs, but also for the construction of in-field facilities will be procured under the grant aid programme. The outline of the facilities is shown in Table 4-1.

Table 4-1 Outline of Facilities

Items	Musaverema	Magudu	Munjanganja	Chinyamatumwa	Mashoko	Mabvute
1. Location						
District	Mwenezi	Masvingo	Gutu	Bikita	Bikita	Zaka
Communal Land	Matibi No.1	Nyajena	Gutu	Bikita	Matai	Ndanga
2. Water Resources						
River Name	Musaverema	Mmedzi	Mutora	Chinyamatumma	Chenyere	Musuche
Catchment Area (km^2)	131.6	41.9	52.8	16.4	27.2	31.1
Annual Runoff (MCM)	4,454	2,891	4,171	1,689	1,306	3,349
3. Dam						
Full Supply Capacity (MCM)	6,653	5,672	1,831	2,255	1,453	5,672
Dam Height (m)	12.7	18.8	18.7	18.8	18.4	19.3
Dam Length (m)	1,700	460	920	580	700	625
4. Conveyance Facilities						
Method	Gravity	Gravity	Gravity	Pump	Gravity	Pump
Design Discharge (l/s)	54	76	49	74	23	151
Length (m)	5,600	7,940	4,720	870	800	860
5. Night Storage Reservoir						
Design Capacity (m^3)	4,600	6,500	4,300	4,300	1,400	8,700
6. Beneficiaries						
Beneficial Area (ha)	44	70	51	50	21	100
Domestic Water (persons)	2,590	2,800	1,710	1,610	570	3,930
Animal Use (LSU)	1,800	2,430	1,500	2,000	790	3,000

4.3.2. Outline of Machines and Equipment

The machines and equipment necessary for the project implementation are summarized as follows. The capacities, specifications and quantities are examined in "CHAPTER 5 BASIC DESIGN".

(1) Machines and Equipment for MEWRD

(a) Earth Work Machine

Bulldozer
Wheel Loader
Motor Scraper
Motor Grader
Roller
Hydraulic Excavator

(b) Transportation Vehicle

Dump Truck
Flat Bed Truck
Water Tank Lorry
Tractor and Trailer
Pick-up Truck
Station Wagon

(c) Grouting Machine

Crawler Drill
Grout Pump
Grout Mixer

(d) Others

Air Compressor
Pump
Generator
Concrete Mixer

(2) Machines and Equipment for AGRITEX

(a) Earth Work Machine

Bulldozer
Wheel Loader
Motor Grader
Land Grader
Land Leveller

(b) Ploughing Machine

Tractor
Disk Plough
Disk Harrow
Ripper

(c) Transportation Vehicle

Dump Truck
Tipper Trailer
Flat Bed Truck
Pick-up Truck
Fuel Bouser
Water Bouser

(d) Others

Pump
Generator
Concrete Mixer
Plate Compactor

4.3.3. Operation and Maintenance Plan

(1) Organization of Operation and Maintenance

The operation and maintenance (O & M) services in the Project shall be rendered for the dams, pumping facilities, canals, night storage reservoirs and in-field facilities for agricultural production as well for equipment and machinery provided under the grant aid programme.

The provincial office of MEWRD shall render the O & M services for dams, pumping facilities, canals, night storage reservoirs, and so on, while the AGRITEX shall render the O & M services for the in-field facilities.

The facilities and major items for O & M are as follows:

Services by MEWRD Provincial Office:

Dam: Repair of embankment slope.
Pumps: O & M and replacement of facilities
Canals: Repair of broken lining, damaged structures
Night Storage Reservoir: Repair of broken embankment and slopes.

Services by AGRITEX Provincial Office:

In-field Canal: Repair and replacement of pipes, flumes, gates, etc.
Appurtenant Structures: Repair and renovation of fences and other structures

(2) O & M Costs

The O & M services shall be made in the same way that has been applied to the existing facilities. According to the MEWRD provincial office, the cost for one irrigation scheme in 1987/88 was about Z$352 on an average.

The average annual cost for the existing irrigation scheme in the province was about Z$2,770 (maximum) and Z$4.0 (minimum) on the basis per hectare of irrigation area.

On the other hand, the costs by AGRITEX were about Z$4.0/ha and Z$27/ha in 1986/87 and 1987/88, respectively.

CHAPTER 5. BASIC DESIGN

5.1. Design Policy

The basic design of the Project will be conducted in line with the following basic policies and concepts taking into consideration the particular conditions of the country, the Project Area and the system of Japanese grant aid.

(1) Because the dams and the irrigation facilities are to be constructed and maintained in communal land, the type of the structure should require simple operation and less maintenance cost.

(2) Taking into consideration that the Zimbabwean government will carry out the construction of the medium size dams with the knowledge and technology transferred through the implementation of the six projects by the Japanese contractor under the grant aid programme, the construction materials should be selected as much as possible from those materials that are easily procured in Zimbabwe.

(3) As the transfer technology through on-the-job training is one of the important factors in the project, those construction methods that are far beyond the level of construction work prevailing in Zimbabwe should not be applied.

(4) The guideline and criteria for design of dam and irrigation facilities in force in Zimbabwe should be applied.

(5) The construction machines and equipment should be selected in view of the further utilization for construction of the medium size dams project after the implementation of the six projects under the Japanese grant aid programme.

5.2. Design Criteria

(1) Hydrology

(a) Runoff at Damsite

Mean annual runoff at dam site is derived from the mean annual rainfall by applying the formula which was proposed by T.B. Mitchell and long been applied by MEWRD as follows:

$$Q = P - (p^{-3} + 1000^{-3})^{-1/3}$$

where Q is the annual runoff (mm), and P the annual rainfall (mm).

(b) Design Flood

Design flood is estimated from the probable maximum flood by applying the coefficient of return-period corresponding to the size and importance of dams. The maximum probable flood is derived from Mitchell's flood formula as follows:

$$\log_e (MPF + 1) = 1.175 (\log_e (A+1))^{0.775} + 3.133$$

where MPF: maximum probable flood (m^3/s)
A : catchment area (km^2)

(c) Sediment

Based on the Report of "Soil and Water Conservation" under National Master Plan for Rural Water Supply and Sanitation Project, sediment volume to reservoir was estimated. For six catchments, the stereoscopic interpretation of aerial photograph is applied to evaluate the state of active soil erosion.

Based on the sediment yield, the total volume of sediment in 20 years equivalent to the dead storage can be worked out by multiplying the catchment area (sq.km) and by dividing by the bulk density of the deposited sediments (= 1.35 tonnes/cu.m)

(d) Reservoir Yield

Reservoir yield at 10 per cent risk levels are evaluated in accordance with "An Assessment of the Surface Water Resources of Zimbabwe and Guidelines for Development Planning" published by MEWRD and commonly applied to calculate the reservoir yield.

The hydrological features of each project are shown in Table 5-1.

(2) Irrigation

(a) Reference Crop Evapotranspiration

The reference crop evapotranspiration (ETo), which is generally recognized as fairly reliable index for calculating consumptive use, is calculated by applying the modified Penman method, based on the climatological data observed at Masvingo Meteorological Station. Estimated reference crop evapotranspiration in the Project is summarized below.

Reference Crop Evapotranspiration (ETo)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
mm/day	6.4	5.5	5.0	4.5	3.5	2.9	3.1	4.4	5.6	6.3	6.4	6.0	
mm/month	198	154	155	135	109	87	96	136	168	195	192	186	1,811

(b) Net Irrigation Water Requirement

The net irrigation water requirements for the proposed cropping programme has been estimated and is shown in Table 5-2.

Table 5-1 Hydrological Features

	Musaverema	Magudu	Munjanganja	Chinyamatumwa	Mashoko	Mabvute
1. Catchment Area (km^2)	131.6	41.9	52.8	16.4	27.2	31.1
2. Design Flood						
(1) Maximum Probable Flood (m^3/s)	1,273	608	708	324	456	499
(2) Return Period (Year)	2,000	2,000	500	500	500	2,000
(3) Design Flood (m^3/s)	835	415	349	163	228	343
3. Runoff						
(1) Annual Rainfall (mm)	580	710	740	800	640	810
(2) Annual Runoff (mm)	34	69	79	103	48	107
(3) Annual Runoff (MCM)	4.454	2.891	4.171	1.689	1.306	3.349
4. Sediment						
(1) Sediment Index	2.3	1.8	1.9	2.0	1.7	1.7
(2) Sediment Yield ($m^3/Y/km^2$)	450	270	320	340	230	230
(3) Sediment Volume (MCM)	873	168	251	83	93	106
5. Reservoir Yield						
(1) Full Supply Capacity (MCM)	6.653	5.672	1.831	2.255	1.453	3.132
(2) Full Supply Area (km^2)	2.504	1.299	0.644	0.471	0.356	0.711
(3) Reservoir Yield (MCM)	0.757	1.012	0.659	0.642	0.313	1.298

Table 5-2 Net Irrigation Water Requirements Weighted for Acreage (mm/year)

Name of Project	Crop	1) IWR (mm/year)	2) CP (%)	3) NIWR (mm/year)
Musaverema	Suger Beans	322	45	145
	Tomatoes	433	15	65
	Groundnuts	425	25	106
	Vegetables	653	15	98
	Maize	651	45	293
	Vegetables	695	10	70
	Early Maize	655	5	33
	Wheat	590	40	236
				1 046
Chinyamatumwa	Suger Beans	290	40	116
	Tomatoes	369	20	74
	Groundnuts	341	20	68
	Vegetables	563	20	113
	Maize	636	40	254
	Vegetables	666	10	67
	Early Maize	632	10	63
	Wheat	519	40	208
				963
Mashoko	Suger Beans	317	45	143
	Tomatoes	422	15	63
	Groundnuts	411	25	103
	Vegetables	636	15	95
	Maize	644	45	290
	Vegetables	691	10	69
	Early Maize	652	5	33
	Wheat	589	40	236
				1 032
Munjanganja	Suger Beans	314	40	126
	Tomatoes	394	20	79
	Groundnuts	351	20	70
	Vegetables	581	20	116
	Maize	635	40	254
	Vegetables	672	10	67
	Early Maize	634	10	63
	Wheat	535	40	214
				989
Magudu	Suger Beans	304	45	137
	Tomatoes	393	15	59
	Groundnuts	379	25	95
	Vegetables	600	15	90
	Maize	618	45	278
	Vegetables	674	10	67
	Early Maize	638	5	32
	Wheat	576	40	230
				988
Mabvute	Suger Beans	268	40	107
	Tomatoes	351	20	70
	Groundnuts	337	20	67
	Vegetables	555	20	111
	Maize	658	40	263
	Vegetables	676	10	68
	Early Maize	635	10	64
	Wheat	520	40	208
				958

Notes

1) IWR - Net Irrgation Water Requirement with Effective Reliable Rainfall (Detailed estimates of IWR are given in Annex 0-0.2.)
2) CP - Cropping Pattern
3) NIWR - Net Irrgation Water Requirement weighted for acreage

(c) Gross Irrigation Water Requirements

The overall project efficiency used in calculating the gross irrigation water requirement is based on the following efficiencies:

Items	Canal Conveyance System	Pump Conveyance System
Conveyance Efficiency	0.95	1.0
Field Canal Efficiency	0.95	0.95
Field Application Efficiency	0.55	0.55
Overall Efficiency	0.50	0.52

(d) Peak Daily Water Requirements

The peak daily water requirement is based on a fully matured crop, assuming crop coefficient of 1.0 irrespective of crop kind, growing on entire average during November when the daily evapotranspiration at Masvingo Meteorological Station is 6.4 mm. In assuming an overall efficiency, the gross daily water requirements will be 1.481 l/sec/ha for canal conveyance system and 2.137 l/sec/ha for pump conveyance system which will be used for planning of irrigation facilities.

(3) Civil Engineering Design

The items of the engineering works for the dams and irrigation facilities shall be determined in accordance with "The Guide to Design and Construction of Medium Size Earth Dams in Rhodesia". If there is no standard in the said guide, the design shall be made in accordance with "The Design Standards for Land Improvement Project" of the Ministry of Agriculture, Forestry and Fisheries of Japan, although the criteria for effect of earthquake force is to be ignored.

(4) Mechanical Equipment

Principal mechanical equipment such as pump pipe and valve shall be installed in accordance with the Japan Industrial Standard (JIS) in view of the fact that equipment is to be procured in Japan by the Japanese contractor under the grant aid programme.

5.3. Basic Plan

5.3.1. Dam and Reservoir

(1) Type of Dam

It is apparently recognized that the fill-type dam should be adopted for all the six sites because of topographical and geological conditions. Each dam site has gentle slopes of abutment. It also has fairly deep deposit or overburden layers on rigid foundation rock at river bed. On the other hand, a concrete type of dam has high cost and is not suitable for each dam site.

Around each dam site soil materials for impervious to semipervious embankment are abundant. Pervious rock materials can also be obtained in the vicinity of dam site. But it is costly as it will need blasting. Rock fill type of dam is not recommendable; thus, the earth fill type is selected for each dam site.

Embankment work in the river bed portion shall be done during dry season in order to save diversion structure for flood flow and secure embankment soil materials in drier condition. To make dam construction easy and less costly, it is recommendable that the use of impervious material will be small. Considering the above condition and dam scale, zoned-fill dam with center core is finally adopted for each site.

(2) Crest Width

The crest width of dam is determined at 6 meters in due consideration of available materials, height of dam, possible roadway requirement for maintenance and practicability of construction works.

(3) Freeboard

Dry freeboard is defined as a vertical distance between the crest of dam and flood water level caused by wave action. The calculation of wave height will be based on the formula below defined under the guideline of Zimbabwe.

Wave height: $h = 0.032 \times V \times F + 0.76 - 0.27 F^{0.25}$

V: Wind speed (55 km/h)
F: Fetch (km)
h: Wave height

There is a further uprush effect of the wave riding up the slope of the dam and the dry freeboard wave allowance can be taken as 1.5 times the wave height calculated above.

Project	Fetch (km)	Wave Height (m)	Freeboard (m)
Musaverema	2.0	0.77	1.2
Magudu	2.1	0.78	1.2
Munjanganja	0.9	0.72	1.1
Chinyamatumwa	1.5	0.75	1.2
Mashoko	2.0	0.77	1.2
Mabvute	2.5	0.80	1.2

(4) Typical Section of Dam

A dam with core width of 50 to 30 per cent against water head can normally maintain safety in any severe construction condition. The width of impervious core is proposed to be more than 50 per cent of water head at any elevation but be more than 30 per cent for embankment in the core trench.

The drainage system for leakage water in the dam will depend on the chimney drain. The top of chimney drain will reach F.S.L. to catch the phreatic surface perfectly. The leakage water in the chimney drain will go outside through sand blanket drain at the river bed.

Considering the soil properties (mostly SC in unified classification) dam height and slope stability, the mean embankment slope is selected to be 1:2.25 for the upstream and 1:2.0 for the downstream. The berm setting on the slope is adopted to reduce the embankment volume but maintain the slope stability.

The upstream slope of earth fill dam must be protected against destructive wave action caused by the wind and rainfall erosion usual types of surface protection for the upstream are dumped rock riprap. The protection of riprap will be set on the upstream slope between H.F.L. and one meter lower position of dead water level. The materials of riprap can be hauled from quarry nearby dam site or utilized by gathering boulders on the riverbed of each site.

Thickness of riprap must be sufficient to accommodate the weight and size of stone necessary to resist wave action. The thickness and size of riprap are recommended for each dam which have about 0.8 m wave height as follows:

Thickness: 30 cm
Max. Size: 30 cm

To prevent the embankment from erosion caused by rainfall runoff a sod-facing will be planned on the downstream slope. A drainage berm is also useful for protection of downstream slope. At the toe of downstream slope rock material will be embanked to prevent slope from destructive washing by back water in flood season.

(5) Foundation Treatment of Dam

To maintain a permanent stable support, stripping must be performed for top soil layer containing organic matter. Sand and gravel layers formed in the river bed are fairly firm and may be resistible against sliding and deformation. However, they must be removed from the dam foundation of upstream side including core trench to avoid or reduce foundation leakage from reservoir. The dam foundation of downstream side allows sand and gravel layers remain.

Core trench must pass through soil, sand and gravel layers and reach foundation rock. The bottom width of core trench is planned at about 6 m. This width is enough to operate excavation work by heavy machine and grouting work.

Through the drilling and other geological survey at each dam site, it is clarified that each site has pervious foundation rock partly or wholly. The permeability is more than $nx10^{-3}$ cm/s or more than 50 lugion. To prevent hazardous leakage every dam site will require the foundation treatment by grouting. The grouting is planned to have one row with hole interval of two (2) to three (3) meters. Bottoms of grouting hole will cover the pervious foundation of more than five lugion.

(6) Spillway

(a) Site and Alignment of Spillway

Spillway is one of the most important appurtenant structures and its construction cost will heavily weigh on the total dam cost. The foundation of spillway sill and its surrounding is required to be sound rock to maintain the structure firm to resist erosion by flowing water. Otherwise it will require a large scale of protection of concrete or masonry which will increase construction cost. Accordingly a site and alignment of spillway must be selected carefully on the basis of topographical and geological conditions.

(i) Musaverema

Both of the dam abutment have very gentle slopes. The right abutment is covered with thick soil and fractured rock layers which exceed about 15 m to reach sound and fresh rock. On the other hand, the left abutment has many outcrops of hard and massive rocks. It is apparent that the site for spillway is left abutment from geological viewpoint.

The sill of spillway will be set in the middle of dam embankment on the left abutment. The foundation of sill will easily reach sound rock after removing shallow top soil. However the excavation of hard rock at just downstream of sill will be somewhat inevitable to avoid the flowing water rushing to one side of channel. The chute channel to connect the flow to main river will be made by mere removal of soil layer.

(ii) Magudu

The spillway alignment will be set on the left abutment. The right abutment has very thick soil and fractured weak rock wholly. Lower slopes of left abutment also have thick weathered or fractured rock. But at the end of left abutment a hard rock for spillway foundation will be obtained in shallow depth. Fractured zone by intrusion of dolerite developed widely at the dam site. The left abutment is not also exceptional. To obtain firm foundation of spillway a sill with short length is recommendable. The foundation of chute channel will meet the fractured zone. It will be protected by masonry for side wall and concrete lining or wet masonry for bottom.

(iii) Munjanganja

Lower slopes of the both abutment have many outcrops especially nearby river bed. But less outcrops are observed as elevation goes up at the both abutment. There are some differences between the right and left abutment. The left is more gentle, lower at top elevation and less deep in soil and weathered rock thickness than right abutment. The top of left abutment gives the limit of reservoir capacity. To make the reservoir volume as large as possible, it is effective to have long sill of spillway which can have small wet freeboard. The gentle slope of the left abutment is apparently suitable for sill setting. A hard and massive rock foundation can be easily obtained by removing soil of about 5 m thickness. The gentle slope of left abutment gives the spillway channel long distance to meet the main river. But it is avoidable by leading the chute channel to the tributary of the main river.

(iv) Chinyamatumwa

Spillway will be set on the left abutment. There is no great difference about shape of slope and thickness of soil and weathered rock between both abutments. But the alignment of spillway on the left abutment is able to make the chute channel shorter because, downstream river is turning to left side. The spillway channel will be placed on the fractured or weathered rock. Side of channel will be mainly exposed to strongly weathered rock, where a protection by the maisonry will be required.

(v) Mashoko

The right abutment has thick soil and weathered layers which may exceed 10 m. The left abutment also has thick soil and fractured rock nearby river bed. But their thickness rapidly becomes small with the increase of the elevation.

On the upper middle of left abutment hard rock exists in shallow depth. Besides, there forms flat terrace which is suitable to place the spillway sill. Accordingly the alignment will be set on the left abutment in the middle of dam embankment. Side wall of chute channel will be mainly placed in the soil layers. It will be protected with dry or wet stone masonry.

(vi) Mabvute

Both abutments have extremely deep soil and strongly weathered soft rock layer except river bed and end of abutment. In order to avoid large volume of foundation excavation morning glory type of spillway at river bed is examined, but it was proved to be out of proportion to river bed size and the project scale. Accordingly normal non-gated spillway is selected on the left abutment where alignment of chute channel is shorter than on the right abutment.

(b) Spillway Sill

In reference to the result of dam and reservoir optimization and hydraulic calculation, the dimensions of sill for each dam are summarized below.

Project	Design Flood (m^3/s)	Overflow Depth (m)	Sill Length (m)
Musaverema	835	2.5	125
Magudu	415	3.0	47
Munjanganja	349	1.0	206
Chinyamatumwa	163	1.5	53
Mashoko	228	1.5	73
Mabvute	343	3.0	39

(7) Outlet Works

A location site of outlet works will be same abutment side with irrigation farm. The alignment of outlet works will be selected at the middle of abutment to place it in the shortest length of conduit pipe.

The intake will be provided with screen and emergency gate. The conduit steel pipe with diameter of 800 mm will be set in the foundation rock and protected with concrete.

The outlet structure will have main and supplementary gates to regulate the discharge. These gates will be installed in the maintenance hut. The pressured water passing conduit and gates will be dissipated at the concrete box.

5.3.2. Conveyance Facilities

The two types of water conveyance facilities; namely, gravity system and pump system have been selected based on the difference of elevation between the outlet of dam and night storage reservoir. Each project is classified as follows.

. Gravity system
  - Musaverema
  - Magudu
  - Munjangauja
  - Mashoko

. Pump system
  - Chinyamatumwa
  - Mabvute

(1) Gravity System

The water conveyance canal between dam and night storage reservoir is planned to have a carrying capacity enough to convey the required quantity per day within 24 hours when the maximum water is required.

The design head is planned to be the difference of altitudes between design low water level in stilling basin of outlet and full water level in night storage reservoir.

Layout of the canal was aligned on a topographical map scaled 1:5,000. Particular attention was given to minimize the length of canal. Since most of the canal alignment pass through sandy pervious soil, protection against leakage is necessary and concrete lining will be planned from the economic viewpoint and in due consideration of construction experience of lining canal in Zimbabwe. The canal section was determined on the basis of Manning's formula with roughness coefficient n=0.016.

Siphons and culverts are planned to be constructed in each place where the route runs across rivers and roads. Reinforced concrete pipe is adopted for siphon as the most economical type of structure. The drop structures are to be installed in canal. The standard drop height is decided at 30 cm in one drop.

The small off-takes are planned to be installed at the suitable places along the conveyance canals in order to supply the livestock water and domestic water for inhabitants.

The main features of Water Conveyance Canal is shown in Table 5-3.

Table 5-3 Main Features of Water Conveyance Canal

Items	Musaverema	Magudu	Munjanganja	Mashoko
1. Design Discharge (l/sec)	54	76	49	23
2. Mannings Roughness Coefficient	0.016	0.016	0.016	0.016
3. Canal Slope	1/1,000	1/400	1/400	1/300
4. Canal Section				
1) Bottom Width (m)	0.30	0.30	0.25	0.25
2) Height (m)	0.35	0.35	0.30	0.25
3) Water Depth (m)	0.25	0.23	0.20	0.11
5. Design Velocity (m/sec)	0.50	0.77	0.69	0.64
6. Length	5,600	7,940	4,720	800
7. Appurtenant Structure				
1) River Crossing (No.)	1	1	1	-
2) Road Crossing (No.)	1	2	-	-
3) Drop Structure (No.)	-	1	15	9
4) Domestic Water Supply (No.)	7	9	6	-

(2) Pump System

The water should be pressurized and conveyed from dam to highly located night storage reservoir where the proposed irrigable area is located higher than the lowest water level in reservoir.

The maximum pump running hours is 16 hours a day even in peak season, taking into account the custom and social environment of inhabitants in the province.

Horizontal double suction volute pumps are to be adopted in view of small capacity but relatively high lift. Two sets of pumps are to be installed for easy operation. As to the motor for pumps, four-pole induction motor is to be adopted. The diesel generator is to be installed for the power of motor.

Steel pipe is used for pipeline to be installed between pump house and night storage reservoir, due to the fact that the total head is rather high and water hammer and negative pressure are predicted by sudden stop of pump.

The main features of pumps and pipelines are shown in Table 5-4.

Table 5-4 Main Features of Pumps and Pipelines

Items		Chinyamatumwa	Mabvute
1. Pump			
1) Design Discharge	(l/sec)	74	151
2) Total Head	(m)	40	55
3) Pump - 2 sets			
Discharge	(m^3/min)	2.22	4.53
Diameter	(mm)	150 x 100	200 x 100
Motor	(kW)	30	74
4) Diesel Generator	(kVA)	90	220
2. Pipeline			
1) Design Discharge	(l/sec)	74	151
2) Kind of Pipe		steel pipe	steel pipe
3) Length	(m)	870	860
4) Diameter	(mm)	300	400

5.3.3. Night Storage Reservoir

The consumption of water varies widely in accordance with the farming programme planned. The night storage reservoir acts as a buffer between the constant supply from the dam and the fluctuating field damand. Furthermore reserved water in night storage reservoir can be used during repair of conveyance canal or pipe caused by unexpected trouble or accident.

The required reservoir capacity is planned to be equal to peak field demand for 24 hours. The reservoir is planned to be the pond enclosed with earth dikes, which is equipped with inlet, outlet, drain, staffgauge, bypass, spillway, etc.

The reservoir itself is a combination of cut/fill earth structure with water depth of 2.0 metres and freeboard of 0.7 metres. The external and internal slopes of embankment are 1:1.5 and 1:2.0 respectively, and the top width is 2.0 metres.

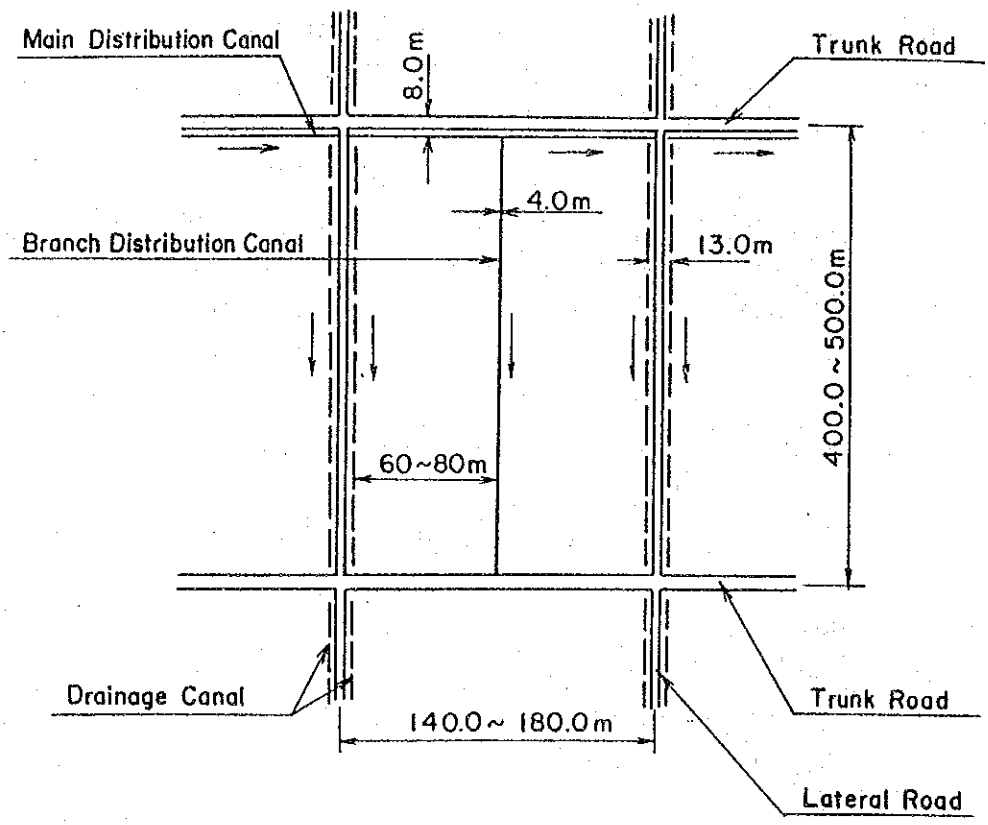
The main features of night storage reservoirs are shown below.

Project	Design Capacity (m^3/s)	Water Depth (m)	Dimension (m)
Musaverema	4,600	2.0	57 x 57
Magudu	6,500	2.0	66 x 66
Munjanganja	4,300	2.0	55 x 55
Chinyamatumwa	4,300	2.0	55 x 55
Mashoko	1,900	2.0	40 x 40
Mabvute	8,700	2.0	75 x 75

5.3.4. In-field Facilities

(1) Farmland Block Plan

The size and shape of the standard unit of field blocks is decided taking into account the farm organization and farming system. The standard farmland block plan is shown below.



(2) In-field Distribution Canal

The irrigation water is distributed to the individual plots by a network of reinforced precast concrete canal (rectangular shape). The distribution canal network should have main and branch canals which enable every unit plot receive the peak amount of water. The flow into each canal is controlled by an adjustable sliding gate. The leading of water to the plots is made by means of plastic siphon tubes in front of the check plate.

(3) In-field Road

Farm roads are planned for easy farming practice and management. The road network will consist of trunk roads and lateral roads. The most suitable route of trunk roads should be planned taking into consideration the easy access to the principal roads, agricultural related facilities and public facilities.

The effective width of trunk road is to be 4 m, and the surface should be at least 20 m higher than the field. The surface is to be paved with gravel to protect the road against heavy traffic and erosion by rainfall.

The lateral road is planned to border at least on one side of field block. The minimum effective width is 3 m. The surface should be at least 20 cm higher than the field and paved with gravel.

(4) Drainage Canal

The-large scale drainage system is not considered necessary to be extended to every field lot because upland farming is planned in the project area where the precipitation is not much. However, the minimum scale of open drain canals are planned along lateral roads considering unforeseeable intensive rain which falls on and severely erodes the lands gently sloping in one direction.

The main features of in-field facilities are as follows:

Project	Farm Area (ha)	Irrigation Area (ha)	Distribution Canal (km)	Drainage Canal (km)	Farm Road (km)
Musaverema	44.0	36.2	5.8	7.7	6.6
Magudu	70.0	51.1	8.5	9.6	10.2
Munjanganja	51.0	33.3	4.9	6.4	7.1
Chinyamatumwa	50.0	34.7	5.4	6.2	9.0
Mashoko	21.0	15.2	2.0	3.5	3.3
Mabvute	100.0	70.5	11.2	14.5	15.7